A randomized controlled trial design to investigate the effectiveness of usage of virtual reality, compared to traditional seminar-based education workshops, in raising awareness about cannabis misuse issues to Canadian high school students aged between 15 to 18.

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Lay summary (Grade 9 readability, 172 words)

Since 2018, cannabis has become legal in Canada. Yet, this brings up important health concerns. It's crucial to educate adolescents about the risks of misusing cannabis. To engage with the younger population, traditional seminars might not be the best way. So, we need to develop more innovative education strategies. Virtual reality (VR) can make learning more engaging and interactive. This study investigates whether VR is an effective tool in educating teenagers about cannabis misuse. We will recruit 200 Canadian high school students aged 15 to 18 in a randomized controlled trial. We will split them into two groups: one using VR and the other attending seminars. Over three months, they will take part in monthly workshops. By the end, we will survey them to see how well they understand cannabis misuse. By comparing the results between the two groups, we can determine if VR is an effective tool. Results will provide evidence for the effectiveness of VR in health education. Findings will offer insights into the use of emerging technologies in health education.

Background

Since the legalization of cannabis in Canada in 2018, there have been growing concerns about cannabis misuse and overdose. Especially among teenagers, there is an increase in the prevalence of cannabis non-medical use. According to Statistics Canada (2024), the proportion of 16- to 19-year-olds who used cannabis for non-medical purposes in the past 12 months of cannabis has increased significantly from 36% in 2018 to 43% in 2023. Besides, there are insufficient cannabis misuse education campaigns available. Statistics Canada (2024) revealed that while the perceived social acceptability of all substances has increased over the years, the proportion of Canadians who reported that they saw any education campaigns or public health messages has decreased significantly from 76% in 2019 to 50% in 2023. This further shows that it is crucial to develop effective interventions in raising

teenagers' awareness about cannabis misuse issues before they reach to legal age to purchase cannabis on their own.

Special attention should be focused on teenagers' cannabis use due to its known detrimental effects on brain development. According to Worley (2019), cannabis use during adolescence is linked to impaired memory, cognition, mental health issues, and risky behaviours. Adolescence are undergoing a critical stage of mastering new skills to gain independence. During this stage, teenagers are particularly sensitive to stressors and are striving to establish a sense of healthy identity and mastery over life skills. Yet, teenagers often exhibit characteristics such as risk-taking, rebellion, and a penchant for adventure. Initially driven by curiosity, teenagers may experiment with small amounts of cannabis, which can escalate to substance dependence over time (Newcomb & Bentler, 1989). Early exposure to cannabis can disrupt the brain's reward system, leading teenagers to prioritize cannabis use over the development of essential life skills (Worley, 2019). Aside from the pleasure cannabis brings, the delayed onset of detrimental effects can create a false belief among teenagers that it is not harmful (Newcomb & Bentler, 1989). This misconception further perpetuates risky behaviours and undermines efforts to address cannabis misuse among adolescents.

Moreover, teenagers tend to have an unstable sense of identity and seek to fit in with peers. To connect with peer groups, teenagers attach themselves to a group and follow that group's interests. If a teenager is in a group of friends who have a habit of misusing substances, the teenager will also likely get engaged in substance misuse (Scull et al., 2009). Study indicates that adolescents who increasingly affiliate with cannabis-using peers are at a higher risk of engaging in cannabis use themselves (Defoe et al., 2019). It is also shown that this pattern of influence may contribute to the development of cannabis use disorder in emerging adulthood (Defoe et al., 2019).

To develop effective interventions for teenage cannabis misuse issues, we should consider the curious nature of teens by taking advantage of technologies while conducting health promotion. Hadley (2014) provides preliminary evidence that VR can be used to generate physiological arousal in response to substance use and sexual risk cues. While most studies focus on using VR during medical staff training (Pottle, 2019) or teenage smoking/alcohol prevention (Prediger et al., 2021), this study extends the investigation into measuring the effectiveness VR-based approach for cannabis misuse education among teenagers. Additionally, most past studies only seek to measure the effectiveness of VR in substance prevention. In our study we acknowledge the effectiveness of traditional health promotion seminar-based talks and the cost of developing VR-based tools, hence we seek to compare the relative effectiveness of VR-based tools versus traditional methods. If no significant increase in effectiveness is found using VR-based tools, it serves as evidence to conclude that it is not economically efficient to develop additional VR-based tools.

