Development of Skill Evaluation System Using Mixed Reality and Measuring the Effect of Evaluation Quality

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In this paper, we propose a skill evaluation and evaluation training system using MR (Mixed Reality) in order to solve the problems in quality of skill evaluation such as the mental workload of the evaluator and the dispersion of evaluation in skills competitions. In this demonstration experiment, the system's viability was measured through three indices : mental workload, evaluation time, and evaluation accuracy, taking the evaluation process used in WorldSkills competition as an example. The results showed that the proposed system has the potential to resolve several issues regarding quality of skill evaluation at skills competitions.

Keywords : Mixed reality (MR), WorldSkills competition, Mental workload, Quality of skill evaluation

1. Introduction

Skill succession of skilled worker is at the heart of manufacturing industry, and one of the most pressing issues throughout industries and academia in recent years is how we should pass it on to future generations in the most efficient and effective ways possible. Examples often brought up as "skilled worker" are competitors who compete in the WorldSkills Competition (hereby referred to as WSC).

This competition, which is the only international skills competition in the world, is held every two years and draws young and skilled competitors from more than 60 countries and regions. There are competitions in 56 skills across wide range of industries in 45th competition[1]. On a national level, the Japanese national skills competition, which is held annually, functions simultaneously as the qualification phase for WSC competitors.

These skills competitions require contestants to complete "test project" composed of several tasks within a limited time, which are then evaluated by experts in the field representing each country according to their specific marking criteria. The WSC uses two evaluation methods : measurement and judgement. Measurement consists of objective criteria with predetermined standards, which means the task is evaluated on a binary basis : whether it has met the standards (Yes) or not (No). Judgement is based on criteria consisting of four scales, and the task is evaluated according to the relevant industrial standard.

Experts are expected to evaluate objectively and fairly. However, two issues are often raised[2] : 1) even if the measurement evaluations are conducted with objective standards, different experts will assign different grades, and 2) the evaluation process takes more time than is desirable. These issues are primarily due to two reasons, which are explained below.

(a) Criteria vagueness

This factor was brought up in interviews conducted during the "One Belt One Load Competition", which is a skills competition that was held in China in June 2019. After the event, 20 experts who participated in the competition agreed to be interviewed, and 17 of those (85%) stated that they did not have a full grasp of the marking criteria before they began performing evaluations.

As for their reasons, nine experts said that the criteria were too vague. In addition, when asked what supplementary materials they would need to resolve this problem, they answered that they required videos and photos of evaluation examples/handbooks, past evaluation examples, and images showing examples where the task in question should receive higher or lower grades. Some also suggested the appointment of a supervisor to whom experts could ask for advice when they were in doubt.

To some extent, these suggestions have already been addressed and implemented as part of attempts to clarify the marking criteria. For example, evalua-

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tion handbooks that provide information for beginners, including photos and images, have been published[3], and WorldSkills International, the WSC host, has begun considering the creation of a similar guideline[1]. However, problems with this approach include the need for experts to keep their guidelines and handbooks immediately at hand while conducting evaluations, and the possibility that evaluations will take even longer than they have up to now.

(b) The lack of evaluation skill in experts

Experts who are tasked to accurately and efficiently conduct evaluations must be able to appraise tasks, each of which are slightly different from each other, while using well-defined memories of experiencing and overcoming similar challenges[4]. This ability is similar to how such skilled worker acquire their skills.

In order to refine their ability to evaluate correctly, they require a cognitive schema that allows them to flexibly adapt to various situations as well as training for their evaluation skills. In this way, even evaluators who have not yet acquired a surfeit of evaluation experience will be able to make accurate judgments, providing they have a system that will assist them appropriately in evaluating works while showing various patterns. Such characteristics, however, exist in huge numbers, and covering each of them within a paper-based guideline would hinder the process due to their sheer quantity.

With the above points in mind, this paper reports on the outcome of an experiment related to the development of a system that allows skill evaluation and evaluation training using mixed reality (MR). In this demonstration experiment, the system's viability was evaluated through three indices : mental workload (MWL), evaluation time, and evaluation accuracy, taking the evaluation process at WSC as an example. It is believed that these indices have the potential to help the system address the abovementioned evaluation issues:criteria vagueness, and the judges' lack of evaluation skills.

