2023-10-10

Effects Of Gaze Distribution On Woodworking Knowledge And Skills

Takashi USUZAKA
Ibaraki University, Japan, takashi.usuzaka.tech@vc.ibaraki.ac.jp

Yujin MOCHIZUKI
Houenji temple, Japan, whi666oxy208@gmail.com

Hiroaki SHOJI
Ibaraki University, Japan, hiroaki.shoji.m@vc.ibaraki.ac.jp

Effects of Gaze Distribution on Woodworking Knowledge and Skills

T. Usuzaka [1]
Ibaraki University
Mito, Japan
ORCID 0000-0003-1265-1081

Y. Mochizuki
Houenji temple
Higashiibarakigun Ibarakimachi, Japan

H. Shoji
Ibaraki University
Mito, Japan
ORCID 0000-0002-0641-8446

Conference Key Areas: *Fostering Engineering Education Research, Innovative Teaching and Learning Methods*
Keywords: *technology and engineering education, gaze distribution, woodworking, knowledge comprehension, skill acquisition*

ABSTRACT

This study investigates the gaze distribution of learners who watched a video about making a screw joint (a woodworking process) and explores its relationship with knowledge comprehension and skill acquisition levels. Twenty university students who had never taken a specialized class on screw joints participated in the study. They watched approximately a three-minute video on making a screw joint and completed knowledge comprehension and skill acquisition surveys based on the video content. Gaze measurements were conducted using Tobii T120, a screen-based eye-tracking device manufactured by Tobii Technology. In the line-of-sight

[1] *Corresponding Author*

T. Usuzaka

takashi.usuzaka.tech@vc.ibaraki.ac.jp

distribution analysis, the objects appearing in the video were categorized into four areas of interest (AOI): human faces, processed areas, subtitles, and tools. Further, the viewing rates for each AOI were calculated. The rates were ranked in descending order: processed areas, human faces, subtitles, and tools. Correlation analysis showed no significant correlation between knowledge comprehension and AOI. However, significant correlations were found between skill acquisition and human faces ($r = .477$, $p < .05$), subtitles ($r = -.531$, $p < .05$), and tools ($r = .510$, $p < .05$). Furthermore, multiple regression analysis showed that human faces ($\beta = 0.52$, $p < .01$) and tools ($\beta = 0.49$, $p < .05$) positively affected skill acquisition. These results suggest that focusing on human faces and tools may enhance skill acquisition.

1 INTRODUCTION

Gaze measurement is expected to be useful for estimating learners' degree of comprehension, attention, performance, etc., for viewing content and designing teaching materials to encourage understanding and concentration. Several studies have investigated the relationship between gaze and comprehension, attention, performance, etc. This includes research on gaze movement and reading comprehension (Cheng et al. 2015; Fahey et al. 2011; Vo et al. 2010) and the relationship between gaze and attention (Min and Corso 2021; Nishiyama et al. 2022; Oishi et al. 2021). A study was also reported on gaze and performance that utilized users' gaze to examine the role of a mirroring tool (i.e., Exercise View in Eclipse) in orchestrating basic behavioral regulation of participants engaged in a debugging task (Mangaroska et al. 2018).

In recent years, digital content such as digital textbooks and YouTube have been used to improve learning quality. When a learner views digital content, the gaze direction, which is where to observe carefully, is an important viewpoint and significantly affects the degree of comprehension. For example, a gaze-based system has been developed to assist users in note-taking while watching lecture videos (Sharma et al. 2014); a gaze-based indicator of students' attention in a Massive Open Online Course (MOOC) video lecture has been proposed (Nguyen and Liu 2016). Therefore, conducting research focusing on gaze distribution in manufacturing in Technology and Engineering Education is necessary. Clarifying what beginners studying manufacturing focus on when viewing digital content, the knowledge they attain, and the skills they can acquire can provide beneficial suggestions for learning content.

This study investigated the gaze distribution of learners who watched a video on screw joint making (a woodworking process) and explored its relationship with knowledge comprehension and skill acquisition levels. To the best of our knowledge, there are no studies clarifying the relationships between the gaze distribution and skill improvement of screw joint making by using eye-tracking technology. Therefore, the findings of this study will be useful for learning guidance when using video teaching materials.