Our study aims to investigate if the use of VR, compared to traditional seminar-based education workshops, is a more effective approach to raising awareness about cannabis misuse and overdose education among Canadian high school students aged between 15 to 18. In our study, we compare the VR-based education (exposure group) with a traditional seminar-based workshop (reference group). Our outcome variable is the effectiveness of raising high school students' awareness about cannabis misuse. Past studies have shown that using multimedia can connect with teenagers and inspire them to analyze before deciding on the scenarios instead of merely taking information (Whitehead, 2004). So, we believe that VR may be related to the effectiveness of raising awareness about cannabis misuse issues among teenagers. We hypothesize that VR education will be a more effective tool than seminar-based workshops (lasting three months) in increasing Canadian high school students' awareness of cannabis misuse. The concept of effectiveness will be measured by knowledge retention and intentions towards future cannabis use through post-intervention questionnaires.

Methods

In this study, eligible participants are teenagers aged 15 to 18 who are attending Canadian high schools. Such eligibility criteria are chosen because the objective of this study is to develop interventions tailored to high school students before they transition into adulthood when they can legally purchase cannabis for entertainment purposes. Therefore, adults (i.e. who are aged at least 19) despite still attending high school will be excluded. The study design chosen for our research is a randomized controlled trial (RCT). Firstly, we will recruit 200 eligible participants from a Canadian high school. A form will be distributed to all students in the school to invite them to participate and compensation will be provided to encourage them to join. Note that there may be volunteer bias in this sampling method since those who are willing to participate are more likely to be interested in the cannabis misuse issue. However, this is unavoidable unless we force all students to participate, which is not ethical. Participants do not necessarily come from the same grade or the same class so we can include a range of participants with different demographics.

Next, we will establish two intervention groups. The treatment group is the VR group while the control group is the traditional seminar group. Participants will be randomly assigned to one of the two groups, and there will be 100 participants in each group. The random assignment can be done by first labelling each participant with distinct numbers, then drawing 100 numbers blindly, and the corresponding 100 participants will be assigned to the treatment group while the remaining participants will be assigned to the control group. In both groups, participants will attend their corresponding intervention workshops monthly for 3 consecutive months. Before receiving any intervention, participants will receive a pre-intervention survey inquiring: (1) On a scale of 1(lowest) to 10 (highest), how would you rate your knowledge about cannabis use? (2) Will you consider consuming cannabis in the future? (Yes/No)

Within the VR group, participants will use a virtual reality simulator to experience the life of a student to a middle-aged person. Each month, the virtual reality setting will be designed to focus on different topics, such as physical health, mental health career, etc. The designed virtual reality settings are composed of interactive activities in which participants will make decisions related to cannabis use and will answer cannabis-related knowledge questions. Example of a decision-making setting: "Your best friends are inviting them to try cannabis for entertainment purposes after a stressful exam period". After deciding, VR will simulate the consequences in the short-term (e.g. being unable to focus to revise due to a decrease in attention span) and the long-term (e.g. liver damage and career issues). This is designed to give students thoughts on the cannabis decisions they made. The feedback shown after making cannabis misuse-related decisions forecasts how a cannabis misuse person may perform in their life and the corresponding impacts on their physical health and social health. As a result, students can be empowered to foresee how teenage cannabis misuse will potentially affect their future. The workshops will end with a mingling session in which students can express their views about the scenarios and review if the consequences shown truly reflect the general situation. Ideally, this activity can help them develop critical consciousness about the cannabis misuse issue. In the traditional seminar group, participants will attend monthly talks presented by professional health practitioners where they will listen to health messages focusing on cannabis misuse. Through these talks, students can gain a more comprehensive idea about the impacts of teenage cannabis misuse from professionals.

By the end of the three-month study, participants will fill in a post-intervention survey to provide feedback about the effectiveness of the interventions. It will consist of two sections: (A) Multiple choice questions related to legal cannabis knowledge (such as legal age to purchase cannabis, legal possession amount of cannabis products) and potential health-related consequences. These questions will be graded as correct or incorrect, so they will be recorded as binary responses (Correct/ Incorrect) ultimately. (B) The 2 questions appeared in the pre-intervention survey.

