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Can Virtual Reality More Arouse Student Empathy?--Meta analysis based on 19 randomized controlled trials

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Abstract: Virtual reality technology,as a new form of education that cultivates student empathy,has received widespread attention.However,there is controversy in existing research on whether virtual reality can trigger student empathy more effectively than traditional forms of education.To clarify the impact of virtual reality teaching on students'empathy awareness and ability,as well as its differences from traditional teaching methods,this study used meta-analysis to systematically evaluate 19 randomized controlled experiments.The results show that virtual reality teaching can effectively improve students'empathy level.The analysis of moderating variables shows that the empathy effect of virtual reality teaching is better than face-to-face teaching,but the difference between virtual reality teaching and flat video teaching is not statistically significant;Knowledge learning and public welfare experience programs have better empathy effects,while disease perception programs have no advantages compared to traditional teaching methods;The program with an experience duration of 10-20 minutes has a significant and stable empathy teaching effect;The third person perspective is more likely to arouse students'empathy than the first person perspective;Virtual reality programs without interactive functions have better empathy teaching effects than programs with interactive functions.This study suggests that empathy teaching based on virtual reality should be improved in terms of integrated applications,content selection,and instructional design,effectively leveraging its advantages in cultivating student empathy.

Key words: Virtual reality; Empathy; Meta analysis; Randomized controlled trials; instructional design

1 Research background

Empathy is crucial for individual moral development and interpersonal relationships.In recent years,with the application and popularization of virtual reality technology,people have gradually believed that teaching based on virtual reality technology is an effective means to arouse students’empathy,but the conclusions are not consistent.This article explores the magnitude and direction of the impact of virtual reality on student empathy through meta-analysis.

1.1 Empathy

Empathy is often regarded as an objective and profound understanding of an individual’s feelings and behaviors towards others.Most studies believe that empathy includes at least two dimensions:cognitive empathy and emotional empathy.Cognitive empathy helps to objectively understand others’perspectives and psychological states,while emotional empathy helps to feel and share others’emotions,making appropriate emotional responses to others.Based on the difference between cognitive empathy and emotional empathy,Davis constructed a four factor model of empathy,which includes four aspects:viewpoint selection,imagination,personal sadness,and empathy concern. This is the most widely used empathy structural model so far. Empathy plays a crucial role in individual social interaction.It can provide a basis for the establishment of a positive organizational atmosphere and interpersonal relationships,and promote individual prosocial behavior.The lack of empathy means that it is impossible to see problems from the standpoint of others or understand their feelings,which often leads to prejudice and violence.Research has also shown that empathy can help improve students’academic performance.Empathy is a special learning influencing factor that can improve learning interaction and motivate students to achieve better learning outcomes.Neuroscience theory suggests that empathy,as a mechanism for collecting information to collaborate with others,is an innate talent in the human brain,but not everyone has a high level of empathy.Therefore,educational researchers have been looking for educational means to cultivate students’empathy,such as games,drama,simulation,etc.The development of virtual reality technology has provided new tools for cultivating students’empathy.

1.2 The Influence of Virtual Reality on Students empathy

Virtual reality is a set of media technologies that provide people with a quasi real experience in a computer-generated environment.It promotes empathy and social solidarity by providing viewers with an immersive experience.American artist Milk referred to it as the"ultimate empathy machine".In the field of education,teachers use virtual reality technology to provide students with immersive experiential learning to stimulate empathy,which is the same as the empathy education method used in traditional classrooms,which allows students to learn from the perspective of others.However,the experience brought by virtual reality is more convenient and realistic.In virtual reality teaching,students share and understand the perspectives of others,experience their lives,establish deep connections between themselves and others,and generate empathy.In addition,virtual reality can create learning contexts that were originally constrained by resources or ethics,expanding the educational content that schools can provide. Presence is an important feature of virtual reality and a key factor

in its role as an empathetic machine.Recent research has shown that presence can regulate the impact of virtual reality on empathy,and more immersive and interactive virtual reality experiences can effectively stimulate empathy.Presence is considered a subjective experience,but it depends more on objective factors such as equipment,theme,or form.Therefore,the design features of virtual reality teaching will have an impact on students'empathy development.

