

An Evaluation of the Effectiveness of Gamified Virtual Reality on Food Preparation Literacy

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Abstract

Virtual reality (VR) and gamification are novel methods that have been used in health and nutrition education (Pilut et al., 2022; Sajjadi et al., 2022). Although both VR and gamification have shown effectiveness and benefits in improving learning outcomes in nutrition or health education (Sajjadi et al., 2022; Van Gaalen et al., 2021), the effects of combining both methods have not been examined. The purpose of this research was to evaluate and compare the effectiveness of gamified VR cooking experience with video-based cooking experience on improving food preparation literacy. It was hypothesized that gamified VR cooking experience would lead to higher food preparation literacy scores while providing a more immersive and motivational learning environment to the participants than a video-based cooking experience. Thirty-three participants were randomly assigned into the VR group ($n = 16$) or the video group ($n = 17$). Each group completed the pre-and post-experience questionnaires, the in-person intervention, and the post-intervention focus groups. Quantitative results indicated no significant difference in food preparation literacy between the gamified VR cooking experience and video experience ($p > .05$). Qualitative findings indicated that the immersive learning environment of gamified VR cooking experience motivated people to want to cook more healthy meals in the future. Individuals who engage in gamified VR cooking may be more motivated to cook in real life and therefore, choose a healthy diet over unhealthy processed food.

¹ yue.li4@student.kpu.ca; Written for Honours Thesis Project II (HSCI 4995). I would like to express my sincere thanks to my research supervisors Dr. Cayley Velazquez, Dr. Ann Marie Davison, and Dr. Farhad Dastur for their recommendation, support, and guidance. I want to acknowledge the Student Research and Innovation Grant for supporting this research. I also want to thank other research students and research assistants for helping and supporting me and my project.

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As global life expectancy increases, chronic diseases have become a severe global health challenge (Thomas et al., 2023). Each year, 74 % of all worldwide deaths are caused by chronic diseases (World Health Organization [WHO], 2022a). Unhealthy diet and poor nutrition are risk factors of chronic diseases, such as heart disease, cancers, and type 2 diabetes (Centers for Disease Control and Prevention [CDC], 2022). Each year, heart disease is responsible for 32% of all deaths globally (WHO, 2022b). High consumption of processed food that contains large amounts of sodium and cholesterol is the main cause of heart disease (CDC, 2022). The WHO (2022c) recommended salt intake per individual is no more than 5 grams per day. Nonetheless, the current global salt intake per individual averages 9 to 12 grams per day (WHO, 2022c). Certain cancers are also associated with unhealthy diets, including breast cancer, endometrial cancer, and colorectal cancer (CDC, 2022). The global prevalence of breast cancer in 2020 reached 2.3 million (WHO, 2021). One of the modifiable risk factors for breast cancer is weight (WHO, 2021). Nutrition and a healthy diet are essential factors for weight control. The global prevalence of type 2 diabetes was 462 million in 2017 and is expected to continue rising (Khan et al., 2020). Risk factors for type 2 diabetes include obesity and poor diet (CDC, 2022). People who are overweight are more likely to develop insulin resistance (Al-Goblan et al., 2014), which can eventually lead to type 2 diabetes (CDC, 2021). Studies have shown that healthy diet can decrease the risk of obesity (Mu et al., 2017). If the risk of obesity is decreased, the risk of developing insulin resistance and type 2 diabetes could also be reduced.

Nutrition and healthy diet are modifiable factors that can be integrated into daily lives (Iriti et al., 2020). Increasing nutrition-related knowledge will increase the likelihood of people making better nutrition and diet choices (Scalvedi et al., 2021). Nutrition education and interventions have shown effectiveness in improving nutrition literacy and increasing knowledge of diabetes and dietary intake, which are important factors to prevent chronic diseases (Hashim et al., 2021; Ojo, 2019). One aspect of nutrition education is food preparation literacy. Individuals with high food preparation literacy will have the knowledge and skills to choose healthier food and to make healthier meals with given instructions (Vidgen & Gallegos, 2014). People with low food preparation literacy may lack the knowledge and skills to make healthy meals and therefore, they

are more likely to consume unhealthy processed food that is high in sugar, sodium, and saturated fat (Poelman et al., 2018).

In recent years, digital technologies such as smartphone applications and virtual online social environments, have been utilized in nutrition research (Brennan & McNulty, 2017). Virtual reality (VR) is a relatively new mechanism that has been used to convey nutrition education (Ershow et al., 2011). VR provides realistic and immersive environments that allow users to have active engagement in learning. In the past few years, VR has gained popularity not only in the field of gaming, but also in the fields of health education and practice. The effectiveness of immersive VR has been examined in nursing and medical education (Behmadi et al., 2022; Choi et al., 2022). Previous studies have compared the effectiveness of VR-based methods on improving nutrition knowledge and skills with non-VR-based methods. A previous study conducted by Ho et al. (2022) found that 3-D virtual nutrition education is more effective than 2-D in increasing food portion knowledge. Another study by Sajjadi et al. (2022) examined whether interactive iVR (immersive virtual reality) is more effective than passive iVR in improving participants' knowledge of nutrition. Interactive iVR allowed participants to handle, cut, and make virtual food with given instructions, food portion size, and calorie amounts. Passive iVR learning only allowed participants to watch and listen (Sajjadi et al., 2022). Both interactive and passive iVR nutrition education led to significant improvements in participants' nutrition knowledge. However, interactive iVR appeared to have an increased effect on perceived learning and immediacy of control compared to passive iVR (Sajjadi et al., 2022). In contrast, the results of Pilut et al. (2022) showed that VR versus PowerPoint with narration had similar effect on healthful food purchasing self-efficacy and adult nutrition literacy education.

Other than VR, gamification is also a relatively novel technological method that utilizes the entertaining environment of gaming to motivate learners and improve their educational outcomes in non-game contexts (Van Gaalen et al., 2021). Gamification has also shown an effect on obtaining better educational outcomes in health and medical education (Krishnamurthy et al., 2022; Van Gaalen et al., 2021). Therefore, a gamification and VR combined method has the potential to lead to better learning outcomes in nutrition education than immersive VR alone. However, the combination of gamification and VR and its effects on improving food preparation literacy have not been evaluated. If gamified VR shows significant effects on improving food preparation literacy, it may become a novel method to teach and motivate people to choose

healthier food and cook healthier meals. In the long term, the prevalence of nutrition-related chronic diseases and their associated health care expenditures could be decreased.

The goal of this study was to assess and compare the effects of a gamified VR cooking experience with a video-based cooking experience on improving food preparation literacy by designing and using new evaluation tools. Those evaluation tools included a demographics questionnaire, pre- and post-experience questionnaires, and post-intervention focus groups. It was hypothesized that a gamified VR cooking experience would result in higher food preparation literacy scores and increased motivation of participants to cook healthy meals at home when compared to video-based cooking experience.

Materials and Methods

Procedures

Recruitment

Participants for this study were recruited through various recruitment methods. The electronic recruitment poster for the public was posted on the Kwantlen Polytechnic University (KPU) Faculty of Science and Horticulture (FSH) Facebook page and other social media platforms. Thirty physical posters were mounted on bulletin boards on the KPU Surrey, Richmond, and Langley campuses. Five classroom presentations were performed in biology and psychology classes at the Surrey and Richmond campuses. A short video of the VR gameplay was created and embedded in the classroom visit presentation PowerPoint. Moreover, a recruitment poster for psychology students was created. The recruitment posters were printed and distributed in classroom visits and posted on KPU Moodle sites of biology and psychology courses. A recruitment presentation video was created and posted on some KPU course Moodle sites. This research was listed in the KPU SONA system which is an online system for the Psychology Research Pool that allows and rewards KPU psychology students for participating in research studies (KPU, 2022c). Lastly, an email announcement was sent out to all KPU Health Science students through the HSCI listserv.