The primary outcome we are interested in is the participants' hard knowledge about cannabis between the two intervention groups. For each participant, we will calculate the number of questions they answered correctly in section (A). We will perform a T-test to test if there is any statistically significant difference in the average number of correctly answered questions between the two groups. The T-test generates a p-value, which indicates the probability of observing the difference in group means if there are truly no differences between the groups. A small p-value (less than 0.05) indicates that the observed difference is unlikely to be due to random chance alone, leading to the rejection of the null hypothesis and the conclusion that there is a significant difference between the groups. Next, we will record participants' change in subjective cannabis knowledge level by comparing their responses before and after interventions for Q1. Similarly, we will perform a T-test to test if there are any statistically significant differences in the average change between the two groups. For each T-test, if significant differences are found between the intervention groups, we will proceed to calculate the group means.

The secondary outcome we are interested in is whether participants will still consider consuming cannabis in the future after the interventions. For each group, we will calculate the proportion of participants who reported "Yes" before and after receiving the interventions respectively. Then, we will take the before-and-after differences in proportion for each group. These differences determine the change in the proportion of participants who will still consider consuming cannabis in the future after receiving their assigned intervention. Lastly, we will compare the differences between the two groups using a T-test.

There are some confounders in this study that we may not be able to take account of. This includes whether the participants have used cannabis before and whether their family members are frequent cannabis users. This is because people who have used or whose family members have used

cannabis before tend to be more aware of the impacts of cannabis and may potentially pose deeper knowledge about cannabis misuse.

Significance

RCT is chosen to establish a causal relationship about how a transition from a traditional seminar-based workshop to a VR-based tool can lead to differences in effectiveness in raising teenagers' awareness of cannabis misuse. In particular, we can conclude that any observed differences in terms of outcome (i.e. awareness) between the two treatment groups are solely the additional effect of the VR-based tool compared to traditional seminar-based workshops in increasing awareness of cannabis misuse. In RCT, participants are randomly assigned to either the treatment group (VR-based tool) or the control group (seminar-based workshops). This randomization ensures that potential confounding variables are equally distributed among the two groups and ensures that the treatment and control groups are comparable pre-interventions. This can be observed by the similar distributions in pre-intervention settings between the two groups (Figures 1 and 2; Figures 5 and 6). Hence, it minimizes the influence of systematic differences that could affect the outcomes. This increases the internal validity of the study and strengthens the reliability of the findings. Overall, RCTs provide a robust framework for evaluating and comparing the effectiveness of the two interventions.

It is anticipated that VR-based tools will yield higher effectiveness in raising Canadian high school students' awareness about cannabis misuse. We anticipate that T-tests will generate small p-values, indicating significant differences between the two groups in hard knowledge, as measured by the change in subjective cannabis knowledge level after interventions (Figures 9 and 10) as well as the correctness of cannabis-related questions (Figures 11 and 12). In particular, we expect that the VR group will show higher means in the average number of correctly answered questions and a greater average increase in subjective cannabis knowledge level (Table 1). Besides, we expect that there will be a

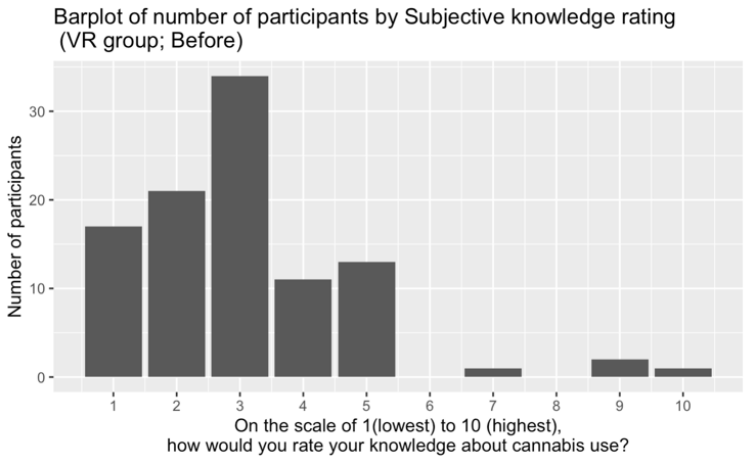
difference in the proportion of participants who still consider consuming cannabis in the future after the intervention between the two groups (Figure 7 and Figure 8). Additionally, the proportions of participants who switched their intention about consuming cannabis in the future from “Yes” to “No” after the interventions are expected to be greater in the VR group (Table 1). As a result, we may conclude that VR is a more effective tool than seminar talks in raising awareness about cannabis misuse issue among teenagers. These study findings will inform the reformulation of student health promotion strategies regarding cannabis misuse. Meanwhile, if no significant increase in effectiveness is found using VR-based tools, we may suggest that it is not economically efficient to develop additional VR-based tools.

