Exploring Collaborative Learning Constructs in the Metaverse: A Pilot Study

Zoe Ruo-Yu Li[1[0000-0002-0628-9891]], Cheng-Huan Chen[2[0000-0001-8495-9312]], and Yong-Cih Yang[3[0000-0001-7643-7071]]

[1] University College London, London WC1E 6BT, UK
[2] National Tsing Hua University, Hsinchu 300044, Taiwan, R.O.C.
[3] National Taiwan University, Taipei 106319, Taiwan, R.O.C.
polarchen.nthu@gmail.com

Abstract. Metaverse, specifically defined and previously known as virtual worlds, has recently gained wide attention from the public to education. Prior literature has validated this immersive virtual reality (VR) on facilitating students' problem-solving, communication, and collaboration. However, many challenges including learning outcomes may result from the scarcity of investigation in collaborative learning activities. Accordingly, this study adopted the repertory grid (RG) technique to identify the collaborative learning constructs in the virtual worlds; we also assessed the RG procedure and modified the constructs for subsequent studies. During the process, six experts from academics and schools were recruited to design activity planners for construct elicitation. After completing the RG survey by the other 6 participants, the consistency results revealed a moderate correlation between two participants both possessing higher related experiences. Most importantly, based on the participants' feedback, this study successfully streamlined the RG flow and determined a 24-construct grid for the upcoming research.

Keywords: metaverse, virtual world, immersive VR, collaborative learning, repertory grid.

1 Introduction

The metaverse, as an epidemic word after Meta launched its virtual reality (VR) product in 2019, seems like a "future expectation" for the educational field. Nevertheless, the associated technology, namely virtual worlds, has been integrated into schools for over two decades [1][2]. Virtual worlds can be a supporting platform of immersive VR (iVR), which refers to a 3D virtual environment in which users wear VR headsets or head-mounted displays to interact with each other with their own avatars [3][4].

According to the prior literature on collaborative learning, the virtual worlds significantly improved students' visual communication, problem-solving, and learning engagement [5][6][7]. However, due to the rapid technological advancement, the learning modes and strategies in virtual worlds for iVR are different from those in non-immersive VR, such as desktop VR. In other words, rare studies investigate what key activities, materials, and instruction in the virtual world can successfully facilitate students' collaboration. Consequently, this gap may cause multiple challenges, such as learning gains, audio communication, and socializing [8][9].

Given that practical examples and studies of virtual worlds for iVR are scarce, Kelly's repertory grid (RG) is adopted in this study to answer this question. The RG technique was originally proposed by Kelly in 1955 based on the theory of personal construct psychology [10][11]. Specifically, the repertory gird allows researchers to extract abstract cognitive concepts through a series of construct elicitation [12][13][14]. Thus, it is an optimal method to identify the latent constructs and build the cognitive model.

In light of this, our current project aims to discover the cognitive constructs of collaborative learning in the virtual world of iVR, using the RG survey. As a pilot investigation, this study attempted to confirm the feasibility of the RG process for collaborative learning of iVR, and adjust the initial constructs for the foundation of further RG survey and experimental research.

2 Method

In order to achieve the research goal, this study employed the repertory grid (RG) technique. Based on the comparison study [15], this study also used the contrast method appropriate for the activity planner contrast. In terms of the participants, six experts whose backgrounds related to iVR curriculum design and iVR teaching experience were invited from both academics and schools in Taiwan.

To illustrate, the whole RG process referred to the study [11], was as follows (see Fig. 1): the researchers first outlined the relevant literature and sent it to the experts for their reference on activity planner design. After receiving the planners, the researchers interviewed each expert online to elicit the constructs regarding collaborative learning in the virtual worlds of iVR. Next, an online RG questionnaire was built based on the expert's constructs. This study then recruited 6 participants to complete the RG survey, and ultimately assessed the consistency and collected data.

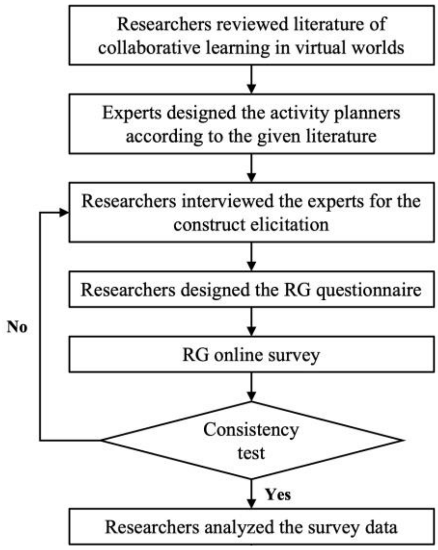

Fig. 1. The proposed procedure in this study.