1.3 Research questions

Although many research conclusions support virtual reality as an effective means of arousing student empathy,some studies have found that virtual reality does not perform better than other traditional educational methods in experimental environments with controlled controls.Meanwhile,some scholars question the ethical risks of using virtual reality as an"empathetic machine". For example,Rueda and Laura pointed out that virtual reality arouses people's empathy with strong emotional arousal and moral tendencies,which may lead to manipulation of the audience and narrow empathy only for members of specific groups.Some scholars believe that although virtual reality provides viewers with cognitive and emotional experiences,it does not provide reasons and meanings for action,which is the essential difference between virtual reality and real situations.Given the above controversy,this study uses meta-analysis methods to comprehensively and evaluate the effectiveness of virtual reality in eliciting student empathy,and determines the impact of different variables on student empathy. Specific questions include:1)Is virtual reality more effective in eliciting student empathy than traditional teaching methods?2)How do factors such as research design,subject content and program characteristics affect the cultivation of students'empathy by virtual reality?

2 Research methods

This study was written in accordance with the"System Evaluation and Meta Analysis Report Specification"and evaluated and analyzed in accordance with the"Cochrane Intervention System Evaluation Manual".

2.1 Inclusion and Exclusion Criteria

This study follows the PICOS principle to determine the inclusion criteria for literature:the study subjects are students,the intervention measures are teaching based on virtual reality technology,the control measures are traditional teaching methods(such as classroom teaching,internships,and screen videos),the outcome indicator is the score of the Empathy Scale(requiring data to be presented in mean and standard deviation or convertible into mean and standard deviation),and the measurement tools must have good reliability and validity,The research type is a randomized controlled experiment.The exclusion criteria are:if the sample size is less than 10,if the data is incomplete or cannot be converted,if the literature is not published in Chinese or English,and if the full text(such as conference abstracts)cannot be obtained,etc.

2.2 Literature Retrieval Strategy

This study was searched on CNKI,EBSCO,ERIC,ProQuest,PubMed,Scopus,Taylor&Francis,Wiley Online Library,and Web of Science databases.The Chinese keywords include virtual reality,augmented reality,extended reality,empathy,morality,ethics,etc.The English keywords include virtual reality,VR,augmented reality,extended reality,empathy,moral,ethics,etc.The time limit is from the establishment of the database to August 2022.In addition,this study also conducted literature tracing on the included references to ensure complete literature collection.

2.3 Literature screening and data extraction

The study first used the literature management software EndNote 20 to remove duplicates,then screened out irrelevant literature by reading the title and abstract,and finally read the entire literature to determine whether it meets the inclusion criteria.The content of literature extraction involves:1)the characteristics of the research object,including sample size,region,age,gender,etc;2) The characteristics of virtual reality teaching methods,including duration,person,interaction,theme,equipment,etc;3)Outcome indicators include scale and outcome type;4)The research design includes randomized methods,control measures,and key elements related to bias risk assessment.Literature screening and content extraction are independently completed by two researchers.In case of differences,they are resolved through negotiation or consultation with a third party.

When there are multiple experimental groups using virtual reality teaching,this study extracts different experimental groups into one set of data,and evenly distributes the sample size of the control group to avoid artificial expansion of the sample size;When the study only reports the standard error of the results,use a specific formula to convert it to the standard deviation;When the baseline data of the study is inconsistent or presented as separate questionnaire entries,the extraction is abandoned;When multiple post test results were reported,the first measurement results after experiencing virtual reality were extracted,but follow-up data was not extracted.

2.4 Risk assessment of bias included in the study

This study used the Risk of Bias Tool(ROB)developed by the Cochrane Collaborative Network to assess the risk of bias in the included literature.This tool is mainly aimed at evaluating the quality of randomized controlled trials,including six domains:random allocation,allocation concealment,blinding,data missing,selective reporting,and other biases.By determining the high risk,low risk,or unclear risk of each domain,the quality of individual studies is determined.

2.5 Statistical analysis

This study used Stata 17 software for meta-analysis,and the data included were all continuous variables.There were differences in the scale tools used in each study.Therefore,the standardized mean difference(SMD)was used as the effect analysis statistic and its 95%confidence interval was calculated.The magnitude of the effect indicates the difference in empathy between virtual reality teaching and other teaching methods,and the positive impact means that virtual reality helps to trigger empathy;The negative impact means that virtual reality is not conducive to triggering empathy.This study used Q-value and I2 statistical test for heterogeneity analysis,if P>0 If I2<50%,it indicates low heterogeneity between studies and can be analyzed using a fixed effects model;If P<0 If I2>50%,it indicates high heterogeneity between studies and can be analyzed using a random effects model. This study conducted subgroup analysis based on variables such as control measures,themes,and program characteristics to explore

the moderating variables that affect the effectiveness of empathetic teaching based on virtual reality.Sensitivity analysis was conducted using a one by one exclusion method to examine the stability of the combined effect quantity.The funnel plot and Egger test were used to evaluate the publication bias of the study at the end of this study.