2. Mixed Reality

This chapter defines the use of 'MR' in this paper.

As shown in Figure 1, MR is a tool that allows real physical objects to coexist with virtual objects[6], which means it has the potential to enable the recreation of real-life phenomenon through virtual objects. It also allows users to concentrate on the virtual world while carrying out certain tasks. These factors differentiate MR from augmented reality (AR).

An MR device that has received significant amounts of attention recently is the HoloLens (Microsoft Corp.)[7]. This is an untethered device with intermittent functions that are activated through an independent Windows personal computer (PC). When linked with a server, the HoloLens can also act as a client. A HoloLens has six communication functions, as shown in Figure 2. Eye movements, gestures, and voice are used when interacting with displayed holograms, and spatial mapping is used to facilitate interactions with the surrounding environment.

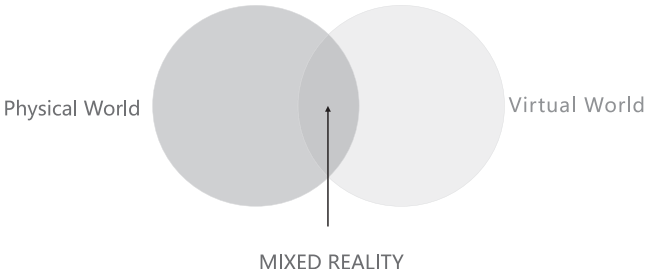


Fig. 1 Mixed Reality[5]

MR systems are being increasingly used in various fields, including education. In a recent study, Kiyokawa et al. explained the use of head-mounted displays (HMDs) and their roles in AR and MR. That study also introduced educational support systems that used AR/VR (Virtual Reality) and discussed their effectiveness, while also touching on future problems related to the contributions of AR/VR-based education through comparisons with other methods[8].

In another study, taking magnetic fields as an example of an invisible phenomenon, Ueda et al. reported on the development of an educational visualization application. More specifically, the authors created a study program and used it in a real-life classroom to demonstrate how MR can provide effective support when studying invisible phenomena[9].

Training programs have also put MR into use. For example, Toyota Motor Corporation has incorporated the technology into their car maintenance and inspection systems[10], and JR East Corporation now uses MR in their maintenance procedures[11]. Kyowa Exeo Corpo-

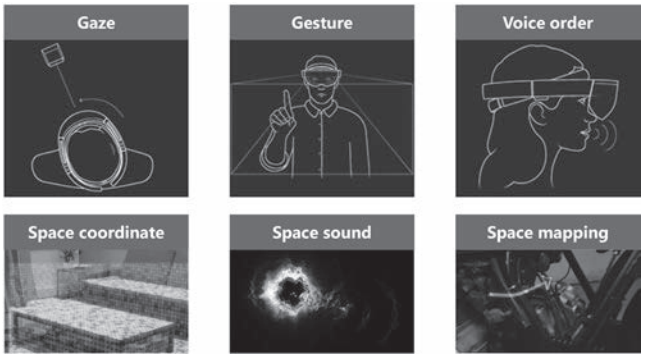


Fig. 2 Interaction method[5]

ration is also currently attempting to utilize MR in its skill training and education programs[12].

3. Overview of the Developed MR System

This chapter provides an overview of our proposed system used in this study and explains its characteristics.

3.1 System Structure and Functions

While it is possible for the client to activate our proposed system independently, we opted for a client–server link configuration that allows various information to be accumulated on the server. The link method uses Quick Response (QR) codes to recognize the subject in order to spare the user the need to navigate the system manually.

This system has three available functions : evaluator training, evaluator testing, and actual evaluation in a competition, any of which can be selected depending on the user's aims (Fig. 3). As a result, the system can be used to test and provide feedback related the evaluator's evaluation skills, but it can also be used in real-life evaluations during competitions, and it can even be used when training the evaluators themselves.