Since this study is only conducted in one Canadian high school, students may show similar characteristics and demographics, such as academic standing, household income, etc. Future studies may consider sampling students from different high schools to include a wide range of students with different demographics so that the samples will not be biased towards a certain type of students. Furthermore, the current study design is only suitable for developed countries such as Canada and the US that have sufficient public health funds to subsidize schools and develop VR tools to organize the above activities. Collaborations between developed and developing countries should be established to support countries that lack resources to address the issue.

(8 pages)

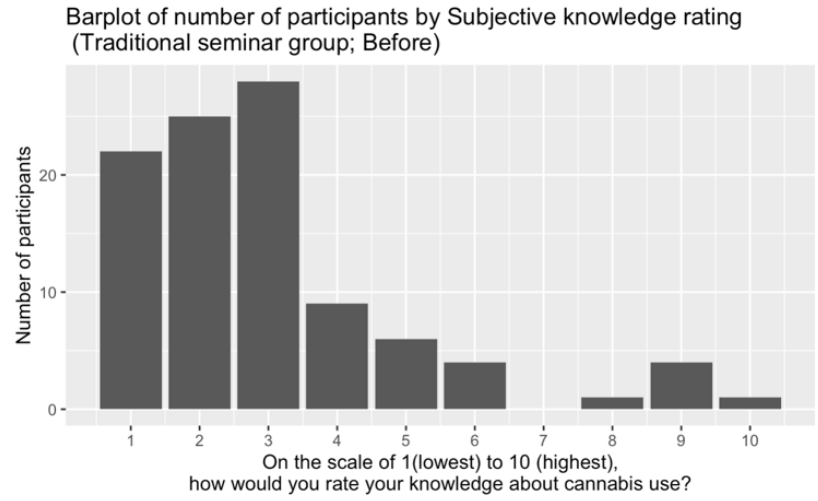
Tables and Figures (Synthetic data summary)

Figure 1: Bar plots of the number of participants by subjective knowledge ratings in the VR group pre-intervention



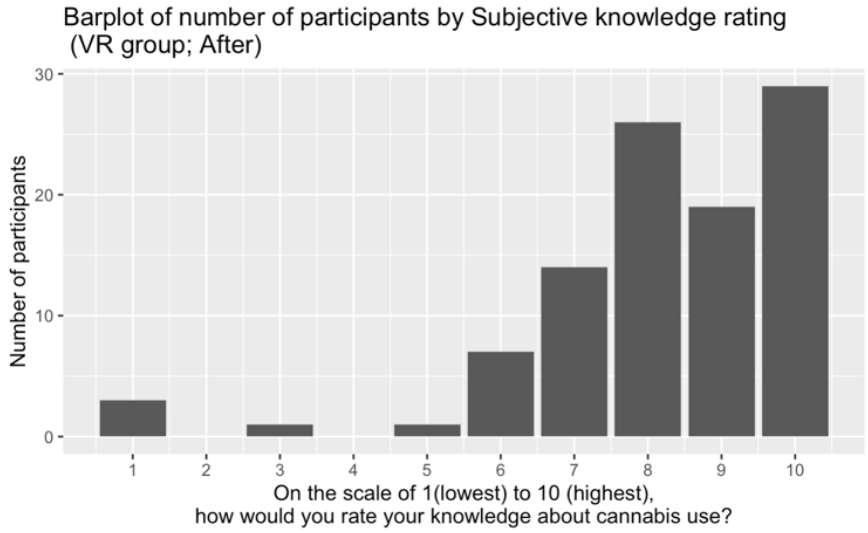
This bar plot shows the distribution of subjective knowledge ratings among VR group participants before receiving the intervention. It is measured by the responses to "*On a scale of 1(lowest) to 10 (highest), how would you rate your knowledge about cannabis use?*". Most responses are in the lower end of the scale. N = 100.