3 Results

This study received data from all the six participants. The participants consisted of 4 females and 2 males, consisting of undergraduates, graduates, and a research assistant holding a master's degree. On average, most of the online questionnaires were completed from 55 minutes to 1 hour and 10 minutes. Specifically, for the first part of the repertory grid (RG) survey, it mostly took the participants 15 to 20 minutes to evaluate the first activity planner and gradually decreased to 10 to 15 minutes for the following planners; on the other hand, the participants finished the second part of impact assessment in about 1.5 minutes. In addition, one participant filled up the answers in around 20 minutes, whose answers were different from the others; thus, we discarded this data before the correlation analysis. Overall, the time spent provided a reliable reference for the researchers to determine the appropriate length of the subsequent RG survey.

Since this pilot study aimed to discover the questionnaire's weight consistency and latent problems, this study performed Pearson's correlation to achieve our objective. The correlation data from the remaining five participants was demonstrated in Table 1. To illustrate, based on the correlation strength in a study [16] shown in Table 2, only P1 and P5 moderately correlated with each other ($r = .58$, $p < .01$). Apart from the data between P2 and P4, along with P3 and P4, the rest of the participants presented weak correlation ($r_{s1s2} = .31$, $p < .001$; $r_{s1s3} = .18$, $p < .05$; $r_{s2s3} = .22$, $p < .001$; $r_{s1s4} = .2$, $p < .05$; $r_{s2s5} = .29$, $p < .001$; $r_{s3s5} = .18$, $p < .05$; $r_{s4s5} = .23$, $p < .01$).

Table 1. Pearson's correlation results.

Variable	*M*	*SD*	1	2	3	4
1. P1	2.36	1.68				
2. P2	2.51	1.39	.31*** [.15, .45]			
3. P3	2.25	1.76	.18* [.01, .33]	.22*** [.05, .37]		
4. P4	2.51	0.70	.20* [.03, .35]	−.04 [−.21, .13]	.00 [−.16, .17]	
5. P5	2.48	1.56	.58*** [.45, .68]	.29*** [.13, .44]	.18* [.02, .34]	.23** [.07, .38]

Note. Values in square brackets indicate the 95% confidence interval for each correlation. **p* < .05. ***p* < .01. ****p* < .001.

Table 2. The strength of correlation coefficients

Absolute value	Correlation
~1	Perfect
0.70–0.99	Strong
0.40–0.69	Moderate
0.01–0.39	Weak
~0.00	Zero

Note. Modified from "Statistics without maths for psychology," by C. P. Dancey and J. Reidy, 2020, *Pearson Education Limited*, p. 304.

After the initial discussion with the six participants, the researchers modified several constructs and improved the questionnaire instruction. We amended some words in c2, c3, c4, c5, c16, c19, c20, and c23, and their contrast constructs to minimize semantic ambiguities in the construct meanings. Furthermore, given the participants reflected they were confused about when to scale with a score of 3 using the 5-point scale, we clearly defined it in the subsequent questionnaire instruction. For example, "Score 3 is marked when you cannot find or are unsure whether to attribute either a similar or contrast construct in the evaluated planner," this statement was added to the instruction. Finally, the updated RG for collaborative learning in the virtual world was determined, as indicated in Table 3.

Table 3. Repertory grid for the following study

Constructs	Activity Planners						Constructs
	1	2	3	4	5	6	
c1 Student groups have interactive learning							c1′ Students study by themselves within the group / there is no interactive learning between groups
c2 Students discuss in the virtual world							c2′ Students do not discuss in the virtual world
c3 Students discuss outside the virtual world							c3′ Students do not discuss outside the virtual world
c4 Peers in the group assess each other / offer feedback							c4′ Peers in the group do not assess each other / offer feedback
c5 Peers between the groups assess each other / offer feedback							c5′ Peers between the groups do not assess each other / offer feedback
c6 Teacher provide constructive materials to students							c6′ Students create constructive materials by themselves
c7 Teacher guidance outside the virtual world							c7′ Self-study activities outside the virtual world
c8 Teacher arouses students’ motivation							c8′ Students directly experience learning context
c9 Teacher-limited scope / specified topic							c9′ Student-chosen topic
c10 Teacher instruct VR operation							c10′ Teacher does not instruct VR operation
c11 Teacher asks questions during the activity							c11′ Teacher do not ask questions during the activity
c12 Teacher highlights the key points							c12′ Teacher does not highlight the key points
c13 Teacher gives grades / feedback							c13′ Teacher does not give grades / feedback
c14 Students observe and explore in the virtual world							c14′ Students do not observe and explore in the virtual world
c15 Students solve problems / complete tasks in the virtual world							c15′ Students do not solve problems / complete tasks in the virtual world
c16 Students verbally explain / report learning content							c16′ Students do not verbally explain / report learning content
c17 Students follow standards to create materials							c17′ Students freely create materials
c18 Students adjust their co-work during the activities							c18′ Students do not adjust their co-work during the activities
c19 Students make final presentations in the virtual world							c19′ Students do not make final presentations in the virtual world
c20 Students present final results in the real world							c20′ Students do not present final results in the real world
c21 With virtual avatar							c21′ Without virtual avatar
c22 Scenes in the virtual world show prompts							c22′ Scenes in the virtual world do not show prompts
c23 Students can do activities in different scenes / attractions within the virtual world							c23′ Students can only do activities in the same scene / attraction within the virtual world
c24 Learning sheets outside the virtual world							c24′ Learning sheets inside the virtual world