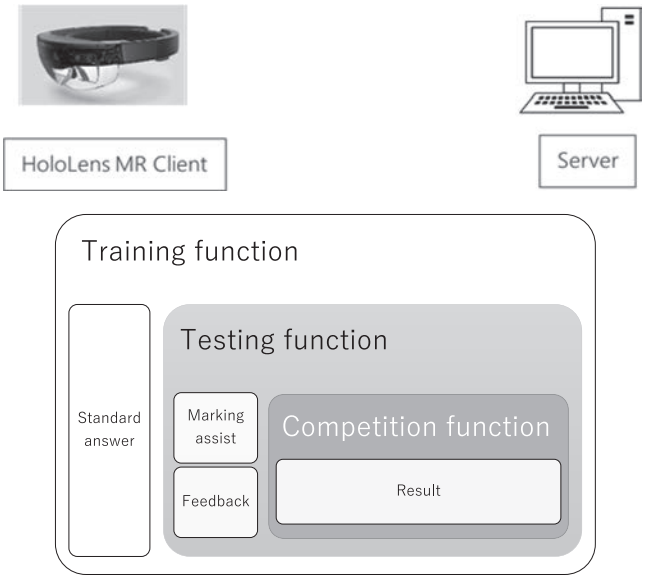


Fig. 3 System architecture

Server	Details	Notes
Information access channel	Server side – access and configure information through Web	• Configure information and save in server database • Server & client will sync up information so client can access data when networking is not stable
Target user	Administrator	Administrator is responsible for content and user management
Functions	1. Contents management – create and edit contents including criteria & aspect 2. User management – add/edit users	

Fig. 4 Server system

3.2 Server System

Figure 4 provides an overview of the server system functions. The administrator accesses the server and logs into the system through Internet Explorer. On the Content management screen (Fig. 5), users can import certain formats into the system in order to create and edit content. This function enables the platform to be used in evaluations of any kind of job or skillset. The system also includes links that have been adapted to QR codes, functions that can be used to create both marking criteria and evaluation test content, standard answer input, and functions for uploading supplementary material such as images and videos. The Judge Management screen allows users to switch modes, and the User Management screen allows the addition and deletion of users.

3.3 HoloLens Client System

Figure 6 shows the Client System functions. Depending on their aims, evaluators can choose from among the three modes shown below:

(a) Training Mode : This mode is for training experts who will conduct evaluations during competitions. It matches the expert's evaluation with a predetermined correct answer on the server, and the result (Pass/Fail) will be shown on the user interface (UI).

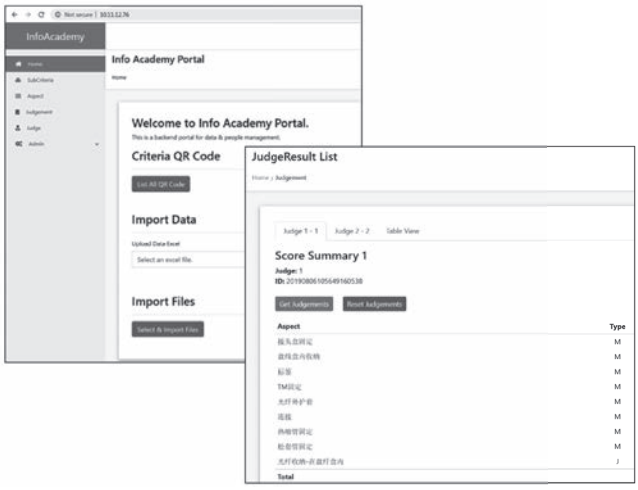


Fig. 5 Content management screenshots; home page and Judgement result page

Client	Details	Notes
Information access channel	HoloLens MR glasses	Only HoloLens1 generation 1 is available.
Target user	Judge	
Functions	1. Training mode 2. Testing mode 3. Competition mode	Difference between three modes

Mode	Standard answer	Real-time feedback
1. Training	Y	Y
2. Testing	N	N
3. Competition	Y	N

Fig. 6 HoloLens client system

(b) Testing Mode：This mode is designed to assess an evaluator's competency level after he or she has been trained on an evaluation method. The assessment results are accumulated on the server, and once the process has been completed, feedback and accuracy rates related to each evaluation are provided to the client.