Figure 2: Bar plots of the number of participants by subjective knowledge ratings in the Traditional seminar group pre-intervention



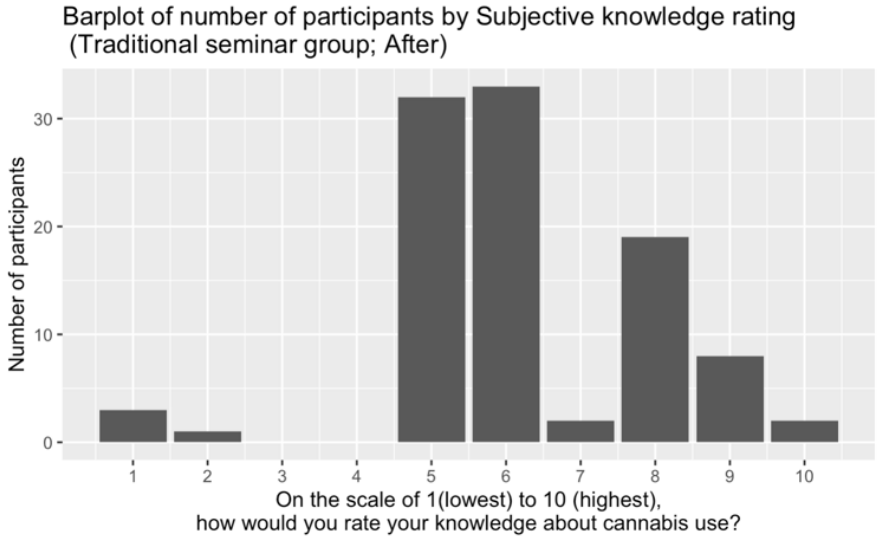
This bar plot shows the distribution of subjective knowledge ratings among Traditional seminar group participants before receiving the intervention. It is measured by the responses to "*On a scale of 1(lowest) to 10 (highest), how would you rate your knowledge about cannabis use?*". Most responses are in the lower end of the scale. N = 100.

Figure 3: Bar plots of the number of participants by subjective knowledge ratings in the VR group post-intervention



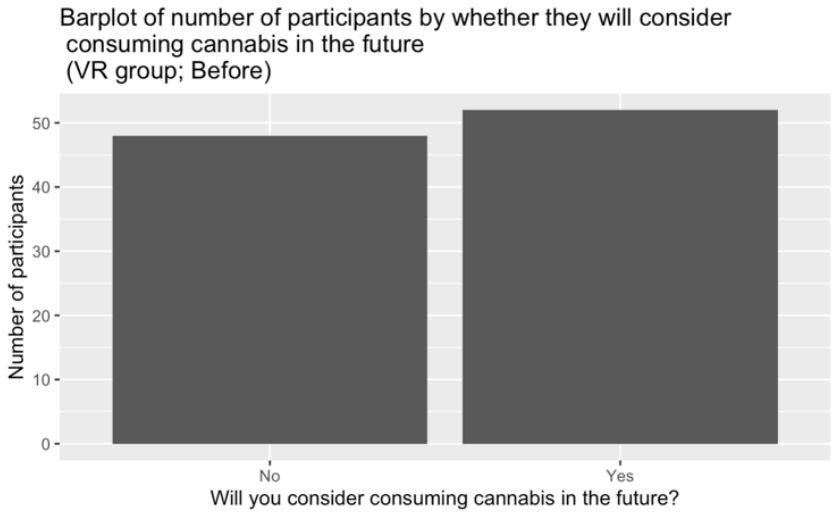
This bar plot shows the distribution of subjective knowledge ratings among VR group participants after receiving the intervention. It is measured by the responses to "*On a scale of 1(lowest) to 10 (highest), how would you rate your knowledge about cannabis use?*". Most responses are in the upper end of the scale. N = 100.

Figure 4: Bar plots of the number of participants by subjective knowledge ratings in the Traditional seminar group post-intervention



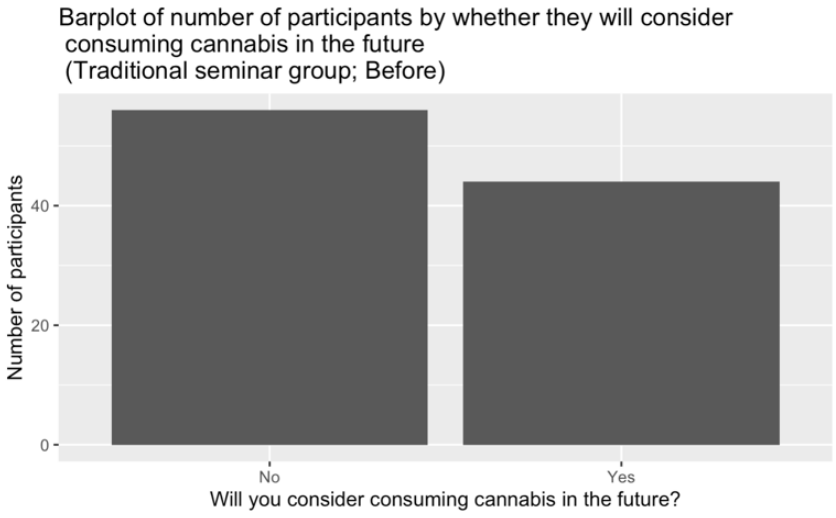
This bar plot shows the distribution of subjective knowledge ratings among Traditional seminar group participants after receiving the intervention. It is measured by the responses to "*On a scale of 1(lowest) to 10 (highest), how would you rate your knowledge about cannabis use?*". Most responses are in the middle range of the scale. N = 100.

