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Training and Competency Development on Virtual Safety Training

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ABSTRACT

In this paper, we explore cutting-edge technologies that enable virtual safety and control systems, drawing upon both traditional and recent literature on human system integration in operational contexts. Our objective is to enhance mission effectiveness and human well-being through the recommendation adoption of virtualization techniques. To achieve this, we design virtualized missions that facilitate the adoption of operational procedures across different organizational teams. The development of successful personnel simulations demands experience in creating training scenarios in industrial open field environments, leading to improved virtual safety experiences for personnel with reduced training infrastructure needs. Our findings reveal that networking-based virtual training and human system integration, implemented on a system-to-system basis, can support physical simulations. By integrating artificial intelligence, we can enhance data collection and support human operations. Future research should focus on refining training and competency, with a particular emphasis on improving data capture and information processing to bolster human decision-making and performance.

Keywords: Virtual training, Industrial training, Competency development, European manufacturing, Internet of things, Human systems integration

INTRODUCTION

Since the 4G, "The reference architectures were shared for hundreds of teams for ongoing development" (Cloutier 2010). Reference architectures are a popular research area for advantages, but how architectural benefits can be created often needs to be clarified (Wahyudi et al. 2017). 4G vulnerabilities for cloud computing are high compared to newer technologies (Cisco 2022). Reference arcs on software are recognized in a variety of instances. The observations on references could contribute more adequately to support their use. (Guess et al. 2014.) The methodology framework needs to be built to address the multi-layer network approaches to more sustainable industrial training and safety generation, occupation safety, and industrial system development recommendation.

The recent architectural changes offer solution where 5G innovation acts as an enabler for cloud-based virtual simulation applications. Thus, broadband networks are shaping the market toward platform as a service (adapted Kaartemo & Nyström 2021). Application streaming (AS) accelerates engineering on virtualizing work (aws 2023). AS is widely adopted in industries:

connectivity becomes part of all industries' infrastructure, advantaging full spectrum sharing. The VR-based cellular network technology for the shared environment for distance training on the platform to train supports learning by simulation.

However, virtual reality simulation platforms have challenges. These are related to training environment difficulties: risk to lack of actual training. (adapted Lin et al. 2021.)

The virtual reality design for industry training requirements in game engine development environments integrates a reality reflection into world-building. The real-world simulation allows industrial developers to test various scenarios on systems' sensing capabilities and behaviors. (Schultz 2022.) This article explores the cellular connectivity virtualized approach to delivering and simulating industrial augmented reality into physical environments.

This study evaluates the future aspects of sustainable computing-based industrial training services on the web.

Virtualized Integration Tecnology on Human Systems Integration

One of the characteristics of the future of the virtual world is the increasing networking capacity. This is because of the mobile networks' usability for delivering training services. The computational intensive tasks can be generated from the edge and cloud servers from access points and satellites that stream data from/to the universe. Simulation of the system adapts to the businesses training 401(K) administration across the Atlantic and Indian oceans. The requirement for employee eligibility by matching compliance and legislative requirements, training, and certification benefits human resources. The safe harbor compliance on business administration awards excellence in organization protocols that are well designed (adapted HR Certification 2023). Harbor enables the creation of new training simulations for the customer's benefit within the next generation—for example, through computation-intensive real-time streaming (Patterson 2019). Arguably, the distance transmission from edge and cloud servers faces stability issues for system-critical tasks. 6G is "expected" to bring advances in areas such as artificial intelligence, extended reality, and the Internet of Things (IoT), which further enhances the capabilities of virtual training for Human Systems Integration (HSI) to increase human performance. (adapted Adhikari & Hazra 2022.)

Research Questions

The main research question (RQ) is how VR-based training can be viewed from the human systems integration (HSI)—the framework for intangible to tangible and the industry's current practice.