(c) Competition Mode：This mode is intended for use in actual competitions. Evaluations are entered directly through the UI, and the results are accumulated on the server. When multiple clients use this mode simultaneously, evaluators can access each other's progress.

This section explains how to use the system from the client side. Before starting, the evaluator will don a HoloLens device and log into the system by either entering his/her user ID or capturing a login QR code. Next, they will capture the QR code attached to the target, which will enable the system to recognize the target and display the appropriate UI (Fig. 7).

Sub-criteria are shown on the left-hand side column of the UI. The evaluator will then finger tap (called "Air-tap") on the sub-criteria that they want to evaluate, which will activate the appropriate evaluation process (Fig. 8). In the case of Training Mode, once the evaluation results are entered, real-time feedback will be provided.

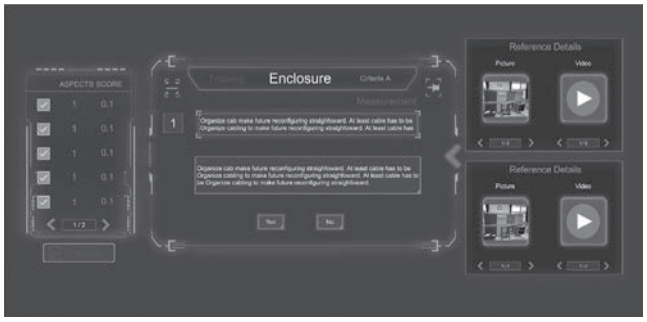


Fig. 7　User Interface



Fig. 8　Screen selection through finger tap

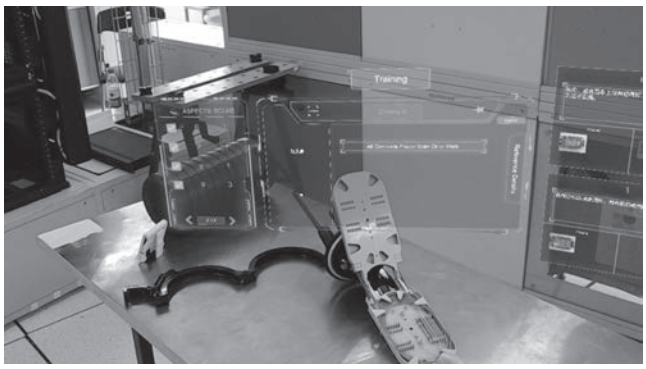


Fig. 9　Evaluator view

Clicking on Reference Information on the right-hand side of the UI screen will display supplementary evaluation material in the forms of photos, videos, and text. Completed evaluations will be shown in green, and incomplete evaluations will be shown in red. This helps the evaluator to easily see which task they should complete next. These screens are located on the left-hand side of the HMD, and will not occlude the object of evaluation in real-life situations (Fig. 9).

4. Measurement of Effectiveness

4.1　Overview

In order to measure the effectiveness of the system as it pertains to non-trained evaluators, we conducted a demonstration experiment at the Shanghai Technical Institute of Electronics & Information, which is a Chinese national training center for the "Information Network Cabling" trade. In this school, competitors aiming for WSC are trained with their coaches.

The evaluation task used in the experiment was optical underground closure installation, which is one of the tasks scheduled for the 45th WSC in 2019. The marking criteria used were the same as those employed in the 44th WSC. The marking criteria were separated into eight parts, seven of which were objective, and one of which was subjective.

There were fifteen subjects in this experiment. Seven already had the skill to complete this task, but had not received training in conducting evaluations (six were trainees with no experience in evaluation, and one was a coach with no experience in evaluating competitions). One was an experienced evaluator (a coach with experience in evaluating competitors), and seven were untrained in both the skill and the needed evaluation techniques.

4.2　Performance Criteria

Three indices were used to measure the system's performance：each evaluator's (1) MWL, (2) evaluation time, and (3) evaluation accuracy.