Figure 5: Bar plots of the number of participants by whether they will consider consuming cannabis in the future in the VR group pre-intervention



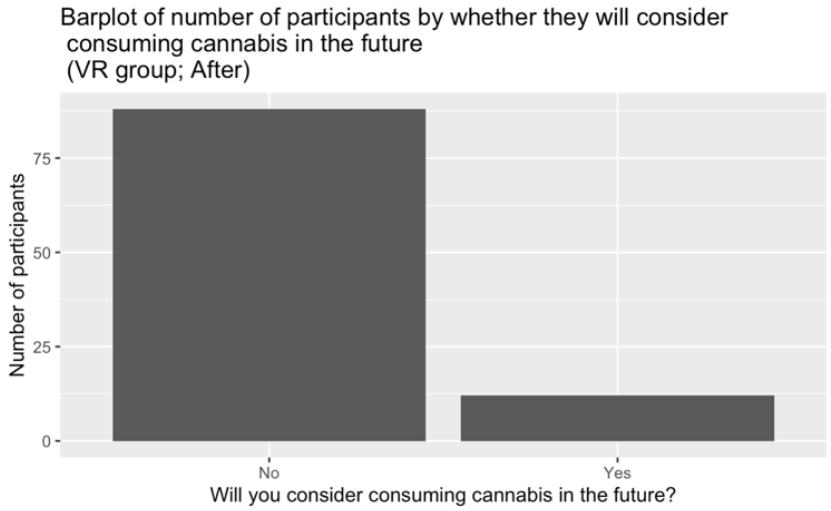
This bar plot shows the proportion of VR group participants according to their intention to consume cannabis in the future before receiving the intervention. It is measured by the binary responses to "*Will you consider consuming cannabis in the future?*". The responses are roughly equally distributed. N = 100.

Figure 6: Bar plots of the number of participants by whether they will consider consuming cannabis in the future in the Traditional seminar group pre-intervention



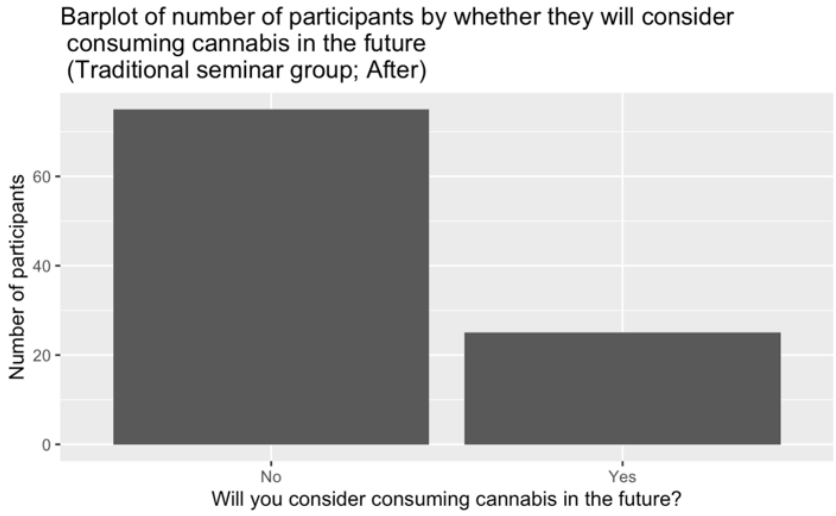
This bar plot shows the proportion of Traditional seminar group participants according to their intention to consume cannabis in the future before receiving the intervention. It is measured by the binary responses to "*Will you consider consuming cannabis in the future?*". The responses are roughly equally distributed. N = 100.