Pre-experience Questionnaire

Prior to taking part in the study, all participants completed a five-minute online pre-experience questionnaire which was designed by the researcher and entered into the website SurveyMonkey. The questionnaire consisted of eleven questions that assessed the food preparation literacy scores of the participants. Each question was scored from 1 to 5 using a 5-point Likert

Scale (1 as strongly disagree, 2 as disagree, 3 as neutral, 4 as agree, and 5 as strongly agree) as shown in Appendix A. The survey questions were reviewed by content experts to determine relevance. Participants were given a separate link in an email or a modified link on SONA to complete the pre-experience questionnaire. The participants had to respond to each question before moving on to the next question. The final scores were hidden from participants after completion of the survey. For participants who couldn't complete the questionnaire at home, another separate link was created for them to complete it in the VR Lab. The participants were asked to complete the questionnaire using a unique ID number to protect their identity and privacy.

In-person Intervention

After completing the pre-experience questionnaire, participants were randomly assigned based on their availability into two equal groups, the VR group, and the video group. For the in-person intervention, the researcher was assisted by at least one research assistant to ensure participants' safety. Research assistants helped the participants to avoid tripping hazard due to VR wires.

VR Group

Participants in the VR group experienced the VR game "Cooking Simulator VR" using the Varjo Base software to learn to cook a healthy dish. The healthy dish chosen for the participants to cook was "Salmon with Asparagus". The participants in the VR group were given a demonstration on how to use the Varjo VR-3 Headset and HTC Vive Controllers in the game. After the demonstration, the participants performed a practice trial using the VR equipment to play the game. After they became familiar with the VR equipment, they handled the virtual food and cooked the "Salmon with Asparagus" dish virtually following the recipe in the game. The time for the participants to complete the VR group intervention ranged from 40 to 50 minutes.

Video Group

Participants in the video group watched a six-minute pre-recorded video showing the process of making the same "Salmon with Asparagus" dish that was played in the VR game. The video was cut to delete irrelevant parts and edited to a slower speed using the Adobe Premiere Pro Software. During the intervention, the participants were only able to watch the video and unable to make the virtual dish or engage in the game. The time for the participants to complete the video group intervention ranged from 20 to 30 minutes.

Post-experience Questionnaire

Immediately after the in-person intervention concluded, all participants completed a five-minute online post-experience questionnaire in the VR Lab. Post-experience questionnaires were designed by the researcher, reviewed by content experts, and entered into SurveyMonkey. The post-experience questionnaire included six 5-point Likert scale questions with response options ranging from Strongly Disagree/Very Unlikely (=1) to Strongly Agree/Very Likely (=5) and five multiple-choice questions to assess the food preparation literacy scores (See Appendix B). The multiple-choice questions were recoded. The correct answers were recoded to 1 and the incorrect answers were recoded to 0 (See Appendix C). The multiple-choice questions were summed to provide a total score.

Demographic Questionnaire

After the in-person intervention, participants were asked to complete a five-minute online demographic questionnaire that consisted of six questions. The questions were in the form of a fill-in the blank, 5-point Likert scale (with response options ranging from Never to Always), and multiple-choice questions to determine the age, gender, and VR or video experience of participants before they took part in the research (See Appendix D).

Focus Groups

After the participants completed the in-person intervention, a total of three VR group focus groups ($n = 10$) and three video group focus groups ($n = 6$) were conducted, and their discussions were automatically transcribed using the Microsoft Teams Software. The transcripts were reviewed and compared with the recordings to correct the errors in the transcripts. The focus groups allowed the researcher to examine participants' gamified VR or video-based cooking experiences. Each focus group included between one and five participants. Focus groups lasted between 15-30 minutes depending on group size. Each focus group followed a pre-determined set of six questions (for the VR group) or eight questions (for the video group). The questions were organized as introductory, main, and concluding inquiries (See Appendix E).

Data Analysis

Quantitative Data

Data from the pre- and post-experience questionnaires were exported from SurveyMonkey to IBM Statistical Package for Social Sciences (SPSS) Statistics version 24. Descriptive analyses were performed on the results of the pre- and post-experience questionnaires to describe the

frequencies and valid percentages of each variable in the study. Median, range, and min-max values were calculated for the 5-point Likert scale questions in the pre- and post-experience questionnaires, where appropriate. Inferential statistics were calculated to determine whether there were differences between the video and VR group on the post-experience questionnaire responses. Cross-tabulations with the use of Fisher's exact test were performed to determine the association between group membership and post-experience questionnaire responses. Fisher's exact test statistic was performed instead of Chi-squared test because more than 20% of the cells had a count less than five. The statistical significance was determined by whether the p value was less than or equal to .05. Mann Whitney U test was performed to determine whether there was a difference between group membership and the Likert scale scores, as well as the median of the multiple-choice total score. Mann Whitney U values represent how likely the results were obtained due to chance, a lower value means that the results were less likely to have happened due to chance (University of Sussex, n.d.).

Qualitative Data

Thematic analysis, a type of qualitative analysis that analyzes, organizes, and derives themes from large qualitative data sets (Nowell et al., 2017), was performed on the transcripts using NVivo version 14. The transcripts were imported in NVivo. Main codes and subcodes were created based on the major points and patterns in the transcripts. Main codes included cooking experience, VR or video experience, motivation, and take away. There were subcodes under the main codes: challenges, recipe, emotions, benefits, and recommendations. Quotes were highlighted and pulled from the transcripts and put under the codes. Similar codes with quotes from different transcripts were identified and grouped into themes.

Results

Thirty-three participants took part in this study, however, only 26 completed the demographic questionnaire.² The mean age among participants was 26.12 years old ($SD = 8.42$). Participants ranged in age from 19-50 years old. Almost all ($n = 22, 85\%$) participants were 19-29 years old. The majority of participants (58%) were female. Before taking part in this research, half of the participants reported cooking one to six meals per week at home by themselves ($n = 13, 50\%$) and the majority of them had never played a VR game with VR equipment ($n = 23, 89\%$). Before

² Only 26 participants completed the demographic questionnaire because the data was not collected immediately after the in-person intervention.

participating in this research, only three participants had ever played a VR cooking game. Additionally, 10 participants (39%) had never watched recorded (VR or normal) cooking videos. See Tables 1-4 for complete findings.

Pre-experience Findings

Almost all ($n = 31$, 94%) of the participants agreed ($n = 15$, 45%) or strongly agreed ($n = 16$, 49%) that they knew how to cook a meal by following a recipe when cooking at home. Over half of the participants ($n = 19$, 58%) strongly agreed that they knew how to use common kitchen appliances that often appear in recipes. Nearly half of the participants ($n = 15$, 46%) responded agree for the questions “I know how to modify a recipe to make it healthier (e.g., reduce the quantity of salt) while still keeping the desired flavour.” Most participants ($n = 17$, 52%) reported agree on knowing when it is appropriate to bake, boil, or grill a particular food item. Almost half of the participants responded agree ($n = 14$, 43%) for the question “I know how to add the appropriate amount and type of a specific spice and/or herb to certain foods.” Only one of the video participants agreed that they had previously watched a recorded VR cooking process. Only two agreed that they had previously cooked a virtual meal following a recipe in a VR cooking game. See Tables 5-7 for complete findings.

Post-experience Findings

After the in-person intervention, all 33 participants completed the post-experience questionnaire. For the 5-point Likert scale questions, slightly more VR group participants (69%) responded agree or strongly agree than video group respondents (65%) to the question “After completing the intervention, I plan to begin (or keep) searching for healthy recipes to cook at home.” For the question, “After completing the intervention, I feel more confident in my ability to cook a meal following a recipe”, more VR group participants responded agree or strongly agree (75%) than video group participants (64%). More VR group participants (56%) strongly agreed that they were able to correctly follow the process of cooking the virtual meal “Salmon with Asparagus” without any confusion when compared to the video group participants (41%); the median of the responses of this question was also higher among the VR group participants (5) than the video group participants (4). Compared to the video group participants (64%), more VR group participants (88%) agreed or strongly agreed that they want to try cooking “Salmon with Asparagus” in reality (See Figures 1-6 for complete findings).