4．2．1　Mental Workload

There is a greater risk that an evaluator will make a mistake when his or her MWL is either too high or too low. There are two types of MWL：external workload (the total amount of conditions and requirements within the system that affects the human physical or mental state), and internal workload (an internal response to external workload that is dependent on the individual's characteristics, such as physical size, age, competency, and skills). These two workloads are correlated. Internal workloads have short-term effects, such as degrading one's ability to focus attention or imparting fatigue, and long-term effects, such as decreasing motivation. On the other hand, they can impart positive effects as well, such as an increased motivation to study[13].

MWL is generally regarded as the external workload that a person experiences while working on a task[13]. Therefore, the proposed system must ensure that it imposes an appropriate amount of workload in order to ensure the user can conduct an evaluation without making mistakes.

There are various indicators that are used to determine MWL. These include physiological indicators, as represented by heart rate variability (HRV), behavioral indicators that evaluate the user's task completion rate[14], and the NASA-TLX, which is a six-factor task load index developed by the US National Aeronautics and Space Administration (NASA) that focuses on mental demand, physical demand, temporal demand, individual performance, effort, and frustration[15].

More simplified subjective indicators are represented by the Subjective Workload Assessment Technique (SWAT)[16] method developed by Reid and Nygren, which computes three factors：time load (T), mental effort load (E), and psychological effort load (S).

The time load signifies the degree of time margin, the mental effort load signifies the degree of mental effort required, and psychological stress load signifies the degree of anxiety, frustration, or confusion the subject experienced.

This method evaluates each factor on a scale of 1-3. These options are stated in short sentences, as shown in Table 1. In this experiment, we used Miyake's simplified SWAT method[14].

The evaluation procedure was as follows:

1) Listing in order of effect：The subjects list the abovementioned three factors, T, E, and S in the order of their effect on the workload. They rank the factors as low (L), medium (M), or high (H). They are not allowed to place more than one factor in each section.
2) Calculating workload and MWL scores：We calculate the MWL scores when subjects undergo the evaluation process without using the system while using factors (a) and (b) described below. The subjects then use the system to perform the evaluation tasks, after which we calculate the MWL scores using the same factors.
   (a) After the evaluation task, the subjects rank T, E, and S factors according to the workload they felt during the task. They choose from ranks 1, 2, or 3, similar to Table 1. Multiple factors can be placed in each section.
   (b) Calculating the workload：We calculate the workload according to Table 2. Note that this table has a weighted multiple of 1：3：9, according to the amount of effect that the T, E, and S factors impart on the workload. The point total becomes the workload figure.

Table 1　Scale value for SWAT evaluation[14]

	Load type	Rank	Description
T	Time load	1	Often have spare time. There are no or only rare interruptions to study various viewpoints and information during work.
		2	Rarely have spare time. There are frequently interruptions to study various viewpoints and information during work.
		3	Almost never have spare time. There are very frequently, or all the time interruptions to study various viewpoints and information during work.
E	Mental effort load	1	There is no need to consciously concentrate the mental effort at all or little.
		2	It is necessary to concentrate mental effort "always and fairly".
		3	It requires very conscious mental effort or mental concentration.
S	Psycological stress load	1	Slight confusion, lack of information, or anxiety exists and can be easyly evaluate.
		2	Moderate stress is added to the workload due to confusion, lack of information and anxiety. A considerable price is required to perform the work reliably.
		3	There is very strong stress due to confusion, lack of information, and anxiety. Considerable decisions and self-control are necessary.

Table 2　Score table for SWAT-E[14]

Load strengh	Effect rate		
	1	2	3
H	0	450/13	900/13
M	0	150/13	300/13
L	0	50/13	100/13

4．2．2　Evaluation accuracy and time

In this subsection, we discuss evaluation accuracy and the time it takes to complete an evaluation. Here, comparisons are made between the results recorded when the subjects used the system and when they did not. A total of eight marking criteria are used.

4．3　Measurements

Prior to the start of the experiment, the subjects received an explanation of the task and the required skill, how to read the marking criteria (without an explanation of its content), and the operation methods of the proposed system. In order to obtain more accurate measurements, the 15 subjects were randomly divided into two groups (Group A：n=8, Group B：n=7) and the order of the experiment was counterbalanced as explained below.