1. What are the current operational policies in Finnish manufacturing firms, and what is the next enhancement to increase competitiveness?
2. How does the human system integration advance on extended reality?
    a. What is the sustainable service solution for tangible effects on virtual training operations?

b. What is the tangible infrastructure where the industries adapt to the metaverse?

The academic, managerial approach for industrialized recommendation is formed based on the solution—next, the method to approach the questions.

Method

Mixed method adaptation on axiomatic design and correlation modeling.

Correlation Modeling and Axiomatic Design

The method to approach RQ1 is based on empirical research. The data is compared to the cross-sectional likelihood of the variable to the other variable correlating, indicated by the intertwined information magnitudes to each other in pairwise comparison. The variables are directly or indirectly related, igniting explanatory discussion and assisting agencies' decision-making. (Heilala et al. 2023.) The RQ2 is based on literature exploration and axiomatic design (AD) based on studies in the field (Fechter et al. 2016; Sadeghi et al. 2017). AD is a process with a hierarchical activity where solutions are based on a sequence of stages of problem definition, solution synthesis, solution evaluation, and implementation. The advantage is that the decoupled designs (DD) on decision-making can be made by deploying iterative Zig-zagging Design (ZD) to meet certain parameters satisfying design axioms (DA). There is a limitation that the axiom cannot be nonlinear because the limit of the fraction increases with complexity. (adapted Suh 1995.) However, axioms of higher dimensions exist in mathematics. For example, 4D quaternion ($a + bi + cj + dk$) can be modeled as 2D complex $i2 = j2 = k2 = ijk = -1$) when the quaternions constants $(a, b, c, d) \in$ scalar community, are equal when coinciding. (Paulson 2022.) From the perspective of AD theories on training, the system robustness requires FRs to be based on CRs. The requirements can have quaternion representation. AD solutions minimize complexity. The minimized system is based on two axioms: the independence axiom and the information axiom. The independence axiom must contribute satisfactorily. From the process starts, the systems are uncoupled designs (UDs), and the system must be broken apart and treated individually to understand the system's characteristics. Only UDs and DD satisfy the independence axiom. (Suh 2007.) As a synthesis, given the complexity of quaternion of any quadratic or higher dimensional challenge, (Suh 2007) says the approach requires minimization, breaking the system components sophisticatedly apart to eliminate combinatorial complexity. UDs contribute to simplicity reducing cognitive load. When the system number of scalars increases, the complexity increases. When the system is simplified, it is stable in the long term. (Adaptation from Paulson 2022 enumerated representation to Suh 2007.)

The following modest findings on the fast-growing virtual training area are covered for the convention. To the base of RQ2ab, RQ1 is based on empirical evidence elaborated next.

Training and Competency Development Data Analysis in Different Firms

The Descriptives

Interpreted from Table 1. Development of Competitiveness and Employment Situations (DCES) and specify model critical quadratic variables Annual Turnover (AT, m23a1) shows yearly revenue (in a million €). The number of Employees (NE, m23b1) indicates the total number of human resources. Manufacturing Capacity Utilization (MCU, m23h) indicates the usage of the main operations. Return of Sales (ROS) value scale indicates (from 1 to 5: negative, 0-2%, >2-5%, >5-10%, and >10%) before tax. The five aspects form the training and competency development (TCD) variable. 1.) The last three years of production employees are based on task-specific focus (TSF). 2.) cross-functional focus (CFF). 3.) support digital production (SIUD) implementation and use. 4.) data security and data compliance (DC2). 5.) and towards creativity and innovation (TCI) (e.g., problem-solving, idea generation, or brainstorming techniques). (source: own study from EMS.).

Results indicate that there are few TSF, CFF, SIUD, and DC2 but a considerable amount of TCI ensuring successful operations management.

Table 1. DCES and TCD variables descriptives (source: own study from EMS).