When comparing the results of the multiple-choice questions, the VR group participants scored higher than the video group participants. Specifically, the median of multiple-choice total score was higher among the VR group participants (4.5) than the video group participants (4) (See Table 8 and Figure 7 for complete findings).

Non-parametric Findings

Comparison of each of the post-experience 5-point Likert scale items between the video group only ($n = 17$) and the VR group only ($n = 16$) revealed no significant differences using the Mann Whitney U test ($p > .05$). Findings from the Mann Whitney U test also indicated no significant differences were found between the median of the post-experience questionnaire Likert items between groups ($U = 111.0, p = .382$). Although the findings didn't attain statistical significance, they were in the predicted direction (See Table 9 for complete findings).

Findings from the Fisher's exact test did not indicate a significant association between any of the post-experience multiple choice questionnaire items and group membership ($p > .05$). When comparing the median of the post-experience questionnaire multiple-choice scores between groups, no significant differences were found ($U = 105.0, p = .276$) (See Table 10 for complete findings).

Focus Group Findings

VR Group

Three themes emerged from the VR focus group transcripts. These themes were: participants found that the recipe was clear and straightforward, the VR experience was interactive and engaging, and the VR cooking experience reminded them that cooking is not that hard.

Theme 1. The recipe was clear and straightforward. Participants found that the recipe was easy to understand and follow. Since most of the participants have never played a VR game before, they had problems grabbing objects and moving in the game.

P1: "I like the instructions were clear in terms of how much that you were going to add in for how long you were going to be cooking it."

P2: "I was able to get the recipe correct and everything, but it was a bit of a problem getting the controls correct and putting the headset on."

P3: "[The] whole VR game was pretty straightforward, and it was pretty easy since there were instructions to follow."

P4: “It already told me what to do, what to get, how many seconds I need, or how many grams. It was pretty easy.”

P5: “I like to be able to keep track of it all and have the numbers readily available. You can see how much time is left and how much you need to add still.”

Theme 2. The VR experience was cool and fun. Participants described their VR experience as cool and fun. They enjoyed their time playing the VR cooking game.

Subtheme. The VR experience was immersive and realistic.

P1: “I felt more immersed since my only like perception was the VR and I was only focus on that.”

P2: “I mean to be completely honest; it was a kind of like an excitement. I did not realize that it would be as realistic as a simulator in terms of getting ingredients and then opening the fridge and going around and everything.”

P3: “It feels very intriguing and fun playing it. So, the time passes really quick.”

P4: “Moving around was kind of difficult for me but overall, I think it was enjoyable.”

P5: “It was definitely [an] interesting experience.”

P6: “I think for me I had a lot of fun.”

Subtheme. VR could be a great method for learning and practicing difficult recipes.

P1: “It would be interesting to do that beforehand and have some virtual experience doing it.”

P2: “I appreciated that the VR was able to let me try something out without wasting anything and it's gotten me to be a little bit more excited to try out like new things, especially if I had more time or if I could try out the other recipes.”

Theme 3. Their VR cooking experience reminded them that cooking is not that hard.

After playing the VR cooking game, the participants felt that their experience in the game reminded them that cooking is not hard or motivated them to try the meal they cooked in the game.

P1: “I would definitely try a similar recipe and then follow the steps that we did in the VR game.”

P2: “But after the VR experience, it actually did inspire me to cook for my big family.”

P3: “After the VR experience, I kind of like thought about trying it at home, it did not seem too bad to cook a little fish.”

P4: “Has reminded me that it's not that hard to cook at all.”

P5: “Any of those reminder type of experience makes me feel like [I should] probably do it a little bit more [and] make sure I am eating a little bit healthier by cooking [at home] and also often saves money.”

Video Group

Three themes were generated from the video focus group transcripts. Those themes were: participants felt that the video was fun, but it went too fast; the video experience did not motivate them to learn more healthy meals but reminded them it is easy to cook; and the VR experience would be more realistic and hands-on.

Theme 1. Watching the video was fun but it went too fast. Most of the video group participants felt that the video was fun and cool to watch. However, many of them think the video went too fast.

Subtheme. The recipe was simple and easy to understand and follow.

P1: "I felt like it was really cool to watch because it was almost like a video game."

P2: "It was really simple [and] fun to watch. [It was] really cool because I haven't done it before."

P3: "It was pretty normal. It was moving too fast, so it was hard to keep [my] attention but [I] somehow got used to it."

P4: "I guess this was pretty much just the same as watching any video for me personally."

P5: "I found it was really simple and easy to understand, although it did move quite quickly because I wasn't controlling what I was doing in it."

Theme 2. Their experience did not motivate them to learn more healthy meals but reminded them it is easy to cook. Most participants found that their experience did not bring a great impact because they have cooking experiences before participating in this research. However, because the recipe is simple, it reminded them how easy it is to cook a meal at home.

P1: "I don't think it has really changed anything for me personally."

P2: "Just watching a video plainly would not necessarily encourage you to do it on your own."

P3: "It made me think about how simple meals can sometimes be."

Subtheme. It would be a good method to teach people who don't have cooking experience how to cook, especially children and young teenagers.

P4: "I think my nephew or nieces would really benefit from it. I think if you've never seen a particular food before, it could be really helpful for sure. But if my mom saw it, I don't think it would do anything for her [because] she cooks a lot."

P5: "I think if young kids could do, it would be really beneficial for sure."

Theme 3. VR experience would be more realistic and hands-on. Participants thought that playing VR would be better than watching a video for learning how to cook a healthy meal. VR

could also be a good method for teaching children and young teenagers to learn cooking in a safe way.

P1: “In terms of just the video, maybe [there will only be] a short-term [impact], but if it's something like a VR or something in real life, I think [that will] have a much longer impact just because you're actually doing it yourself.”

P2: “I guess a hands-on experience is much more prefer in terms of learning. VR is like a pretty good substitute.”

P3: “I think VR would be really good for young teenagers, especially ones that don't necessarily have parents who know how to cook simple and healthy meals. If they have no one to teach them, how are they supposed to learn? [By] learning [how to cook] at a [young] age, they could cook a really healthy meal for their whole family, and it would be really good.”

Discussion

This research evaluated and compared the effectiveness of a gamified VR cooking experience with a video-based cooking experience on improving food preparation literacy. Nutrition literacy which includes food preparation literacy is particularly important for preparing, choosing, and consuming healthy food items which can impact chronic disease prevention. Individuals with high food preparation literacy are generally thought to have the necessary nutrition knowledge and cooking skills needed to make healthier meals with given instructions (Vidgen & Gallegos, 2014), whereas people with low food preparation literacy are more likely to choose unhealthy processed food because they lack the knowledge and skills to make healthy meals (Poelman et al., 2018). Previous studies have focused on the effects of gamification in health and medical education to obtain better learning outcomes (Krishnamurthy et al., 2022; Van Gaalen et al., 2021). The effects of gamification and VR as a combined method on improving food preparation literacy have not been examined. Therefore, this research assessed the effects of gamified VR on improving food preparation literacy.

Although it was hypothesized that participants in the gamified VR group would have higher food preparation literacy scores than participants in the video group after partaking in this experience, the quantitative results did not indicate that gamified VR cooking experience improved food preparation literacy more than video-based cooking experience. These findings are unexpected and in contrast to the results of Sajjadi et al. (2022) which suggested that VR is an effective method to improve nutrition knowledge and skills after the intervention. Instead, these

findings mirror the results of Pilut et al. (2022) which suggested that VR had no significant effect on improving adult nutrition literacy education compared to a PowerPoint presentation with narration.