The procedure used is intended to equalize the effects of extraneous variables, based on the principle of local control, which is the second of the three principles outlined by Ronald Aylmer Fisher[17].

The order of the experiment signifies whether each group has conducted the evaluation using the MR system (hereafter referred to as MR group) first, or if the conventional paper-based evaluation system (hereafter referred to as the non-MR group) was used first.

Group A：MR first → then non-MR

Group B：non-MR first → then MR

In the evaluation task, two different objects were used for both the MR and non-MR evaluations (a total of four different objects).

4．4　Analysis

4．4．1　Power Analysis

Before we analyzed the results, we conducted a power analysis. This analysis aims to prevent Type Ⅱ errors (β), which occur when evaluators determine that there are no differences between the compared conditions when, in fact, differences exist. Statistical power is defined at $1-\beta$, but because it is generally thought that statistical power below 0.8 heightens the risks of Type Ⅱ errors (β) [18], a number over 0.8 is desirable.

Statistical power is also determined by the number of subjects, the effect size (indicating the amount of difference between conditions), and the implemented significance level. We set the statistical power at 0.8, and for the two subjects of analysis (total group of n=15, non-experienced evaluators n=7) we set the effect size as large (more than 0.5). The significance levels were set at 0.05 and 0.10. For power analysis, we used the pwr.r.test function included in Basic Functions for Power Analysis of the CRAN Package of free statistic software[19].

The results show that when the significance level was 0.05, neither of the subjects gained sufficient statistical power (n=15；0.694, n=7；0.315), but when the significance level was 0.10, and the effect size was large (0.6) at n=15, the statistical power was 0.798. On the other hand, an n=7 analysis showed that statistical power was 0.447, even when the effect size was the same (0.6).

From these results, it can be inferred that the MWL examination in 4.4.2 will gain the necessary statistical power at a significance level of 0.10, which allows statistical analysis. However, since examination of evaluation time and accuracy only allows for non-experienced evaluators (n=7), it will be necessary to conduct a real, rather than statistical, analysis for this data in order to prevent Type Ⅱ errors (β).

4．4．2　MWL Examination

A Wilcoxon signed-rank test was used to compare the MWL and its sub-factors between the MR and non-MR groups. Table 3 provides the descriptive statistics and the amount of statistics for both groups.

Although Table 3 suggests that the MR group has lower MWL than the non-MR group (T=22, Z=1.643, p =.100, r =.300), no statistically significant differences could be found in the sub-factors of either group.

From these results, it can be inferred that the subjects experience MWL when undergoing evaluations, but that it significantly decreases when using the system, even when no explanation of the marking criteria is provided beforehand. These results provide further evidence of the system's effectiveness.

4．4．3　Evaluation Time and Accuracy Examination

In the next stage, evaluation time and accuracy examinations were conducted on non-experienced evaluators who have the skills required for the task being evaluated, but no experience in conducting evaluations. The purpose of these evaluations was to eliminate inac-

Table 3　Descriptive statistics and amount of statistics for the MR and non-MR groups

	n =15	*M*	*SD*	*T*	*Z*	*r*
Mental Work Load (MWL)	MR	36.13	27.69	22	1.643	0.300 †
	Non-MR	46.39	36.18			
Time load	MR	14.86	23.87	23	0.463	0.085
	Non-MR	11.28	23.81			
Mental effort load	MR	11.01	11.61	11.5	0.917	0.167
	Non-MR	18.19	23.90			
Psychological stress load	MR	10.26	14.87	21.5	1.026	0.187
	Non-MR	16.91	23.33			

† p = .10

curacy resulting from the evaluator's lack of knowledge in the required task. As stated above, there was no statistical analysis of this data.

Table 4 indicates the evaluation time and score based on the non-experienced evaluators' order of the experiment.

A comparison of the evaluation times shows that in Group A, the MR group took approximately 31 seconds longer than the non-MR group, whereas Group B took approximately 20 seconds less. This is likely due to the fact that when using the system, subjects were required to learn how to use the device at the same time they were expected to conduct a task evaluation.