3 Research results

3.1 Literature screening process and results

This study initially obtained 7359 references;1341 duplicate articles were removed,5914 were excluded from the initial screening,and 85 were excluded after reading the entire article. A total of 19 studies were ultimately included in the analysis(see Figure 1).

3.2 Basic Characteristics of Literature and Risk Assessment of Bias

The 19 studies included in the analysis were all randomized controlled trials,with a sample size of 1949 people,including 1066 in the experimental group and 883 in the control group.The research subjects were from nine countries,including China,the United States,and Australia,with two studies using Chinese students as samples.All studies were published after 2010,with 11 studies published after 2020,accounting for 57.89%.The detailed information of the included literature is shown in Table 1.

This study used RevMan 5.4 software to evaluate the risk of bias.The results showed that four studies had a high risk of bias,while 15 studies had an uncertain risk of bias.This is because most studies do not provide a detailed description of random methods and allocation concealment methods,thus being evaluated as uncertain risks.In addition,compared to traditional teaching,virtual reality teaching has significant differences,and there are objective difficulties in implementing the subject blind method. The final bias risk assessment does not include the subject blind method dimension.

3.3 Analysis results

Researchers obtained 22 effects of virtual reality on student empathy from 19 included literature.Heterogeneity testing showed moderate heterogeneity between studies(P<0.01,I2=70.74%),so this study used a random effects model for analysis.The results showed that virtual reality teaching elicited better student empathy than traditional teaching methods[Hedges'g=0.32,95%CI(0.15,0.50),P =0.0003],and the difference was statistically significant.The meta-analysis forest map is shown in Figure 2.

3.4 Subgroup analysis

Researchers conducted subgroup analysis on the results based on control measures,themes,and program characteristics,and found that the above variables had a moderating effect on the effectiveness of empathetic teaching based on virtual reality.The results are shown in Table 2.

The results of subgroup analysis show that:1)Virtual reality teaching is more effective than face-to-face teaching(Hedges'g=0. 56,P<0.01),but compared to traditional 2D video based on display screens(Hedges'g=0.21,P=0 158)or 3D video(Hedges'g=0.28,P=0 125)The differences in teaching are not statistically significant;2) Virtual reality knowledge learning teaching(Hedges'g=0.84,P<0.01) is more likely to evoke empathy among students than public welfare experiential teaching(Hedges'g=0.33,P=0.001).The difference between disease perception teaching(Hedges'g=0.18,P=0.276) and traditional teaching is not statistically significant;3)The virtual reality teaching effect is better when the experience duration is 10 to 20 minutes(Hedges'g=0.34,P=0.002),and less than 10 minutes(Hedges'g=0.26,P=0 103)The effect quantity is not statistically significant;4)The empathy effect of virtual reality programs designed from the third person perspective (Hedges'g=0.40,P=0.01)is more effective than that designed from the first person perspective(Hedges'g=0.25,P=0.025);5) The empathy effect of virtual reality programs with interactive functions(Hedges'g=0.21,P=0.097)is lower than that of programs without interactive functions(Hedges'g=0.32,P=0.012),and the effect magnitude is not statistically significant.

Table 1 Basic information of included literature

Author and year of publication	Sample size(person)	Research site	Project Theme	Control measures	Intervention duration(minutes)	Personal perspective	interaction
AlBasri(2019)	34	the United States of America	Disease perception	Face to face teaching	20	First person	unknown
Bang&Yildirim(2018)	44	the United States of America	Public welfare experience	3D Video	10	unknown	Yes
Calvert&Abadia(2020)	79	Australia	Knowledge learning	3D Video	unknown	unknown	Yes
Christofi et al.(2020)	40	Cyprus	Public welfare experience	3D Video	10i	First person	not have
Cohen et al.(2021)	70	Israel	Public welfare experience	2D Video	8	Third person	not have
Cole(2022)	93	the United States of America	Public welfare experience	2D Video	unknown	Third person	not have
Han et al.(2022)	148	korea	Disease perception	3D Video	10	unknown	unknown