	MIN	MAX	M	MED	MOD	STD	SKEW	KURT	SUM	VALID
AT21	0	339	26.22	6.00	1	52.44	3.77	17.64	2071.33	79
AT19	0	326	24.84	6.00	1	52.66	3.87	17.47	1912.69	77
NE21	3	600	84	40.00	12	115.4	2.335	5.98	7140	85
NE19	2	500	78.23	40.00	6	105.8	2.104	4.249	6493	83
MCU21	0	100	66.67	75.00	0	28.975	-1.227	0.664	4267	64
MCU19	0	100	63.3	75.00	0	31.812	-0.907	-0.34	3861	61
ROS16	1	5	3.42	4.00	5	1.567	-0.509	-1.29	267	78
TSF	0	1	0.7	1.00	1	0.46	-0.884	-1.24	11	123
CFF	0	1	0.49	0.00	0	0.502	0.034	-2.033	11	123
SIUD	0	1	0.38	0.00	0	0.488	0.486	-1.794	11	123
DC2	0	1	0.6	1.00	1	0.492	-0.413	-1.86	11	122
TCI	0	1	0.45	0.00	0	0	0.204	-1.992	54	122

Training and Competency Model Correlations

A simple model from Table 2 follows that the companies that offer TSF highly benefited from positive MCU in 2019. CFF is expected to be utilized when NE19-21 is positively higher, and it relates to TSF for companies utilizing it. SIUD is related to large companies and MCU in 2019. DC2 is very rarely used to improve competitiveness. TCI has a positive effect on ROS. While all factors relate to each other, meaning that when respondents choose an option, it is probable that they choose more than one option.

Table 2. DCES and TCD variables correlations (source: own study from EMS).

	AT21	AT19	NE21	NE19	MCU21	MCU19	ROS	TSF	CFF	SIUD	DC2	TCI
AT21	1											
AT19	.991***	1										
NE21	.818***	.807***	1									
NE19	.822***	.831***	.983***	1								
MCU21	0.045	0.032	0.086	0.085	1							
MCU19	0.245*	0.244*	0.209	0.195	0.075	1						
ROS	.233**	0.221*	0.221*	0.203*	-0.030	0.241*	1					
TSF	-0.024	-0.050	0.068	0.039	0.093	.259**	0.116	1				
CFF	0.093	0.079	.230**	.220**	-0.135	-0.035	0.041	.280***	1			
SIUD	0.132	0.103	.252**	.221**	0.167	.266**	0.045	.329***	.356***	1		
DC2	0.007	-0.002	0.144	0.130	0.095	-0.028	0.137	.393***	.463***	.469***	1	
TCI	0.010	0.010	0.151	0.127	0.132	0.048	.237**	.336***	.350***	.252***	.465***	1

Reinforced Training Matrix

For the supply chain of the training, delivery conditions are extending reality on TCD with respect to internalized operations. For CFF, mostly internal, but also external and e-learning-based often; for SIUD, internal and external supplying is almost balanced, while e-learning is difficult. DC2 is internalized, while external and e-learning are balanced and outsourced. For TCI, the internal is mostly connecting but also externally supplied, and e-learning stands for opportunities.

Table 3. DCES and TCD contracting variables correlations (source: own study from EMS).

	TSF	CFF	SIUD	DC2	TCI
TSF-internal	.493***				
TSF-external	0.102				
TSF-e-learning	0.132				
CFF-internal		.613***			
CFF-external		.383***			
CFF-e-learning		.214**			
SIUD-internal			.556***		
SIUD-external			.521***		
SIUD-e-learning			.270***		
DC2-internal				.465***	
DC2-external				.183**	
DC2-e-learning				.230**	
TCI-internal					.665***
TCI-external					.313***
TCI-e-learning					.204**

Refining the Results

Companies more often provide all training from internal channels, but some provide them from external and virtualized manner. TCI dominates the management of operations that profit from internal practices. On the other hand, in the biggest companies like CFF and SIUD-like practices from the

MCU perspective, DC2 is used sparingly, usually internally but externally, and mostly offered virtually.