In this respect, Group A had to multi-task (which took them longer) whereas Group B had the opportunity to learn how to conduct evaluations during the paper-based phase, which allowed them to concentrate on working the device, thereby leading to shorter completion times. In regard to evaluation scores, Group A scored 1 point (12.5%) higher in the MR group than in the non-MR group, while the Group B results were the same.

Table 5 indicates a summary of each group's evaluation time and score.

In comparison to the non-MR group, the evaluation time of the MR group was 9.57 seconds longer and the evaluation score was 0.572 points higher. The increase in evaluation time is caused by the low level proficiency of the subject, and the evaluation time is considered to decrease as the subject becomes proficient in the system. On the other hand, even if system proficiency is inadequate, an increase in evaluation score is considered to indicate that this system has an effective role in improving the accuracy of evaluation.

Table 4 Evaluation time and score according to the order of experiment

			M	*SD*
Evaluation time (s)	Group A (n =4)	MR	226.00	93.08
		Non-MR	194.50	12.97
	Gropu B (n =3)	Non-MR	195.00	9.00
		MR	175.33	23.44
Evaluation score (points)	Group A (n =4)	MR	5.25	0.96
		Non-MR	4.25	0.50
	Group B (n =3)	Non-MR	5.00	1.00
		MR	5.00	1.00

Table 5 Evaluation time and score of each group (summary)

	n = 7	*M*	*SD*
Evaluation time (s)	MR	204.29	72.45
	Non-MR	194.71	10.55
Evaluation score (points)	MR	5.14 (64.29%)	0.90
	Non-MR	4.57 (57.13%)	0.79

It should be noted that this experiment involved both a small number of marking criteria and a short completion time, which created an environment where significant differences were unlikely to occur. However, since longer times and increased criteria numbers are likely to boost the amount of effort required and MWL-related stress, these differences can be expected to be more significant in real-life cases such as the WSC, which has around 200 marking criteria.

Furthermore, in cases involving evaluators who were not used to handling MR devices, it will be necessary to provide instructions on how to use the HMD, as well as how to conduct evaluations. This can be expected to require additional effort and longer time commitments on the evaluators' part, especially if it is necessary for them to use the system without the opportunity to practice.

5. Conclusion

This paper reported an MR-based evaluation system that is designed to improve evaluation skills and help train evaluators, as well as on measurements related to its effects taking the evaluation process used in WSC as an example. Our MWL calculations utilized the SWAT method, and evaluation times and accuracy levels were measured. From these results, the following effects are proved by using the proposed system; (1) MWL (Time load, mental effort load and psychological stress load) that the evaluator feels at the time of evaluation is reduced, and (2) evaluation accuracy is improved.

The proposed system has the potential to resolve several issues regarding evaluations in skills competitions, as discussed below:

(a) Regarding marking criteria vagueness, MR allows evaluators to conduct assessments without keeping supplementary materials on hand and could encourage judgements based on clarified marking criteria. However, in order to shorten evaluation times, further discussion regarding training methods is required.

(b) Regarding the lack of evaluation skills on the part of the evaluators, we note that since non-experienced evaluators scored high levels of accuracy when using MR, our proposed method has the potential to compensate for shortfalls in this area.

In our future studies, we hope to provide enhanced functions that will further support evaluators, such as a remote function that will allow them to seek advice from experts in other locations and a function that will allow the evaluation object to be displayed in virtual reality.

This system is also expected to enable skills competition subjects and skill trainees to better educate them-

selves using the marking criteria, even when coaches are unavailable, and we hope to develop it further as a skill training system.