2 METHODOLOGY

2.1 Participants

A total of 20 (11 males and 9 females) healthy university students aged 20 to 24 years (mean age 21.90 years) participated in this study. All participants did not have knowledge on screw joint making, which were selected by preliminary survey. Before the experiment started, the purpose and procedure of this study were explained and informed consent for participation was obtained from all participants.

2.2 Video teaching material

A video of a screw joint making of which the participants lack the knowledge was selected. The video is a teaching material in the digital textbook of a junior high school for Technology and Engineering Education in Japan (Tokyo Shoseki co., ltd. 2016), which was created for beginners and judged to be appropriate for the participants. The video lasted for 2 minutes and 53 seconds.

2.3 Knowledge comprehension survey

For measuring knowledge comprehension, the participants were asked to answer 12 questions about the video content they watched using survey forms. Questions 1 and 2 asked participants to answer the names of the hand gimlet auger (Japanese Kiri) types. In questions 3-10, the participants were asked to answer (fill in the blanks in the text) the screw joint procedure. Questions 11 and 12 were short-answer questions. Question 11 examined in what order participants would screw in and why they had multiple screws. Question 12 enquired participants how and why to choose a screwdriver correctly. The 12 questions totaled 100 points. Questions 3, 4, 8, and 9 scored 5 points each, whereas the remaining questions scored 10 points each.

2.4 Skill acquisition survey

To measure skill acquisition, participants were asked to complete skill acquisition surveys based on the video content. The complete sample comprises the following items on the workbench where the participants worked: 6 countersunk head wood screws (thickness 3.1 mm x length 25 mm), a square drill (total length 300 mm x needle diameter 3.5 mm), a triangular drill (total length 340 mm x needle diameter 3.5 mm), a counter sink drill (12 mm), a three-pointed Japanese drill bit, called nezumibagiri (3 mm), cross screwdriver (axis length 40 mm x axis width 6 mm), one scribed wooden board A (thickness 12 x width 150 x length 330), two scribed wooden boards B (thickness 12 x width 150 x length 65), scrap wood for underlay, and a jig for stably standing upright wooden boards B. Before initiating the work, the participants were instructed to follow the procedure shown in the video: select appropriate tools, consider safety, and use scrap materials and jigs for the underlay. The viewpoints of skill evaluation are as follows:

●Viewpoint of the items in progress

(1) A pilot hole was drilled using a triangular drill.

(2) The pilot hole depth was approximately two-thirds of the wood screw.

(3) A countersink drill was used for countersinking.

(4) The screwdriver was properly used.

(5) The screw heads on the screws were completely screwed in.

(6) The screws were tightened orderly (from outside to inside).

(7) No deviation from the scribed line before starting the screw joint was confirmed.

(8) No deviation from the scribed line was confirmed before the complete embedding of screw joints.

●Viewpoint of the finished product

(9) No part deviated by more than 2 mm from the scribed line.

(10) All the screws were screwed in until the end.

(11) No gap of 2 mm or more was present between the ground and two wooden boards B (no rattling).

Eleven viewpoints totaled 100 points. Viewpoints 7 and 8 were worth 5 points each, and the remaining questions were 10 points each.

2.5 Experimental procedure and gaze measurement

First, the participants watched the video teaching material. Fixing the face and body of a participant during the eye-gaze measurement was possible because the eye-gaze measurement was performed in a video. Therefore, a screen-based eye-tracking device called Tobii T120, manufactured by Tobii Technology, was used. As a precaution before viewing, participants were informed that they had to measure their gaze while watching the video. They could relax while watching but could not move their heads or bodies as much as possible. In addition, as a survey would be conducted after the video, they must understand the content. Subsequently, because the shape of the eyes differs, calibration (processing to measure differences due to eyeball size, presence or absence of contact lenses, and ambient lighting environment) was performed before the participants watched the video. Knowledge comprehension surveys were conducted after watching the video. Finally, skill acquisition surveys were conducted.