Figure 7: Bar plots of the number of participants by whether they will consider consuming cannabis in the future in the VR group post-intervention



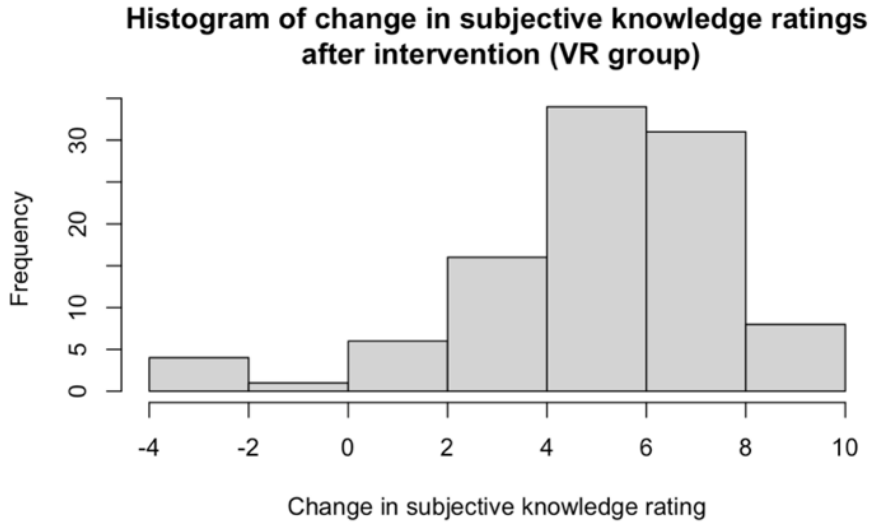
This bar plot shows the proportion of VR group participants according to their intention to consume cannabis in the future after receiving the intervention. It is measured by the binary responses to "*Will you consider consuming cannabis in the future?*". More than 80% of the respondents expressed no intention in consuming cannabis in the future. N = 100.

Figure 8: Bar plots of the number of participants by whether they will consider consuming cannabis in the future in the Traditional seminar group post-intervention



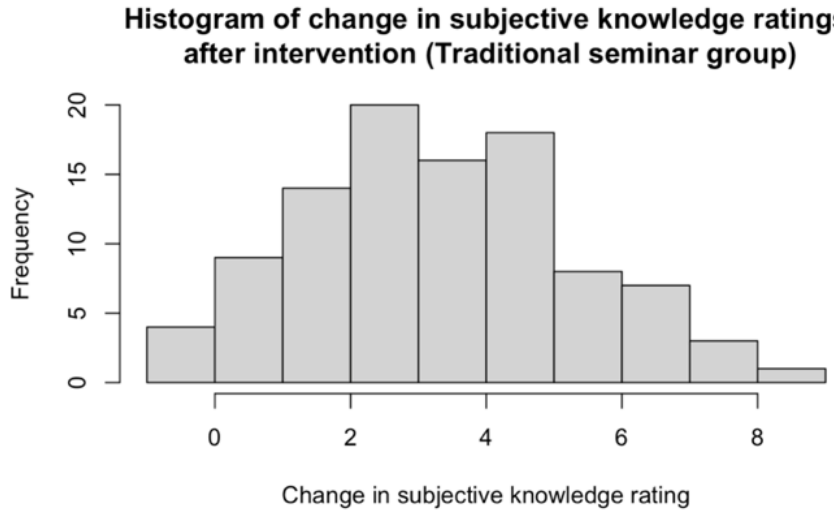
This bar plot shows the proportion of Traditional seminar group participants according to their intention to consume cannabis in the future after receiving the intervention. It is measured by the binary responses to "*Will you consider consuming cannabis in the future?*". Around 70% of the respondents expressed no intention in consuming cannabis in the future. N = 100.

Figure 9: Histogram of change in subjective knowledge ratings in the VR group



This histogram shows the distribution of change in subjective knowledge ratings among VR group participants after receiving the intervention. It is measured by recording the change in ratings to the question "*On a scale of 1(lowest) to 10 (highest), how would you rate your knowledge about cannabis use?*" before and after receiving intervention. N = 100.

