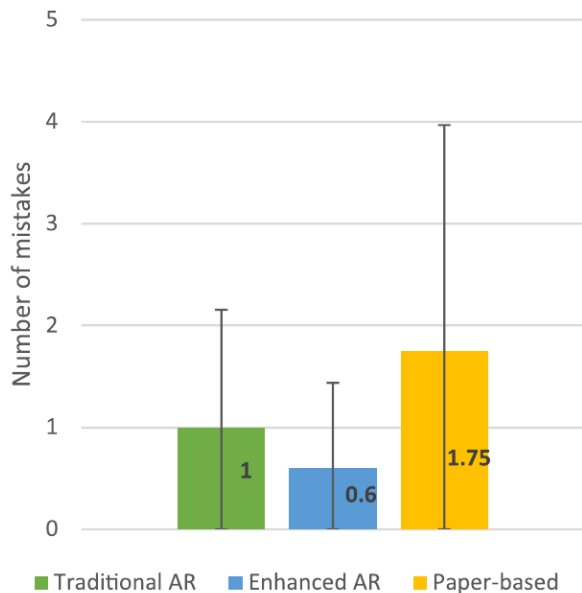**Fig. 4.** Mean Task Completion Time.

Fig. 5. Mean number of mistakes.

among groups ((F(2,10) = 1.335, p = 0.306).

4.8. Knowledge retention and reusability correlation

The associations between knowledge retention and knowledge reusability along as well as between short- and long-term retention were shown on the Table 6. Point-Biserial Correlation determined that

Table 6
Knowledge retention scores relative to the baseline.

	Traditional AR group (4 People)	Enhanced AR group (5 People)	Paper-based group (4 People)
ST	* *61.37 %	* *67.27 %	* 43.18 %
LT	* *54.54 %	* *74.54 %	* 40.91 %
LT - ST	-6.83 %	7.27 %	-2.27 %
ST (short-term), LT (long-term)			

*p < 0.05
* *p < 0.01

knowledge reusability had a statistically significant positive correlation with short-term retention score (rpb = 0.672, n = 13, p = 0.012), but not for long-term retention scores (rpb = 0.466, n = 13, p = 0.108). However, when knowledge retention between short- and long-term was analyzed, Pearson's correlation showed that there was a positive correlation between both, which was statistically significant (rp = 0.717, n = 13, p = 0.006). Fig. 6 illustrates the comparison for the success rate of wiring a second sensor by comparing the traditional AR, Enhanced AR and Paper based approaches, achieving 50%, 80% and 25% respectively..

5. Discussion

Many applications have shown that AR technology can improve learnability when acquiring new skills or concepts over traditional training in terms of knowledge comprehension rate and knowledge retention. The superiority of AR lies in its capability to overlay interactive and animated information in a timely manner. This helps to increase user's motivation to engage with the content which is essential to encourage learning. Besides, allowing users to see the necessary information at a favorable time results in a more efficient use of cognitive resources and in turn accommodates more learning. Nevertheless, the current paradigm in using AR for training seems to focus on a limited aspect of productivity such as task performance and knowledge retention enablement. In the light of Industry 5.0 which emphasizes on human centric, sustainability, and resilience, technology is expected to be developed in ways that serve human needs for upskilling or reskilling, with efficient use of resources, and better equip human to deal with uncertainties [15,31]. In attempt to expand the knowledge in this area, this study sought to base the development of AR system for training on human centric principles to facilitate meaningful learning and achieve improved learnability in terms of retention test and transfer test (see. Table 7).

The results in the retention test showed that all users demonstrated statistically significant understanding in the given task regardless of which training system (see Table 5). However, users in the AR groups were able to get an overall higher number of correct answers (18% for the traditional and ~25 % for the enhanced) than paper-based manual despite completion time and number of mistakes committed were similar across groups. Although the differences were not significant in the short-term test, the higher scores observed in AR groups could be due to more extraneous processing occurred in the paper-based manual group whereas more essential processing occurred in the AR groups. Essential processing involves intrinsic load or essential material/
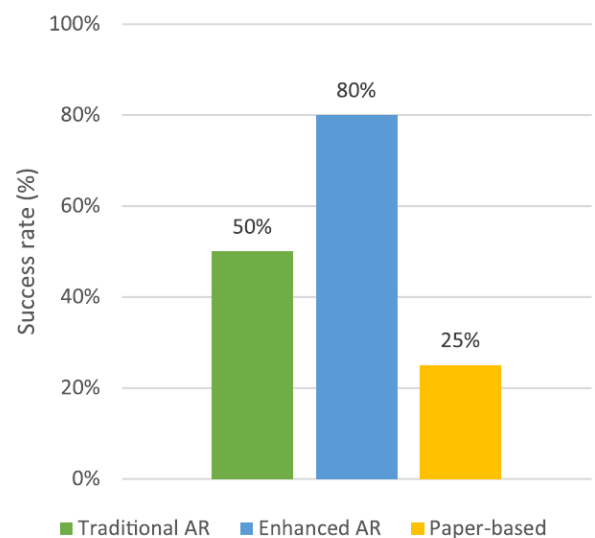

Fig. 6. Success rate of wiring a second sensor.