Hasler et al.(2021)	100	Israel	Public welfare experience	2D Video	1	First person	not have
Herrera et al.(2018)	345	the United States of America	Public welfare experience	Face to Face Teaching/2D Video	15	First person	Yes
Kalyanaraman et al.(2010)	52	the United States of America	Disease perception	Face to face teaching	4.5	First person	not have
Kandaurova&Lee(2019)	85	Canada	Public welfare experience	2D Video	3.17	unknown	unknown
Ma et al.(2021)	69	the United States of America	Disease perception	3D Video	10	First person	Yes
Mado et al.(2021)	275	the United States of America	Public welfare experience	Blank control	10	First person/ Third person	Yes/No
Marques et al.(2022)	102	Portugal	Disease perception	2D Video	7	First person	Yes
Mcevoy et al.(2016)	52	the United States of America	Public welfare experience	2D Video	0.5	Third person	not have
Schutte&Stilinović(2017)	24	Australia	Public welfare experience	2D Video	8	First person	not have
Wu et al.(2021)	131	China	Disease perception	2D Video	6.87	First person	Yes/No
Zare-Bidaki et al.(2022)	144	Iran	Disease perception	Face to face teaching	4.5	First person	unknown
Liu Ruixue et al(2019)	62	China	Knowledge learning	2D Video	13	First person	not have

Experimental group			control group			Effect quantity	weight	Inclusion in research
	N	Mean	SD	N	Mean	SD		[95%Cl](%)
AlBasri2019	17	5.06	3.2	17	1.41	4.7		0.89[0.20,1.58]3.27
Bang2018	22	5.04	.76	22	5.05	1.055		−0.01[−0.59,0.57]3.85
Calvert2020	44	4.51	.56	35	4	.64		0.85[0.39,1.31]4.59
Christofi2020	20	19.6	5.68	20	19.4	6.87		0.03[−0.58,0.64]3.70
Cohen2021	33	5.5	1.1	37	4.8	1.34		0.56[0.09,1.03]4.50
Cole2022	47	56.617	8.74159	46	54.8261	11.7195		0.17[−0.23,0.58]4.95
Han2022	74	22.7	3.34	74	22.77	3.71		−0.02[−0.34,0.30]5.49
Hasler2021	50	4.35	1.46	50	4.17	1.33		0.13[−0.26,0.52]5.04
Herrera2018-1	61	5.29	1.18	56	5.8	1.2		0.41[0.05,0.77]5.21
Herrera2018-2	115	5.16	1.26	113	5.21	1.12		−0.04[−0.30,0.22]5.88
Kalyanaraman2010	26	3.94	.5099	26	3.66	.5099		0.54[−0.00,1.09]4.05
Kandaurova2019	44	4.8	1.18	41	3.38	1.64		0.99[0.54,1.44]4.66
Ma2021	37	6.57	.68	32	6.2	.76		0.51[0.03,0.98]4.48
Mado2021-1	97	5.2	1.13	39	4.62	1.32		0.49[0.11,0.86]5.14
Mado2021-2	100	4.69	1.08	39	3.97	1.42		0.60[0.23,0.98]5.14
Marques2022	51	44	10.67	51	46.61	10.54		−0.24[−0.63,0.14]5.06
Mcevoy2016	26	4.24	12.34	26	5.47	12.34		−0.10[−0.63,0.44]4.11
Schutte2017	12	35.42	4.12	12	28.83	8.07		0.99[0.17,1.82]2.68
Wu2020-1	44	5.197	1.178	22	5.597	.733		−0.38[−0.89,0.13]4.27
Wu2020-2	43	5.357	.778	22	5.597	.733		−0.31[−0.82,0.20]4.26

Zare-Bidaki2022	72	128.764	9.39657	72	121.986	12.3875	0.61[0.28,0.95]5.41
Liu 2019	31	4.26	.71	31	3.6	.86	0.83[0.31,1.34]4.25
Overall							0.32[0.15,0.50]

Heterogeneity:τ2=0.12,I2=70.74%,H2=3.42
Test ofθi=0j:Q(21)=69.51,p=0.00
Test ofθ=0:Z=3.65,p=0.00 Random effect mode Figure 2 Meta-analysis Forest Map