2.6 Gaze distribution analysis method

In the line-of-sight distribution analysis, the objects appearing in the video were categorized into four areas of interest (AOI): human faces, processed areas, subtitles, and tools. The viewing rates for each AOI were calculated. When the scene of the video teaching material changed, it was necessary to reconfigure the AOI in each scene. The video teaching material was divided into 31 scenes. The time spent watching human faces, processed areas, subtitles, tools, and other areas that appeared in the 31 scenes was totaled, and the participants measured where and how long they watched the approximately three-minute video. The analyzable data differed for each participant. Therefore, we calculated the gaze ratio to the locations where the AOI was set during gaze measurement.

3 RESULTS

3.1 Video viewing trends

The length of time the participants watched the four objects set in the AOI as they appeared in the video was calculated. Table 1 shows the average data of 20 participants.

Table 1. Percentage of the time the gaze was directed to the appearance time of the AOI setting (mean of 20 people)

	Human faces (%)	Processed areas (%)	Subtitles (%)	Tools (%)
Mean	17.66	57.50	16.81	8.08

The proportion of gaze directed is higher in the order of processed parts, human faces, subtitles, and tools. The percentage of processed parts was 57.50%, which were the scenes participants could easily pivot their eyes. The percentages of human faces and subtitles were 17.66% and 16.81%, respectively. The percentage of tools used was the lowest at 8.08%.

3.2 Relationship between gaze distribution and knowledge comprehension and skill acquisition

Table 2 shows the participants' knowledge comprehension and skill acquisition survey scores. Pearson's product-rate correlation coefficients were calculated using the percentage of participants who watched the AOI settings, their comprehension scores, skill scores, and the mean scores for both, as shown in Table 2. Table 3 provides the correlation coefficients. No significant correlation was found between the comprehension scores and the percentage of participants watching the AOI setting, suggesting a least significant relationship between eye gaze and comprehension. However, a positive correlation was found for human faces ($r=.477$, $p<.05$) and tools ($r=.510$, $p<.05$), and a negative correlation was found for subtitles ($r=-.531$, $p<.05$) to the skill scores. Multiple regression analysis was conducted using the skill scores and percentages of participants who watched human faces, subtitles, and tools to examine the causal relationship. The results of the multiple regression analysis are presented in Table 4.

Table 2. Participants' scores on the comprehension and skills surveys

Participants	Comprehension	Skill	Mean score
A	75	85	80
B	70	80	75
C	70	85	77.5
D	95	100	97.5
E	80	60	70
F	90	75	82.5

G	45	50	47.5
H	65	90	77.5
I	50	55	52.5
J	55	80	67.5
K	80	75	77.5
L	75	75	75
M	65	80	72.5
N	90	75	82.5
O	60	60	60
P	65	70	67.5
Q	80	80	80
R	90	75	82.5
S	75	80	77.5
T	75	85	80
Mean value	72.5	75.8	74.1

Table 3. Correlation coefficient between AOI settings, comprehension score, and skill score

	Human faces	Processed areas	Subtitles	Tools	Other
Comprehension	.214	-.005	-.009	.129	-.066
Skill	.477*	-.137	-.531*	.510*	.133
Mean score	.386	-.076	-.291	.353	.032

* p<.05

Table 4. The results of the multiple regression analysis

	Standard error	Standard partial regression coefficient	t-value
Human faces	1.518	.517	3.040**
Subtitles	.687	-.175	-.867
Tools	1.131	.487	2.418*

* p<.05, ** p<.01

The results showed a significant multiple correlation coefficient ($R^2=0.587$, $p<.05$). The tools ($\beta=0.487$, $p<.05$) positively affected skill acquisition. The degree of skill acquisition was considered to increase by focusing their eyes on the tools. Possibly, by watching the tools, the participants understood the usage and structure of the tools used in the video and could proceed with the work with an advantage. As shown in Table 1, the percentage of participants who watched these tools was low. Focusing on tools has been suggested as effective.

Moreover, human faces (β=0.517, p<.01) positively affected skill acquisition. Although the comprehension gained by watching a human face does not seem necessary, understanding where to watch during the task and when looking for deviations from the scribed line is important. Therefore, when more people check other human faces and gaze while watching videos, their skills are improved while performing similar tasks.