In contrast, qualitative results indicated that gamified VR is perhaps a more motivational method than pre-recorded VR video for inspiring participants to cook healthy meals at home. Specifically, the results of this research determined that gamified VR may serve to remind people who have prior cooking experience how easily a healthy meal can be made and therefore, inspire them to cook more healthy meals at home. These findings are in line with the results of previous literatures which indicate VR can increase learning motivation among medical students and social workers (Hsiao, 2021; Sattar et al., 2019).

There are several limitations related to the methods of this study. The questions in the pre- and post-experience questionnaires were not the same. The pre-experience questionnaire contained 11 questions and the post-experience questionnaires included six questions. Therefore, the researcher was unable to determine whether within group differences on food preparation literacy were present after completion of the in-person intervention. The questions on the questionnaires were not pilot tested for understanding and therefore, they were not validated. Other limitations of this research are response biases of questionnaires, which include recall bias and social desirability bias. Recall bias occurs when individuals answer questionnaires after the event or experience and their self-reported responses alter from the actual values or experiences (Althubaiti, 2016). Social desirability bias is when individuals overreport or underreport on questionnaires based on desirable social impressions (Latkin et al., 2017). These response biases will affect the accuracy and reliability of questionnaire results. Another limitation is that the participants may have known what answers the researcher wanted since they knew which group they are in (experimental or control group). Therefore, they may have the tendency to give the researcher the desired answers in post-experience questionnaire and focus groups. Furthermore, another limitation is that this research was previously designed to collect and analyze eye tracking and galvanic skin response (GSR) data. However, the eye tracking data was collected for both groups but was not analyzed due to time constraints and GSR data was only collected for the video group due to the inconsistent connection of the iMotions Shimmer 3 GSR Model. A limitation of thematic analysis is that the interviewer may have the bias or tendency to choose quotes and conclude themes toward the desired results. This bias or tendency could be reduced if the transcripts and derived themes were

reviewed by other research members other than the interviewer. However, due to time constraints, the transcripts were not reviewed by other research team members.

This research had a small sample size with limited age range. Due to limited time and resources, the sample size may not be large enough to achieve generalizability to the larger population. Due to the small sample size, this research is considered as a pilot study. A possible future study could be a larger study that determines whether there is statistical difference if the sample size is expanded. Since most participants were between 19-29 years old and had experience cooking at home, playing the VR cooking game may not show a greater effect on their ability to read and follow a recipe than watching a cooking video. However, if the participants were children or young teenagers who have never cooked, the impact of VR may be greater than video for teaching them how to cook healthy meals. Moreover, the recipe that both groups followed during the intervention was relatively simple and therefore, may not have been challenging enough to detect significant differences between the two groups. Therefore, a future study could be partnering with the KPU Advanced Game Development program to design a more educational and advanced VR cooking game to educate children and young teenagers on nutrition, healthy eating behaviours, and food literacy while maintaining the immersive and motivational learning environment. The VR cooking game could be designed to teach cooking a more difficult recipe while showing the nutrients and calories of food. Furthermore, if the developed VR game is effective at educating people on nutrition and cooking skills, it could also be combined with VR exergaming to achieve better health outcomes. A previous study has shown that the combination of nutrition and physical activity can better improve the health of individuals than either nutrition or physical activity alone (Witard & Ball, 2018). Therefore, another future research could be combining gamified VR nutrition education with VR exergaming to evaluate their effects on promoting healthy eating behaviours and healthy lifestyle habits.

Tables

Table 1

Description of the age range of the research participants (n = 26).

Age Range (Year)	Number (%)
19 – 20	4 (15)
21 – 23	10 (39)
24 – 26	5 (19)
27 – 29	3 (12)
30 – 50	4 (15)

Table 2

Description of the genders of the research participants, the video group participants only, and the VR group participants only.

Demographic Question	Number (%)					
	Total (n=26)		Video Group (n=11)		VR Group (n=15)	
	Male	Female	Male	Female	Male	Female
What is your gender?	11 (42)	15 (58)	4 (36)	7 (64)	7 (47)	8 (53)

Table 3

Description of demographic questionnaire responses among all the research participants (n = 26).

Demographic Questions	Number (%) *						
	0 meals/week	1 – 3 meals/week	4 – 6 meals/week	7 – 9 meals/week	10 – 12 meals/week	13 – 15 meals/week	16 or more meals/week
On average, how many times per week do you usually cook at home by yourself?	4 (15)	9 (35)	4 (15)	3 (12)	0 (0)	2 (8)	4 (15)
	0 hours/week	1 – 2 hours/week	3 – 5 hours /week	6 – 8 hours /week	9 – 12 hours /week	13 – 15 hours /week	16 or more hours/week
Before taking part in this research, how many hours (on average) do you spend playing virtual reality (VR) games with a VR headset and controllers per week?	23 (89)	1 (4)	1 (4)	1 (4)	0 (0)	0 (0)	0 (0)

Note. *Row percentages may not add to 100% due to rounding.

Table 4

Description of demographic questionnaire responses among all the research participants (n = 26).

Demographic Questions	Number (%) *				
	Never	Rarely	Sometimes	Often	Always
Before participating in this research, how often did you play a VR cooking game?	23 (89)	3 (12)	0 (0)	0 (0)	0 (0)
Before taking part in this research, how often did you watch recorded (VR or normal) cooking videos?	10 (39)	7 (27)	6 (23)	3 (12)	0 (0)

Note. *Row percentages may not add to 100% due to rounding.

Table 5*Description of the pre-experience questionnaire responses among the research participants (n = 33).*

Pre-experience Questionnaire Questions	Number (%) *					Median	Min-Max Score
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree		
1.) I usually search for healthy recipes when cooking a meal at home.	1 (3)	2 (6)	12 (36)	14 (43)	4 (12)	4	1 - 5
2.) I know how to cook a meal by following a recipe when cooking at home.	0 (0)	0 (0)	2 (6)	15 (45)	16 (49)	4	3 - 5
3.) I find it easy to follow a written recipe when cooking a meal at home.	0 (0)	8 (34)	4 (12)	13 (39)	8 (24)	4	2 - 5
4.) I find it easier to follow a video recipe than a written recipe when cooking a meal at home.	0 (0)	4 (12)	9 (27)	13 (39)	7 (21)	4	2 - 5
5.) I know how to use common kitchen appliances that often appear in recipes (e.g., stove, oven, and mixer).	0 (0)	0 (0)	2 (6)	12 (36)	19 (58)	5	3 - 5
6.) I know how to modify a recipe to make it healthier (e.g., reduce the quantity of salt) while still keeping the desired flavour.	1 (3)	3 (9)	9 (27)	15 (46)	5 (15)	4	1 - 5
7.) I know how to modify a recipe that is originally intended to feed 1 person to instead feed 4 people.	1 (3)	2 (6)	6 (18)	13 (39)	11 (33)	4	1 - 5
8.) I know how to replace an ingredient in a recipe with another healthier ingredient while still keeping the desired flavour.	0 (0)	9 (27)	10 (30)	11 (33)	3 (9)	3	2 - 5
9.) I know when it is appropriate to bake, boil, or grill a particular food item (e.g., bake a cake, grill a piece of meat).	0 (0)	3 (9)	1 (3)	17 (52)	12 (36)	4	2 - 5
10.) I know how to add the appropriate amount and type of a specific spice and/or herb to certain foods (e.g., how much ginger or lemon juice should be added to fish).	0 (0)	7 (21)	4 (12)	14 (43)	8 (24)	4	2 - 5
11.) I have previously cooked a virtual meal following a recipe in a VR cooking game or I have watched a recorded VR cooking process on social media platforms.	22 (67)	7 (21)	1 (3)	3 (9)	0 (0)	1	1 - 4

Note. *Row percentages may not add to 100% due to rounding.

Table 6

Description of the pre-experience questionnaire responses among the video group participants only (n = 17).