Figure 10: Histogram of change in subjective knowledge ratings in the Traditional seminar group



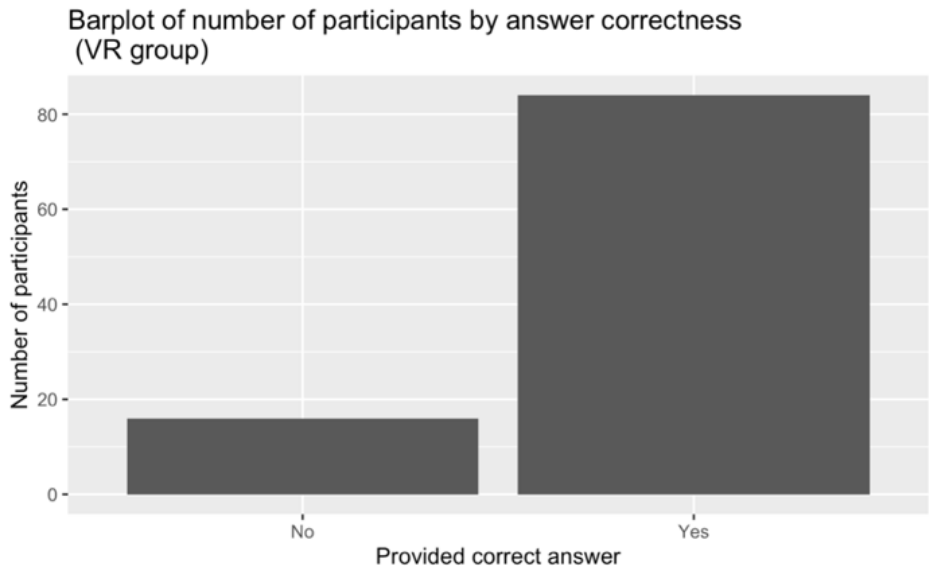
This histogram shows the distribution of change in subjective knowledge ratings among Traditional seminar group participants after receiving the intervention. It is measured by recording the change in ratings to the question "*On a scale of 1(lowest) to 10 (highest), how would you rate your knowledge about cannabis use?*" before and after receiving intervention. N = 100.

Table 1: Summary table of pre- and post- interventions measures

	Traditional seminar group	VR group
Average change in subjective knowledge ratings	3.79	5.37
Proportion of participants who considered consuming cannabis in the future before intervention and changed their stance after intervention	57.4%	86.0%

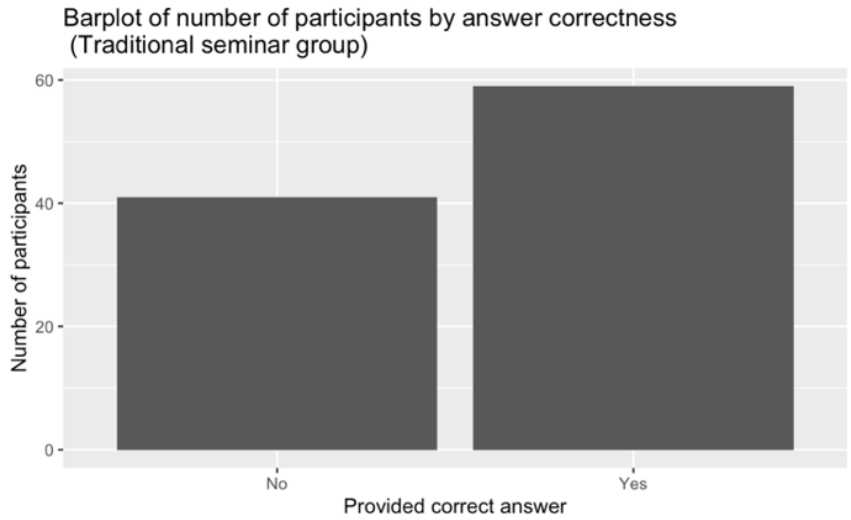
This first row displays the average change in subjective knowledge ratings pre- and post-interventions among the two groups. The second row displays the proportion of participants who considered consuming cannabis in the future before intervention and changed to not considering after interventions among the two groups. Most noticeably, both measures are higher in theVR group.

Figure 11: Bar plots of the number of participants by answer correctness to one knowledge-based question in the VR group



This bar plot shows the distribution of answer correctness to a knowledge-based cannabis misuse related question among VR group participants. It is measured by recording whether participants provided a correct answer to the question (Yes = Provided correct answer, No = Provided incorrect answer). N = 100.

Figure 12: Bar plots of the number of participants by answer correctness to one knowledge-based question in the Traditional seminar group



This bar plot shows the distribution of answer correctness to a knowledge-based cannabis misuse related question among Traditional seminar group participants. It is measured by recording whether participants provided a correct answer to the question (Yes = Provided correct answer, No = Provided incorrect answer). N = 100.

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