4 Discussion and Conclusion

This pilot study attempted to evaluate and improve the repertory grid (RG) for the subsequent investigation for collaborative learning constructs in virtual worlds of iVR. The result enabled us to preferably estimate the survey's total duration and streamline the research procedure. Despite the pilot results failing the consistency test, this research considered the correlation coefficient between participant P1 and participant P5 to be higher than the others due to more experience in the related topic. In other words, it might be derived from the fact that other participants did not obtain master's degrees and had relative limited associated background knowledge. Nevertheless, their opinions were valuable for developing the following RG questionnaire for iVR. We modified our constructs to be more understandable according to the suggestions from these participants and finally built the RG framework. This grid comprising 24 constructs will then be delivered to the same group of interviewed experts for our upcoming research, exploring the key constructs of collaborative learning in the metaverse.

Acknowledgments. This study was funded by the Research Projects for Emerging Young Scholars under Grant NSTC 112-2628-H-468-001 from the 2030 Cross-Generation Young Scholars Program of the National Science and Technology Council, Taiwan, R.O.C.

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

References

1. Ahn, S., Heo, Y.: The principles and practices of college writing education using the metaverse. Korean J. Gen. Educ. 17(1), 63–76 (2023)
2. Bailey, F., Moar, M.: The vertex project: Children creating and populating 3D virtual worlds. J. Art Des. Educ. 20(1), 19–30 (2001)
3. Monahan, T., McArdle, G., Bertolotto, M.: Virtual reality for collaborative e-learning. Comput. Educ. 50(4), 1339–1353 (2008)
4. Slater, M., Sanchez-Vives, M. V.: Enhancing our lives with immersive virtual reality. Front. Robot. AI 3, 1–47 (2016)
5. Dirin, A., Nieminen, M., Laine, T. H., Nieminen, L., Ghalebani, L.: Emotional contagion in collaborative virtual reality learning experiences: An eSports approach. Educ. Inf. Technol. 28(11), 15317–15363 (2023)
6. Han, H. C., Hung, L.: Virtual technology in an art classroom. Int. J. Arts Educ. 19(1), 47–67 (2021)
7. Yeh, Y.-L., Lan, Y.-J., Lin, Y.-T., R.: Gender-related differences in collaborative learning in a 3D virtual reality environment by elementary school students. J. Educ. Technol. Soc. 21(4), 204–216 (2018)
8. Makransky, G., Andreasen, N. K., Baceviciute, S., Mayer, R. E.: Immersive virtual reality increases liking but not learning with a science simulation and generative learning strategies promote learning in immersive virtual reality. J. Educ. Psychol. 113(4), 719–735 (2021)

9. Prasolova-Førland, E., McCallum, S., Estrada, J. G.: Collaborative learning in VR for cross-disciplinary distributed student teams. In: Proc. 2021 IEEE Conf. Virtual Real. 3D User Interfaces Abstr. Workshops (VRW), pp. 320–325 (2021)
10. Latta, G. F., Swigger, K.: Validation of the repertory grid for use in modeling knowledge. J. Am. Soc. Inf. Sci. 43(2), 115–129 (1992)
11. Phythian, G. J., King, M.: Developing an expert support system for tender enquiry evaluation: A case study. Eur. J. Oper. Res. 56(1), 15–29 (1992)
12. Chu, H.-C., Hwang, G.-J., Tsai, C.-C.: A knowledge engineering approach to developing mindtools for context-aware ubiquitous learning. Comput. Educ. 54(1), 289–297 (2010)
13. D'Ambrosio, D.: Conceptualizing metadata via repertory grids: Exploring a method for the development of domain-specific systems for knowledge organization. Knowl. Organ. 34(1), 41–57 (2007)
14. Gray, D. E.: Facilitating management learning: Developing critical reflection through reflective tools. Manag. Learn. 38(5), 495–517 (2007)
15. Neimeyer, G. J., Bowman, J. Z., Saferstein, J.: The effects of elicitation techniques on repertory grid outcomes: Difference, opposite, and contrast methods. J. Construct. Psychol. 18(3), 237–252 (2005)
16. Dancey, C. P., Reidy, J.: Statistics without maths for psychology, 8th edn. Pearson Education Limited, Harlow, England (2020)