Although multiple regression analysis showed no significant standard partial regression coefficient, Table 3 reveals a negative correlation (r=-.531, p<0.5) between subtitles and skill acquisition. Because the work on the video continues to progress even when the subtitles are on, participants are expected to be more likely to gain comprehension from other parts of the video if they read and comprehend the subtitles as quickly as possible.

4 CONCLUSIONS

The study results suggest that focusing on human faces and tools may enhance skill acquisition on screw joint making. Instructors must clarify the points they want students to concentrate on when they show videos for skill improvement. To improve skill acquisition, instead of just having the students watch a video, teachers could ask them in advance to focus on the gaze of the person working or what kind of tools the person is using.

However, this study does not confirm whether transfer of learning is observed when watching video teaching materials related to other tools. In addition, variables (e.g., psychological, age, personality) that may influence the conclusions need to be examined in the future. Finally, experiments with additional research participants are needed to obtain statistically stable results.

REFERENCES

Cheng, S., Z. Sun, L. Sun, K. Yee, and A. K. Dey. 2015. "Gaze-Based Annotations for Reading Comprehension." *CHI '15: Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems, Seoul Republic of Korea, April 18-23, 2015*. pp.1569-1572. https://doi.org/10.1145/2702123.2702271

Fahey D., T. Gedeon, and D. Zhu. 2011. "Document Classification on Relevance: A Study on Eye Gaze Patterns for Reading." *ICONIP 2011: Neural Information Processing, Shanghai, China, November 13-17, 2011*. pp.143-150. https://doi.org/10.1007/978-3-642-24958-7_17

Mangaroska K., K. Sharma, M. Giannakos, H. Trætteberg, and P. Dillenbourg. 2018. "Gaze Insights into Debugging Behavior Using Learner-Centred Analysis." *LAK '18: Proceedings of the 8th International Conference on Learning Analytics and Knowledge, Sydney, Australia, March 7-9, 2018*. pp. 350-359. https://doi.org/10.1145/3170358.3170386

Min K., and J. J. Corso. 2021. "Integrating Human Gaze into Attention for Egocentric Activity Recognition." *2021 IEEE Winter Conference on Applications of Computer Vision (WACV), Waikoloa, HI, USA, January 3-8, 2021*. pp.1068-1077. https://doi.org/10.1109/WACV48630.2021.00111

Nishiyama M., M. Inoue, and Y. Iwai. 2022. "Gender Recognition Using a Gaze-Guided Self-Attention Mechanism Robust Against Background Bias in Training Samples." *IEICE TRANSACTIONS on Information and Systems*, Vol. E105-D, no.2: 415-426. https://doi.org/10.1587/transinf.2021EDP7117

Nguyen C., and F. Liu. 2016. "Gaze-based Notetaking for Learning from Lecture Videos." *CHI '16: Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems, San Jose, California, USA, May 7-12, 2016*. pp. 2093-2097. https://doi.org/10.1145/2858036.2858137

Oishi S., K. Koide, M. Yokozuka, and A. Banno. 2021. "4D Attention: Comprehensive Framework for Spatio-Temporal Gaze Mapping." *IEEE Robotics and Automation Letters*, Vol. 6, no. 4: 7240-7247. https://doi.org/10.1109/LRA.2021.3097274

Sharma K., P. Jermann, and P. Dillenbourg. 2014. " “With-me-ness”: A Gaze-Measure for Students’ Attention in MOOCs." *Proceedings of International Conference of the Learning Sciences 2014, Colorado, USA, June 23-27, 2014*. Vol. 2, pp.1017-1022.

Tokyo Shoseki co., ltd. 2016. *PC Software for Instructors, Digital textbook, technology and home economics*. Tokyo: Tokyo Shoseki co., ltd.

Vo T., B. S. U. Mendis, and T. Gedeon. 2010. "Gaze Pattern and Reading Comprehension." *ICONIP'10: Proceedings of the 17th international conference on Neural information processing: models and applications – Vol. Part II, Sydney, Australia, November 22-25, 2010*. pp.124-131.