Table 2 Summary of subgroup analysis results

divide into groups	Number of included effects	Heterogeneity test results		Meta analysis results			
		I^2 value(%)	P-value	Effect model	Effect quantity	95%CI	weight(%)
Control measures							
facing each other	4	0.00	=0.65	regular	0.56	(0.35,0.77)	19.98
2D Video	11	78.65	< 0.01	random	0.21	(−0.08,0.50)	55.33
3DVideo	5	64.30	=0.02	random	0.28	(−0.08,0.63)	24.68
Theme content							
Knowledge learning	2	0.00	=0.95	regular	0.84	(0.50,1.18)	8.84
Public welfare experience	12	60.55	< 0.01	random	0.33	(0.13,0.53)	54.86
Disease perception	8	76.35	< 0.01	random	0.18	(−0.14,0.50)	36.29
Experience duration(minutes)							
t < 10	10	77.93	< 0.01	random	0.26	(−0.05,0.58)	48.72
10 ⩽ t ⩽ 20	10	60.64	< 0.01	random	0.34	(0.13,0.55)	51.28
Personal perspective							
First person	13	70.86	< 0.01	random	0.25	(0.03,0.47)	73.91
Third person	5	49.33	=0.09	random	0.40	(0.09,0.71)	26.11
interaction							
have	8	73.84	< 0.01	random	0.21	(−0.07,0.49)	47.73
not have	10	59.88	=0.01	random	0.32	(0.07,0.56)	52.29

3.5 Cumulative meta-analysis results

Cumulative meta-analysis refers to conducting multiple meta-analyses of included studies in a certain order,and the results can reflect the dynamic trend of the combined effects,while also evaluating the impact of each study on the overall results.This study uses cumulative analysis to examine the dynamic changes in the impact of virtual reality teaching on student empathy with the increase of publication year and experience duration.

The cumulative analysis in chronological order shows that the point estimation value and confidence interval of the combined effect amount tend to be stable over time,indicating that the reliability and accuracy of the results are improving.The first time the merged results were statistically significant was in 2018(P=0.041),and after 2019,all results had P values less than 0.05,indicating that technological updates have a promoting effect on the effectiveness of empathetic teaching based on virtual reality. The cumulative analysis according to the order of experience time shows that the point estimation value and confidence interval of the effect amount tend to be stable with the addition of the study of longer experience time.After being included in studies for more than 10 minutes,the combined results continued to show significance,and the subsequent research results showed a positive trend of a small increase in effect size and a reduction in confidence interval.This

indicates that an experience duration of more than 10 minutes can have a significant positive effect on empathetic teaching based on virtual reality.

3.6 Sensitivity analysis and publication bias assessment

The sensitivity analysis of the analysis results using the method of elimination one by one shows that the elimination of any one of the research results has little impact on the combined effect amount(0.29-0.35)of empathy results,and the point estimation of the new combined effect amount fall within the 95%confidence zone of the overall analysis,indicating that the research results are stable. This study evaluated the publication bias of the included literature by drawing a funnel plot and Egger test(see Figure 1).No significant asymmetry was found in the results;The Egger test has a P-value of 0.29,indicating a low likelihood of publication bias.

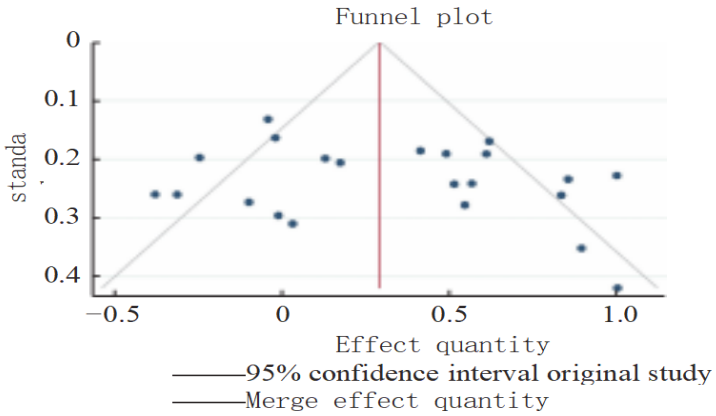

Figure 3 Publication bias funnel diagram

F igure1 Publication bias funnel diagram

4 Discussion and Reflection

4.1 The overall effect of virtual reality teaching on arousing students'empathy.This study focuses on the effectiveness of empathy teaching based on virtual reality