Augmented reality training for improved learnability

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ABSTRACT

In the current era of Industry 4.0, many new technologies offer manufacturing industries to achieve high productivity. Augmented Reality (AR) is one of the emerging technologies that has been adopted in industries to aid users in acquiring complex skills and carrying out many complicated tasks such product assembly and maintenance. Nevertheless, most AR applications have been developed without clear understanding of how such technology can facilitate improved learnability in terms of knowledge reusability. This paper proposed an enhanced AR-based training system that provides multimodal information with a contextualized information to improve task comprehension and knowledge reusability compared with traditional AR that presents unimodal and decontextualized information. An empirical test was carried out to assess the task performance and the task learnability aspects of this enhanced AR compared to the traditional AR and the paper-based document. The experiment consisted of a training phase where participants carried out an electrical connection task of a sensor followed by a knowledge reuse phase where participants had to wire a second sensor using their previous training. A pre-test quiz was given before the experiment followed by the post-tests phase after the training. Post-tests consist of one post-test given directly after the experiment (short-term retention test) and a second post-test quiz given one week later (long-term retention test) to measure information retention. The results indicated that AR-based approaches could enhance knowledge acquisition by around 18 % for traditional AR and almost 25 % for enhanced AR as compared to paper-based approach. While all training systems achieved relatively equivalent well for short-term retention test, trainees who used the enhanced AR training systems statistically outperformed those in the paper-based group for long term retention test. Furthermore, there was a positive correlation between the score of short-term retention test and the score in the knowledge reusability which was also shown by the higher scores in knowledge reusability for the enhanced AR training system compared to the other two approaches. These findings are discussed in relation to the Industry 5.0's human centric core value.

1. Introduction

The adoption of Industry 4.0 technologies enables new capabilities to produce and to deliver product faster with a better quality, and more cost efficient. However, this industrial revolution is leading to an increased complexity of manufacturing systems and an increasingly rapid renewal of these systems. Consequently, upskilling employees' competencies to handle and maintain the complex engineering assets (CEAs) is indispensable. In recent years, finding a skilled worker has become a difficult task. The reason is that there is a talent shortage nowadays. Indeed, in 2018, 45 % of employers said that they could not find the necessary skills among candidates [17]. Furthermore, a new issue will arise from adapting to the changing job dynamics brought about by digitalization [27]. Despite the increased interconnectedness and availability of information globally, the progress of digitalization has not been uniformed across countries or even within industries within the same country [14]. To face this challenge and meet with the adoption of Industry 4.0, employers need to find a new way to ensure their workforces are sufficiently equipped to work with CEAs. In the aviation sector, research examined that traditional training such as in-class training and paper-based manual are not reliable means for teaching job tasks and the skills for visual inspection for the future trend in aviation [11,29]. Visual inspection requires Aircraft Maintenance Technician (AMT) to identify certain characteristics of all types of faults and make decision to troubleshoot various systems from one airplane to another. Due to highly complexity and interrelated components in the

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▌ New customer's development and increasing the sale of product

My country economy at this season keeps escaping from Odoba of business though holds a crude oil high so on unstable element that continues still, and recovering gradually and well.
In the IT industry, there is an influence such as competing intensification in narrowing investment field.

【The main product and service at this season】

◆From the product headquarters

In the image business, the new model turning on of the A3 high-speed, two sided color scanner that achieved a high-speed reading aimed at. wroom was established in United States, Europe, and Asia/Oceania.

◆Image business

1) Scanner class

A3 high-speed, two sided color scanner "fi-5900C" that 100 high-n function to enable industry-leading was installed was announced in ScanSnap gotten popular because of an office and individual use.

2) DLM solution scanner

The DLM solution that used received the rise of the concern to efficient management and internal management of the corporate private circum-

Satisfaction rating to new product

stances report in recent years and attracted attention. The function of software that the inspection of data is possible by the sense that turns over the file is strengthened, and easiness to use has been improved.
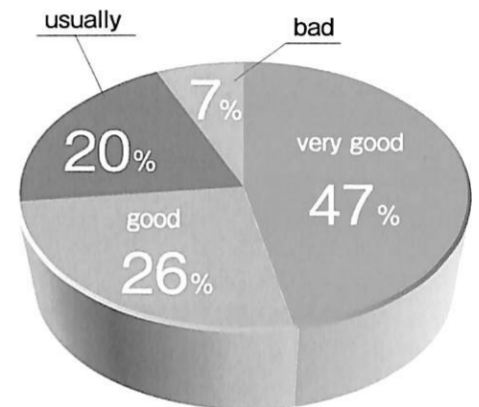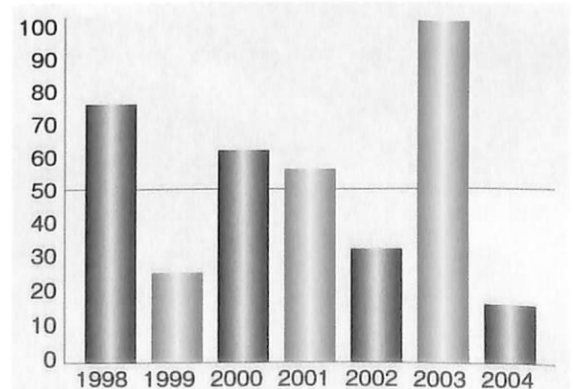
【approach on business risk】

◆In-house activity

The attestation intended for each office in Shinbashi, Kansai, and Tokai was acquired in environment ISO in February, 2006. In addition, it participates in the minus 6% that is a national movement of the global warming prevention, and "Culbiz" is done. The scandal of the enterprise has frequently generated is received, concern is sent to the system mainte-nance including the observance of the law in recent years.

◆Enhancement of system of management

The committee that aimed at the decrease of a variety of business risks in an individual business talk was newly established. Moreover, the recognition of "Privacy mark" is received to manage customer and employee's individual information appropriately in 2001, and the activ-ity based on the protection of individual information policy is continued. It is ..bAsia/Oceania in globalIn addition, our technology, commodity power, and correspondence power were evaluating acquired.

Satisfaction rating to new product