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References

1) WorldSkills International, WorldSkills Competition : webpage, https://worldskills.org/, Reference date : 2019-5-14
2) Takuo Kikuchi : Empirical Research on Expert's Skill in WorldSkills Competition, The Journal of JSVET, Vol. 32, No. 1, pp. 45-54, 2016
3) Takuo Kikuchi : Designing a Comprehensive skills Evaluation and Development for FTTH installer, Journal of Computer Technology and Application, Vol. 6, No. 1, pp. 5-13, 2015
4) Takashi Yamamoto, Kenichi Mori : Study of the skill transfer strategy by cognitive scientific method (in Japanese), Journal of Japan industrial management association, Vol.53, No2, pp.161-169, 2002
5) John Zhang : Mixed Reality, Technical paper, Jingteng Information Technology, Ltd., 2019
6) Shinji Chiba : The new world which Mixed Reality brings (in Japanese), IPSJ SIG Technical Report, pp. 1-5, Vol.2018-CTIM-210, No.21, 2018
7) Microsoft HoloLens, webpage, https://www.microsoft.com/ja-jp/hololens,Reference date : 2019-6-23
8) Kiyoshi Kiyokawa : Trends on Head Mounted Displays for AR and their Applications on Vision Augmentation (in Japanese), The Journal of IEICE, Vol. J102-C, No. 5, pp. 170-178, 2019
9) Ueda Tatsuro and Kawada Hiroki : Results of Lessons Using Magnetic Field Visualization by MR (in Japanese), Japan Society for Science Education report, Vol. 32, No. 10, pp. 29-32, 2018
10) Toyota : webpage, https://blogs.windows.com/japan/2019/05/30/toyota-hololens2/, Reference date : 2019-7-8
11) JR East : webpage, https://special.nikkeibp.co.jp/atclh/NBO/17/microsoft0419/p15/, Reference date : 2019-8-1
12) Kyowa Exeo : webpage, http://www.exeo.co.jp/jigyou/billing/hololens.html, Reference date : 2019-8-1
13) Etsuko Harada and Kazumitsu Shinohara : Attention and Safety – Theories and Applications of Cognitive Psychology 4- (in Japanese), Kitaohji Shobo, pp.166-185, 2011
14) Shinji Miyake and Masaharu Kumashiro : Subjective mental workload assessment technique - An introduction to NASA-TLX and SWAT and a proposal of simple scoring methods-(in Japanese), Ergonomics, Vol. 29, No. 6, pp. 399-408, 1993
15) S. G. Hart and L. E. Staveland : Development of NASA-TLX (Task Load Index) : Results of empirical and theoretical research. In : P. A. Hancock and N. Meshkati (eds.) : Human Mental Workload, pp. 139-183, Elsevier Science Publishers B. V., Amsterdam, 1988
16) G. B. Reid and T. E. Nygren : The subjective workload assessment technique : a scaling procedure for measuring mental workload. In : P. A. Hancock and N. Meshkati (eds.) : Human Mental Workload, pp. 139-183, Elsevier Science Publishers B. V., Amsterdam, 1988
17) Shigeaki Amano, Point of psychological experiment (in Japanese), pp.641-648, The Journal of the Acoustical Society of Japan, Vol.74, No.12, 2018
18) Cohen, Jacob, A power primer : Psychological Bulletin, Vol. 112(1), pp. 155-159, 1992
19) Stephane Champely (2018) : pwr : Basic Functions for Power Analysis. R package version 1.2-2.Web page, https://CRAN.R-project.org/package=pwr, Reference date : 2019-8-30

Biography



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Takuo Kikuchi received the Ph.D degree in engineering from Kyushu Institute of Technology. He is currently an associate professor, dept. of electrical and computer engineering at Polytechnic University. Since 2017, he has been a Skill competition manager of "information network cabling" competition of Worldskills international. His research interests include "Information network cabling" and "Skill analysis and evaluations". He is a member of the JSEE, IEICE and JSET Japan, also Japanese HoD of ISO/IEC JTC1/SC25.



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Lin Zhao is a technical engineer in fiber optics engineering center at Fujikura China. After receiving his Bachelor of Electrical and Information Engineering from Shanghai University of Electric Power, Lin joined the ULVAC (Shanghai) Trading Co., Ltd and worked primarily as the technical support engineer for installing and testing vacuum equipment at site. Since joining Fujikura China in 2012, he has worked as technical engineer in fusion splicer department to give customer and distributor the technical support and introduction of product.



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