Meta analysis,and the included literature are all randomized controlled experiments with a large sample size,high quality original research methods,and certain reliability of the analysis results.The results indicate that virtual reality teaching can help stimulate student empathy compared to traditional teaching. This result can be attributed to the fact that virtual reality allows students to experience the feelings and experiences of others in a vivid way,allowing them to easily access the originally complex social interaction experience,thereby triggering empathy for others.Another explanation suggests that positive results may come from the"novelty effect"and"exposure effect",meaning that the improvement in empathy in the experimental group is only due to learners'curiosity and love for virtual reality technology. This explanation has not yet received more empirical research support,and further exploration is needed through follow-up and controlling the baseline level of participants.In addition,the higher sense of presence provided by virtual reality teaching may strengthen emotional and cognitive responses,including empathy. A sense of presence will attract students'attention and increase their learning engagement.The theory of embodied learning holds that the sensation of incarnating others brought about by virtual reality activates neural pathways in the brain and enhances learning ability. Therefore,the effectiveness of virtual reality teaching in arousing empathy depends on the quality of the experience itself,and the objective factors that affect the learning experience will also affect the effectiveness of empathy teaching.

The results of this study are basically consistent with the analysis results of Ventura et al.and Martingale et al.Compared to the final effect size of 0.32 based on virtual reality empathy teaching in this study,the effect sizes of the above two studies are 0.207 and 0.223,respectively.This may be because these two studies did not only include student samples,and the publication time of the included literature was before 2019.The particularity of the student population in this study and the advancement of virtual reality technology may have led to an increase in the magnitude of the effect.

4.2 The moderating variables of students'empathy triggered by virtual reality teaching

1.Control measures

Virtual reality teaching has a better promoting effect on student empathy than face-to-face teaching,achieving a moderate equivalent stress(Hedges'g=0.56).It is generally believed that the methods of moral imagination,role-playing,and ethical dilemma discussion used in face-to-face teaching to cultivate empathy require a significant amount of cognitive effort,which may lead to high cognitive burden on students and hinder the occurrence of empathy.Virtual reality teaching can directly present scenes that originally needed to be constructed in the mind,making students'learning easier and more focused.Virtual reality has no advantage in eliciting student empathy compared to 2D and 3D videos.For this result,Shen Dongxi(2018)found that the stimulation of empathy in virtual reality may depend more on the characteristics of participants,such as empathy tendencies,intentions,and behaviors,rather than the media itself.Another possible reason is that most participants are familiar with video teaching and have less experience with virtual reality.Their curiosity about technology may outweigh their focus on experiential content,resulting in poor effectiveness of empathy teaching.

2.Project Theme

The empathy effect of knowledge learning projects has a significant effect(Hedges'g=0.84),while the empathy effect of public welfare experience projects has a medium equivalent effect(Hedges'g=0.33).Disease perception projects do not show significant effects compared to other teaching methods.This result confirms the findings of Formosa et al.that even if virtual reality only provides situational experience and participation without explicit knowledge teaching,the measurement of participants'knowledge learning outcomes will still improve,indicating that virtual reality has a natural advantage in knowledge teaching.Public welfare experience projects are currently widely used in fields such as charitable fundraising and social services.This type of project has a larger number of projects compared to other theme projects and generally has better empathy effects,which may be due to the fact that the participants of such projects often have a clearer experience purpose and higher moral sensitivity.The theme content of this type of project is complex,involving sub themes such as climate change,poverty,and refugees.Future research can refine the classification and discussion. The main reason why empathy teaching in disease perception projects is ineffective is that such projects can bring more pain and worry to participants,as high-level negative experiences that persist for too long no longer promote individual empathy,but instead lead to empathy fatigue and avoidance.

3.Experience duration

The duration of virtual reality experience between 10 and 20 minutes has a promoting effect on student empathy,and the impact of less than 10 minutes on student empathy is no different from traditional teaching methods.Cumulative meta-analysis showed that after incorporating research results for more than 10 minutes,the overall analysis effect became stable and consistently statistically significant.This is in line with the design duration of current mainstream virtual reality experience projects,and researchers generally.

It is widely believed that an experience time of about 10 minutes can reduce discomfort while maintaining educational effectiveness.The founder of the Virtual Interpersonal Interaction Laboratory at Stanford University in the United States,Baronson,believes that prolonged use of virtual reality can lead to discomfort symptoms such as dizziness,visual fatigue,and confusion between reality and reality.Therefore,the duration of each use of virtual reality should not exceed 20 minutes.In recent years,the development of virtual reality devices and technologies has extended comfortable usage time.However,due to the fact that the duration of virtual reality interventions clearly known in this study is less than 20 minutes,it is not possible to obtain a longer duration of teaching effect and compare it.