The empirical findings suggest in connecting and exploring broad creativity-based virtual reality and training for investigating sustainable operations and, current and future infrastructure design domain.

Distance Training, Operations, Safety and Maintenance

Enabling robust, cost-effective operations for training and offer the training virtually. The virtual layout has to integrate into the HSI domain throughout the system's lifecycle. The system of systems (SoS) covers networks of networks from organizations to individuals virtualized as per request. Operations condense on maintaining missions and people safe. SoS-knowledge for supporting requires deep learning on safety. The HSI ensures that the skills are aligning for operations. Virtualized operations management requires teams to process DA to field operations. For example, autonomous aircraft, spacecraft (e.g., Mourtzis et al. 2022), groundcraft or seacraft training involves ground and flight/sea crews, operators for metal additive manufacturing (e.g., Pusateri et al. 2022) on for operations continuity service level contracts (SLAs). The command center occupied control room for operations always has infrastructural requirements on satisfying information. The safety of analyzing the system on engineering software embedded in hardware and survivability aspects, quality assurance, and quality management is led by knowledge of EFs. Performing state-of-the-art designed missions on simulated training in an industrial environment require minimized training facilities, design, and method for assessing manpower knowledge.

One framework domain for researching this is system intelligence (SI). High SI on knowledge of HSI on EFs' safety domain sustains manpower performance. Management of adverse effects of operations requires human nutrition, acoustics, lightning, and other environmental factors. EFs in concentration can pollute the operation environment and affect cognitive performance (adapted Zhang et al. 2018). High organizational performance inversely appears to have negative SI on behalf of stress (adapted Jumisko-Pyykkö et al. 2022). The living and working become sustainable on the suitable growth medium of the plant. The communication channel maintenance and data interfaces define the acquisition when system uptime, availability, and mission encounter. The maintenance quantifies all-out the stash inventory to coordinate operations from manpower and increases availability to the lifecycle (LC) aspect. (adapted Karwowski & Zhang 2021.)

Typical Fixed, Portable and Mobile Training Equipment

mmersive technologies will develop in the coming years to even higher quality in terms of resolution while their usability will improve. The Table 4 presents the operations side resource operations safety and maintainability dependence to the context. HFs surrounded by engineered computerized environments establish a metaverse. The data produced and generated decisions by automation require system intelligence. The HFs' training on mental and physical aspects of succesful operations requires a realistic environment. The sensory space of industrial environments can be complex to model in the new environment. (Laksono 2022). The biggest practical changes come on the VR side to control immersion. Most expectations are on the side of research centers and companies that can make new adapted applications based on technologies. What needs to be clarified is whether AVE is of any use. (Vasconcelos et al. 2019, 141.) VR response to follow training can rely on different biosignals: HSI's smart biosignal measurement on processing complex tasks in solving require attention and abilities that frequency domain can classify and predict (Qazi et al. 2016). The training and competency infrastructure is present in Table 5, and the empirical part for delving deeper into the firms utilizing technology is researched.

Table 4. Complex prototype for hybrid operations human system integration of a LC on maximizing the vertical on core organization functions.

	Sustainable competence	Mission for vision	Environment retention	Resource retrieval
Training	X			
Operations		X		
Safety			X	
Maintenance				X

Table 5. Training and competence development infrastructure on PLC (Yankong 2022) on AR (Xiaoming et al. 2017) on VR (Weising & Miller 2020; Connor 2018; Kiemele et al. 2018) on CAVE (Cruz Neira & Reiners 2019) and on BIO (Lee et al. 2017).