Pre-experience Questionnaire Questions	Number (%) *					Median	Min-Max Score
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree		
1.) I usually search for healthy recipes when cooking a meal at home.	1 (6)	0 (0)	6 (35)	7 (41)	3 (18)	4	1 - 5
2.) I know how to cook a meal by following a recipe when cooking at home.	0 (0)	0 (0)	1 (6)	7 (41)	9 (53)	5	3 - 5
3.) I find it easy to follow a written recipe when cooking a meal at home.	0 (0)	2 (12)	2 (12)	9 (53)	4 (24)	4	2 - 5
4.) I find it easier to follow a video recipe than a written recipe when cooking a meal at home.	0 (0)	2 (12)	6 (35)	6 (35)	3 (18)	4	2 - 5
5.) I know how to use common kitchen appliances that often appear in recipes (e.g., stove, oven, and mixer).	0 (0)	0 (0)	1 (6)	5 (29)	11 (65)	5	3 - 5
6.) I know how to modify a recipe to make it healthier (e.g., reduce the quantity of salt) while still keeping the desired flavour.	1 (6)	1 (6)	3 (18)	8 (47)	4 (24)	4	1 - 5
7.) I know how to modify a recipe that is originally intended to feed 1 person to instead feed 4 people.	1 (6)	1 (6)	0 (0)	7 (41)	8 (47)	4	1 - 5
8.) I know how to replace an ingredient in a recipe with another healthier ingredient while still keeping the desired flavour.	0 (0)	4 (24)	4 (24)	7 (41)	2 (12)	4	2 - 5
9.) I know when it is appropriate to bake, boil, or grill a particular food item (e.g., bake a cake, grill a piece of meat).	0 (0)	2 (12)	0 (0)	6 (35)	9 (53)	5	2 - 5
10.) I know how to add the appropriate amount and type of a specific spice and/or herb to certain foods (e.g., how much ginger or lemon juice should be added to fish).	0 (0)	2 (12)	4 (24)	5 (29)	6 (35)	4	2 - 5
11.) I have previously cooked a virtual meal following a recipe in a VR cooking game or I have watched a recorded VR cooking process on social media platforms.	11 (65)	4 (24)	1 (6)	1 (6)	0 (0)	1	1 - 4

Note. *Row percentages may not add to 100% due to rounding.

Table 7

Description of the pre-experience questionnaire responses among the VR group participants only (n=16).

Pre-experience Questionnaire Questions	Number (%) *					Median	Min-Max Score
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree		
1.) I usually search for healthy recipes when cooking a meal at home.	0 (0)	2 (13)	6 (38)	7 (44)	1 (6)	3.5	2 - 5
2.) I know how to cook a meal by following a recipe when cooking at home.	0 (0)	0 (0)	1 (6)	8 (50)	7 (44)	4	3 - 5
3.) I find it easy to follow a written recipe when cooking a meal at home.	0 (0)	6 (38)	2 (13)	4 (25)	4 (25)	3.5	2 - 5
4.) I find it easier to follow a video recipe than a written recipe when cooking a meal at home.	0 (0)	2 (13)	3 (19)	7 (44)	4 (25)	4	2 - 5
5.) I know how to use common kitchen appliances that often appear in recipes (e.g., stove, oven, and mixer).	0 (0)	0 (0)	1 (6)	7 (44)	8 (50)	4.5	3 - 5
6.) I know how to modify a recipe to make it healthier (e.g., reduce the quantity of salt) while still keeping the desired flavour.	0 (0)	2 (13)	6 (38)	7 (44)	1 (6)	3.5	2 - 5
7.) I know how to modify a recipe that is originally intended to feed 1 person to instead feed 4 people.	0 (0)	1 (6)	6 (38)	6 (38)	3 (19)	4	2 - 5
8.) I know how to replace an ingredient in a recipe with another healthier ingredient while still keeping the desired flavour.	0 (0)	5 (31)	6 (38)	4 (25)	1 (6)	3	2 - 5
9.) I know when it is appropriate to bake, boil, or grill a particular food item (e.g., bake a cake, grill a piece of meat).	0 (0)	1 (6)	1 (6)	11 (69)	3 (19)	4	2 - 5
10.) I know how to add the appropriate amount and type of a specific spice and/or herb to certain foods (e.g., how much ginger or lemon juice should be added to fish).	0 (0)	5 (31)	0 (0)	9 (56)	2 (13)	4	2 - 5
11.) I have previously cooked a virtual meal following a recipe in a VR cooking game or I have watched a recorded VR cooking process on social media platforms.	11 (69)	3 (19)	0 (0)	2 (13)	0 (0)	1	1 - 4

Note. *Row percentages may not add to 100% due to rounding.

Table 8

The median post-experience questionnaire (multiple choice responses) score among all research participants, the video group participants only, and the VR group participants only.

Post-experience Multiple-choice Questions	Total (<i>n</i> = 33)			Video Group (<i>n</i> = 17)			VR Group (<i>n</i> = 16)		
	Median	Range	Min-Max Score	Median	Range	Min-Max Score	Median	Range	Min-Max Score
	4	5	0 – 5	4	5	0 – 5	4.5	3	2 – 5

Table 9

Comparison of the post-experience 5-point Likert scale items between the video group only (n = 17) and the VR group only (n = 16) for individual questions and overall (n = 33).

Post-experience Questionnaire 5-point Likert Scale Questions	Median of Video Group (Min-Max Score)	Median of VR Group (Min-Max Score)	Mann Whitney U	P-value
1.) After completing the intervention, I plan to begin (or keep) searching for healthy recipes to cook at home.	4 (2 – 5)	4 (2 – 5)	124.50	0.683
2.) After completing the intervention, I feel more confident in my ability to cook a meal following a recipe.	4 (2 – 5)	4 (3 – 5)	134.0	0.958
3.) During the intervention, I was able to correctly follow the process of cooking the virtual meal “Salmon with Asparagus” without any confusion.	4 (2 – 5)	5 (2 – 5)	117.0	0.510
4.) I find it easier to follow a VR or video recipe than a written recipe.	4 (1 – 5)	4 (3 – 5)	134.0	0.958
5.) I want to try cooking “Salmon with Asparagus” in reality, using the same recipe that was shown to me on VR or video.	4 (2 – 5)	4 (3 – 5)	116.0	0.488
6.) How likely are you to recommend that other people use VR or a recorded VR video to learn how to cook healthy meals?	4 (3 – 5)	4 (2 – 5)	117.5	0.510
Median of post-experience questionnaire Likert items	4 (3 – 5)	4 (3.5 – 5)	111.0	0.382

Table 10

Comparison of the post-experience multiple-choice responses between the VR and the video group for individual questions and overall (n = 33).

Post-experience Questionnaire Multiple-choice Questions	P-value*	
1.) How much salt was added to the 210 grams salmon fillet?	0.335	
2.) How much black pepper was added to the salmon fillet?	0.656	
3.) How long did it take to fry each side of the salmon?	1.000	
4.) How much salt was added per 1000 milliliters of water to cook 80grams asparagus?	0.438	
5.) How long did it take to boil the asparagus?	0.438	
Median of Post-experience Multiple-choice Questions	Mann Whitney U	P-value
	105.0	0.276

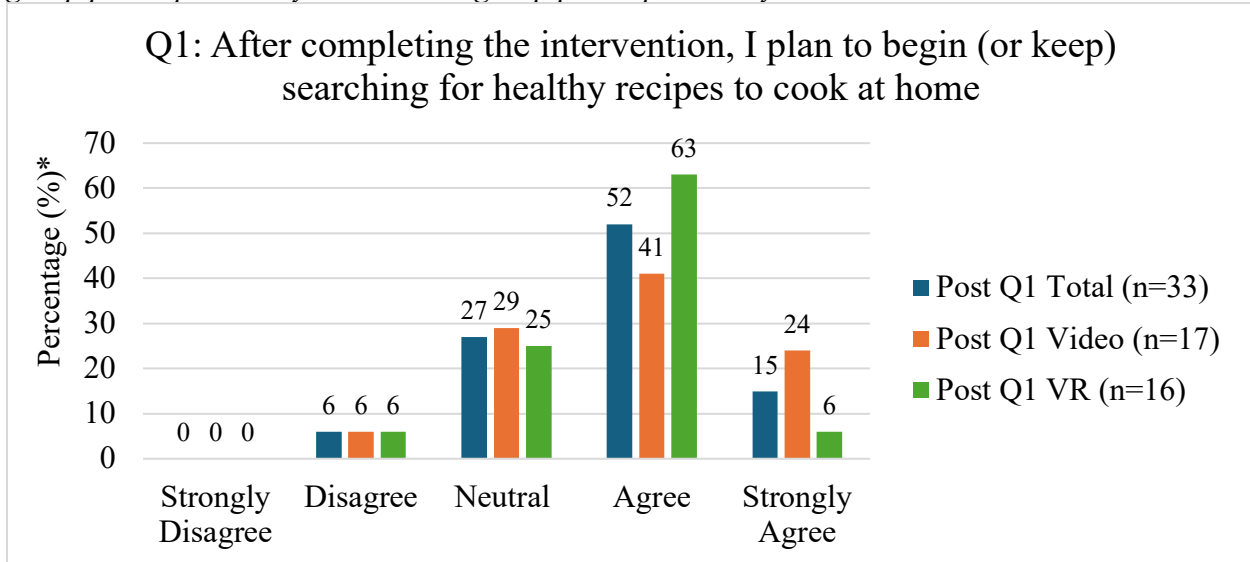
Note. *Fisher's exact test was performed because more than 20% of cells had an expected count

less than 5. Statistical significance was set at $p < .05$.

Figures

Figure 1

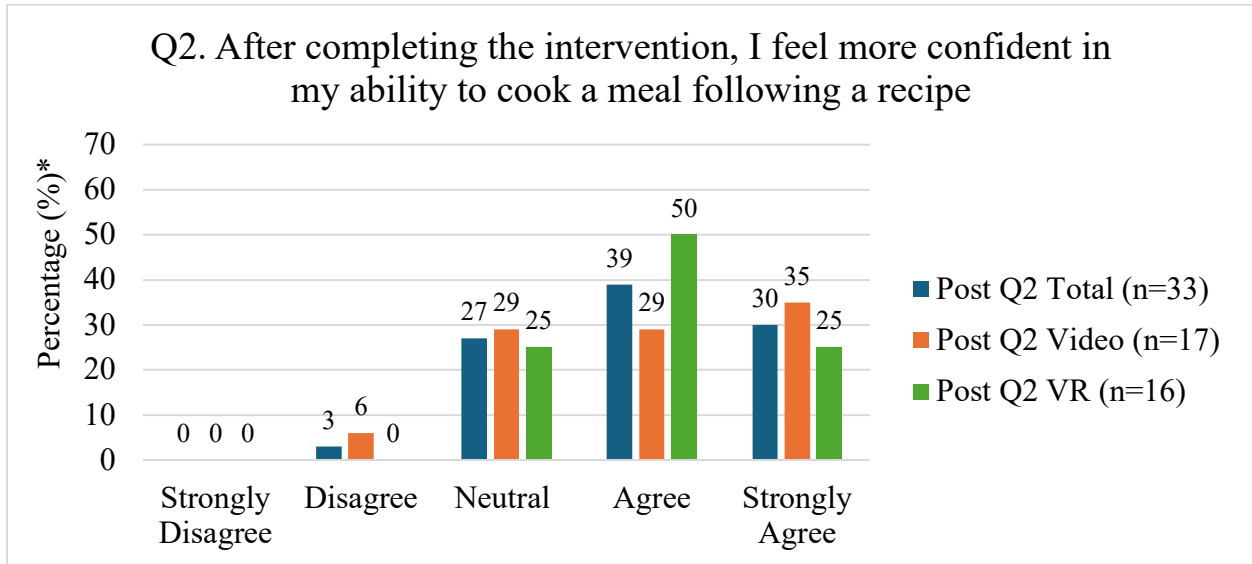
Post-experience Likert-scale question 1 responses among the research participants, the video group participants only, and the VR group participants only.



Note. *Percentages within each group may not add to 100% due to rounding.

Figure 2

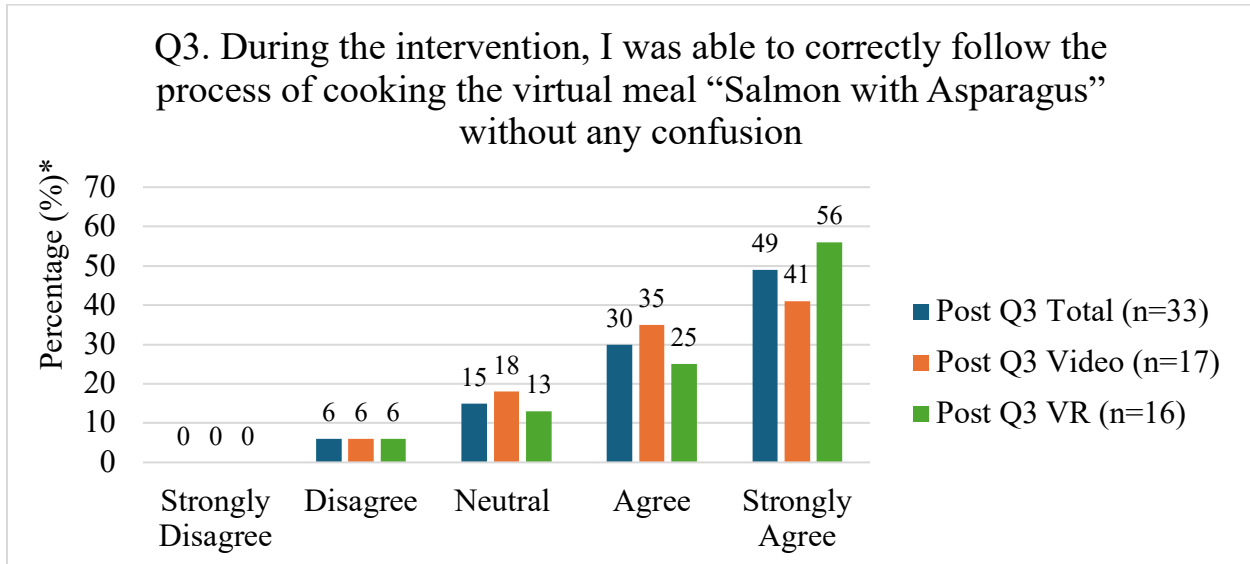
Post-experience Liker-scale question 2 responses among the research participants, the video group participants only, and the VR group participants only.



Note. *Percentages within each group may not add to 100% due to rounding.