	System infra-structural total control	Extended augmented reality	Interactive virtual reality	Automatic virtual environment	Biosignal feedback and control
PLC	X				
AR		X			
VR			X		
CAVE				X	
BIO					X

RESULTS

The study draws results on virtualized competency training models from manufacturing firms that reflect the environment of operation models. It was discovered that large corporations were found that supported by the preliminary research on large corporations (Heilala & Singh 2023ab). For the best return on investment, creativity has to be supported adequately. Vulnerable is whether the training can be virtually or physically set up a simulation on the specific task. For this, we found a supportive and simple framework from technology. We found several benefits of VR applied in HSI SoS. The VR on 5G networks is expected to be enhanced by 6G, the next generation of wireless technology. As technology advances, 6G and forthcoming, it is expected to provide faster, more reliable, and lower latency network connections for industries' use. The beneficial domains of virtual training were found to benefit data-intensive computing on transferring virtual environment operators or designers into space on training or designing various elements of HSI. Networking technology allows human systems to engage in interactive and real-time training simulations. The benefits of the capital increase are difficult to evaluate per se based on manufacturing firms' competitive edge on applying AD domain criteria of simple infrastructure, which is both technologically and from software aspect scalable depending on the markets and customer requirements. The manufacturing industry emphasizes creativity overall. (RQ1) Thus, the next VR and communication technologies are offered to improve the gaps of imagination by offering simulations that are more creativity-based, giving a competitive edge over the requirements of the next viewpoints.

From another angle to the HSI to virtual reality, we found the process cost; investment with the uncertain return is realizable – but is it robust to follow the calendar and schedules and decide that the training is complete? No, changing the environment rearranges the problems and, like democracy, can add value to virtualized HSI only when equality is achieved (also applies in Laarni & Ylönen 2020). Training manpower in virtualized environments forms sustainable proficiency in the tangible environment. When the training is not met or when the environment changes, humans can virtually and physically need further training. Consideration is important in adapting the training for properly integrating the industry system. Most people do not like the idea of being integrated but rather follow the integration principles, and if not voluntarily, this requires better training environments (RQ2a).

Operations side, the mission leading towards a vision is important to win the trust through training within a simulation only on the nearest environment that corresponds to individuals' sake of living. To all industries, safety in all aspects of failure disposition is achieved by retention of the environment through crisis management and prevention. The resource retrieval minds the input to the business operations, and the simulation on the side of HSI on virtualized retention of facts prolong the lifecycle of the industrial operations. Thus, the virtualized training helps to perform like in industry, as serious game simulation and the training-reinforced results set challenges for companies, whether to adopt or not to adopt policy digitalization requirements based on increased competitiveness. The changing environment challenges changing the simulation and retraining personnel. For large-scale designs, the retraining becomes each work item separately, something to be learned before starting and continuing operations (RQ2b).

To the ground from the heights of digital cloud-based simulation, the tangible asset of green human resource management becomes succesful in integrating the industries training facts and adopting the digitalization requirements for the agenda of raising business by leveraging the operations over the economic fence through encouraging employees for integrative creativity, but also on recruiting new agents to carry the business.

CONCLUSION

Our study concludes that Anon's standard cellular connectivity technology, 6G, will improve the development of virtual training capabilities and human system integration. SoS-based networking extends reality safer than physical simulation, and there is an opportunist viewpoint for new applications.

Industrial operations management advanced interconnectivity of equipment into simulation enables distance control and measurement. The environment data acquisition narrows the EFs measurement suitable to prepare batches of knowledge via AI to support operations for new development projects.

FUTURE STUDIES

The Institute of Occupational Health (TTL 2023), Business Finland, and the University of Turku support robust, cost-effective virtual training and practical operations. With segmentation, operations based on the empirical data and future training studies to the human research systems in the University of Turku can support cutting-edge training and competency development research nationwide.

Developing new technologies and innovative ways to connect humans and robots is interesting to further research with innovative applications. Thousands of times denser frequencies to usual wireless fidelities that support fast cloud/edge processing with smart devices adaptable to the training area, for example, support human decision-making and increase performance could improve industries' efficiencies.

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