Figure 3

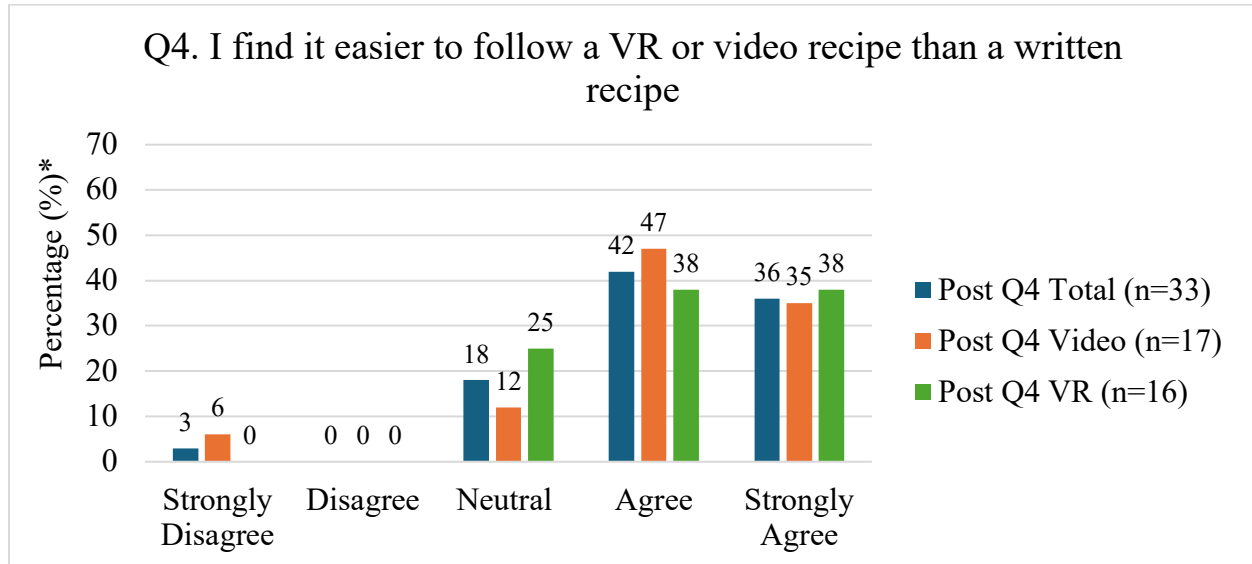
Post-experience Liker-scale question 3 responses among the research participants, the video group participants only, and the VR group participants only.



Note. *Percentages within each group may not add to 100% due to rounding.

Figure 4

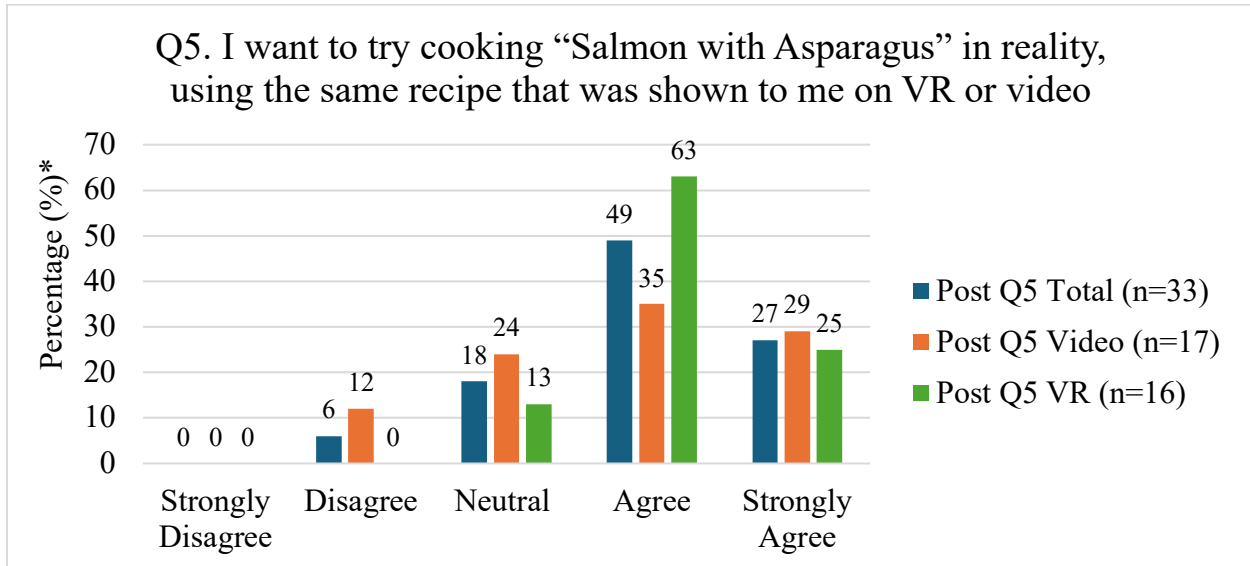
Post-experience Liker-scale question 4 responses among the research participants, the video group participants only, and the VR group participants only.



Note. *Percentages within each group may not add to 100% due to rounding.

Figure 5

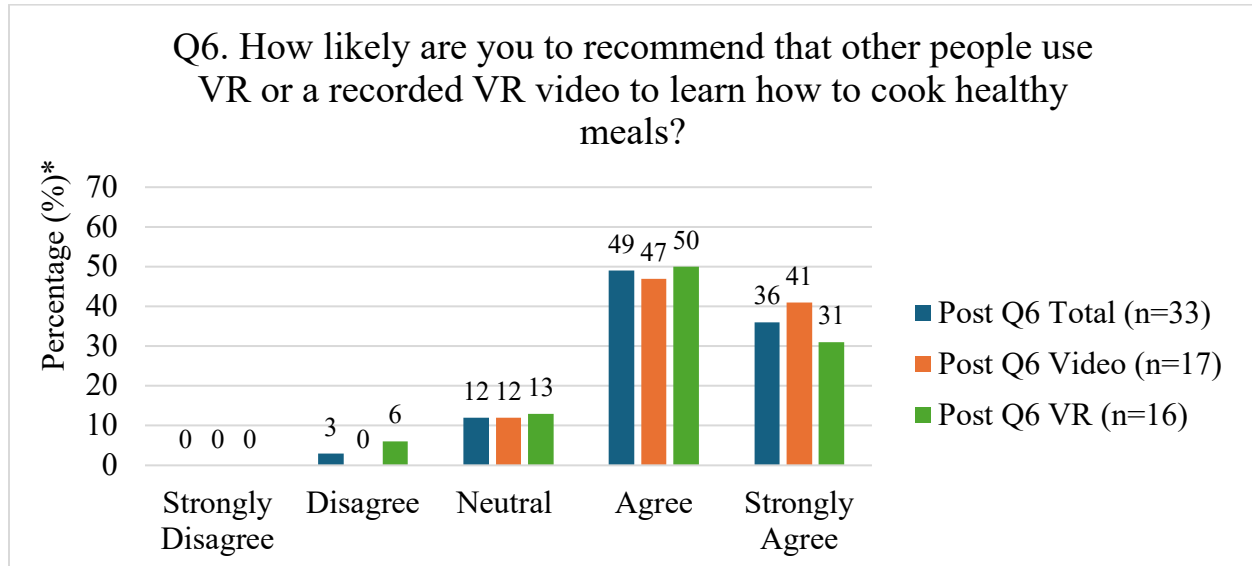
Post-experience Liker-scale question 5 responses among the research participants, the video group participants only, and the VR group participants only.



Note. *Percentages within each group may not add to 100% due to rounding.

Figure 6

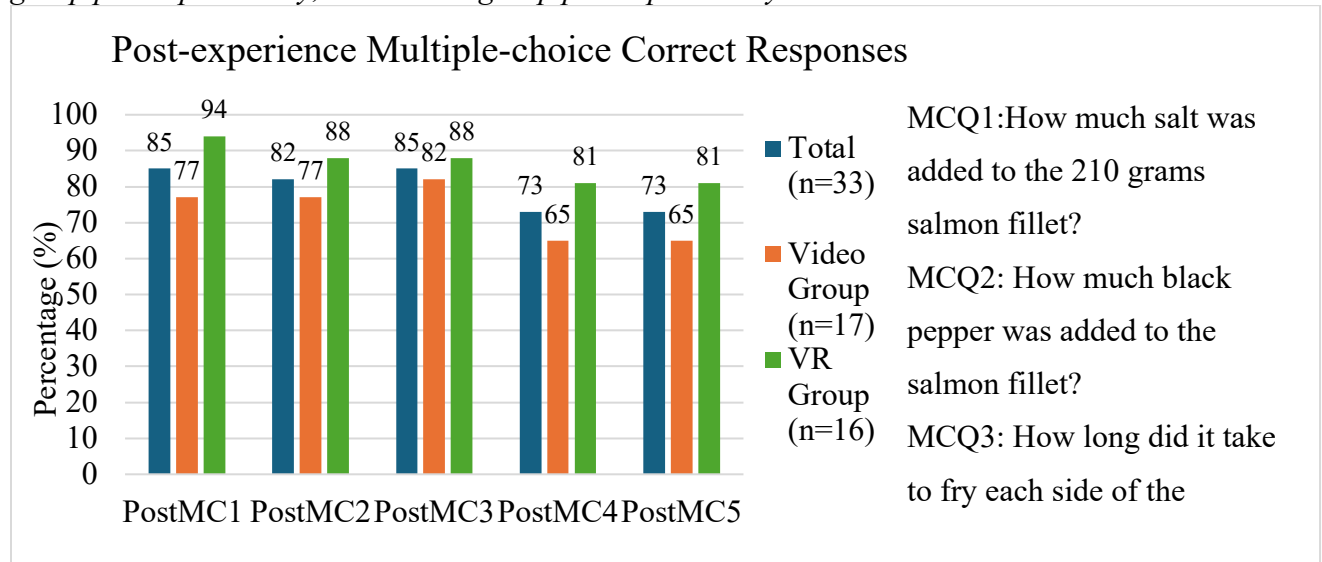
Post-experience Liker-scale question 6 responses among the research participants, the video group participants only, and the VR group participants only.



Note. *Percentages within each group may not add to 100% due to rounding.

Figure 7

Post-experience multiple-choice correct responses among the research participants, the video group participants only, and the VR group participants only.



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Appendix A

Pre-experience Questionnaire

The eleven 5-point Likert Scale questions of the pre-experience questionnaire.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	1	2	3	4	5
1. I usually search for healthy recipes when cooking a meal at home					
2. I know how to cook a meal by following a recipe when cooking at home.					
3. I find it easy to follow a written recipe when cooking a meal at home.					
4. I find it easier to follow a video recipe than a written recipe when cooking a meal at home.					
5. I know how to use common kitchen appliances that often appear in recipes (e.g., stove, oven, and mixer).					
6. I know how to modify a recipe to make it healthier (e.g., reduce the quantity of salt) while still keeping the desired flavour.					
7. I know how to modify a recipe that is originally intended to feed 1 person to instead feed 4 people.					
8. I know how to replace an ingredient in a recipe with another healthier ingredient while still keeping the desired flavour.					
9. I know when it is appropriate to bake, boil, or grill a particular food item (e.g., bake a cake, grill a piece of meat).					
10. I know how to add the appropriate amount and type of a specific spice and/or herb to certain foods (e.g., how much ginger or lemon juice should be added to fish).					
11. I have previously cooked a virtual meal following a recipe in a VR cooking game or I have watched a					

recorded VR cooking process on social media platforms.					
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Appendix B

Post-experience Questionnaire

The six 5-point Likert scale questions of the post-experience questionnaire.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	1	2	3	4	5
1. After completing the intervention, I plan to begin (or keep) searching for healthy recipes to cook at home.					
2. After completing the intervention, I feel more confident in my ability to cook a meal following a recipe.					
3. During the intervention, I was able to correctly follow the process of cooking the virtual meal “Salmon with Asparagus” without any confusion.					
4. I find it easier to follow a VR or video recipe than a written recipe.					
5. I want to try cooking “Salmon with Asparagus” in reality, using the same recipe that was shown to me on VR or video.					
	Very unlikely	Unlikely	Neither likely nor unlikely	Likely	Very likely
6. How likely are you to recommend that other people use VR or a recorded VR video to learn how to cook healthy meals?					

Appendix C

Post-Experience Questionnaire Response Options and Recoding

The response options and recoding of the five multiple choice questions of the post-experience questionnaire.

Questions	Response Options	Recording
1. How much salt was added to the 210 grams salmon fillet?	1 gram 2 grams 3 grams 4 grams 5 grams	1 – 4 gram(s) = 0 (Incorrect) 5 grams = 1 (Correct)
2. How much black pepper was added to the salmon fillet?	1 gram 2 grams 3 grams 4 grams 5 grams	1 – 4 gram(s) = 0 (Incorrect) 5 grams = 1 (Correct)
3. How long did it take to fry each side of the salmon?	20 seconds 30 seconds 40 seconds 50 seconds 60 seconds	20 – 50 seconds = 0 (Incorrect) 60 seconds = 1 (Correct)
4. How much salt was added per 1000 milliliters of water to cook 80grams asparagus?	20 grams 30 grams 40 grams 50 grams 60 grams	30 – 60 grams = 0 (Incorrect) 20 grams = 1 (Correct)
5. How long did it take to boil the asparagus?	60 seconds 70 seconds 80 seconds 90 seconds 100 seconds	60 – 90 seconds = 0 (Incorrect) 100 seconds = 1 (Correct)

Appendix D

Demographic Questionnaire

1.) What is your current age in years?

2.) What is your gender?

Female	Male	Transgender	Other	Prefer not to say

3.) On average, how many times per week do you usually cook at home by yourself?

0 meals/week	1-3 meals/week	4-6 meals/week	7-9 meals/week	10-12 meals/week	13-15 meals/week	16 or more meals/week

4.) Before taking part in this research, how many hours (on average) do you spend playing virtual reality (VR) games with a VR headset and controllers per week?

0 hours/week	1-2 hours/week	3-5 hours /week	6-8 hours /week	9-12 hours /week	13-15 hours /week	16 or more hours/week

5.) Before participating in this research, how often did you play a VR cooking game?

Never	Rarely	Sometimes	Often	Always

6.) Before taking part in this research, how often did you watch recorded (VR or normal) cooking videos?

Never	Rarely	Sometimes	Often	Always

Appendix E

Focus Group Questions

The introductory, main, and concluding questions of the focus group.

VR Group Questions	Video Group Questions
Introductory Questions	
First, I would like to know do you have any experience cooking meals at home? Do you find it difficult or easy to cook meals at home?	First, I would like to know do you have any experience cooking meals at home?
Sometimes it can be challenging to prepare meals at home. Could you tell me some of the factors that either help or prevent you from cooking at home?	Sometimes it can be challenging to prepare meals at home. Could you tell me some of the factors that either help or prevent you from cooking at home?
	When you cook at home, do you prefer following a written or video recipe?
Main Questions	
Could you tell me about your experience trying to follow the 'salmon with asparagus' recipe in the game?	Could you tell me about your experience trying to follow the 'salmon with asparagus' recipe in the video?
I would like to learn more about how you felt during your VR experience. Could you tell me about any emotions, reactions, or thoughts that you had while playing the VR cooking game?	I would like to learn more about how you felt while watching the video. Could you tell me about any emotions, reactions, or thoughts that you had when watching the video?
I would like to know whether you think this VR experience benefited you in any way. Could you tell me more about whether or not you learned or gained something with respect to cooking or anything in general from your VR cooking experience?	I would like to know whether you think your experience in this research benefited you in any way. Could you tell me more about whether or not you learned or gained something with respect to cooking or anything in general from watching the recorded VR cooking video?
I am curious to know whether or not you think your VR experience has motivated you in any way, for example, has your VR experience motivated you to want to use VR to learn preparing other healthy meals or whether or not it has motivated you to cook healthy meals in real life?	I am curious to know whether or not you think your experience has motivated you in any way, for example, has watching the video motivated you to want to follow VR cooking videos to learn preparing other healthy meals or whether or not it has motivated you to cook healthy meals in real life?
Concluding Questions	
Are there any other thoughts related to your experience in this study that you want to share with me?	I would like to know whether or not you want to try playing a VR cooking game to learn how to cook a healthy meal after watching the VR cooking video.

	Are there any other thoughts related to your experience in this study that you want to share with me?
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