4.Personal perspective

Compared with the first person perspective(Hedges'g=0.25),the third person perspective of virtual reality teaching(Hedges'g=0.40) has significantly improved the effect of arousing empathy among students.This result seems to contradict people's common sense. Most people believe that the first person perspective can enable participants to better immerse themselves in the experience,thus triggering a higher level of empathy.But Cambay and Nakajima believe that there are two reasons for this situation:first,the first person perspective will make participants treat the experience with a"player"mentality,and participants will treat virtual reality teaching as a game to bring their own personality and views into the role they play.Becoming a'player'can lead to cognitive ambiguity between oneself and the other,weakening perception of the other's difficult situation.Participants will mainly rely on their own needs to think and no longer pay attention to the other's feelings,ultimately reducing the effectiveness of virtual reality teaching in cultivating empathy.Secondly,the difference in visual information obtained by the first person and the third person due to their different perspectives will affect the empathy of the participants.The third person may obtain more information about actions,expressions and environment,which will enable the participants to understand the other's situation more comprehensively,thus triggering empathy.

5.Interaction situation

The virtual reality empathetic teaching with no interactive function(Hedges'g=0.32)is more effective than with interactive function(Hedges'g=0.21).The results of this study are inconsistent with existing research.Most studies believe that higher interactivity can lead to a higher sense of presence and participation,thereby achieving a higher level of empathy.However,this study did not find that virtual reality teaching with interactive functions has a significant advantage in improving presence and empathy.The reason may be that excessive interactive functions can also cause st udents'"player"mentality,Distract attention and increase cognitive load,resulting in poor empathy.

4.3 Brief Reflection

1.Applications based on virtual reality empathy teaching can be integrated with other teaching forms

The results of this study indicate that there are differences in the effectiveness of different teaching methods in eliciting student empathy.However,different teaching methods have their own advantages and disadvantages,and the selection of teaching methods in actual educational scenarios can be based on their strengths and mixed use.Firstly,the role of virtual reality teaching should be viewed correctly.Virtual reality teaching requires a significant investment in hardware equipment and software development,but it may not necessarily achieve better results in specific teaching contexts and goals than face-to-face teaching or screen video teaching.The educational problems faced by the real environment are more complex,and the selection of teaching methods should be based on the actual teaching situation.Secondly,virtual reality teaching requires assistance from other forms of teaching. Kaliana Raman et al.found that relying solely on simulation is often not enough to maximize students'development,and other forms of supplementation are needed,such as lectures,written explanations,and physical simulations.Finally,the overall impact of different teaching forms on students'cognition,emotions,and behavior is not yet clear,and the complex relationship between these developmental dimensions determines that we need to further explore the integrated application effects of different educational forms.Therefore,it is necessary to combine virtual reality with traditional teaching methods for research in the future.

2.The content of empathetic teaching based on virtual reality should revolve around appropriate themes

The results of this study indicate that the content of virtual reality teaching can affect students'empathy,and suitable teaching content with appropriate themes is particularly necessary.Firstly,the use of virtual reality teaching in knowledge learning courses can also cultivate students'empathy.Research has confirmed that

students'empathy ability and academic performance have been improved in the process of using virtual reality technology to learn knowledge.At the same time,the improvement of students'empathy level is often accompanied by a subtle acceptance of knowledge. This provides a direction worth exploring for implementing moral education in students'knowledge learning courses.Secondly,public welfare experience projects have a wide range of applications in virtual reality,and their effectiveness has been verified by a large amount of research.They should be a key focus of virtual reality empathy teaching.Public welfare experience projects usually focus on ethical and moral issues that society urgently needs to explore,helping students to have a concrete understanding of the true state of phenomena such as the environment,poverty,and vulnerable groups,which has a direct and significant effect on enhancing students'empathy.Finally,most of the disease perception projects are used in medical and nursing education.The reason for the poor effect of such thematic empathy is the particularity of its specialty. This type of course content often triggers negative emotions among students,leading to emotional imbalance and ultimately affecting empathy performance.Therefore,in the future,virtual reality empathy teaching should tailor effective virtual reality empathy teaching plans tailored to different professions,majors,knowledge types,and students'actual needs.

3.The design of empathetic teaching based on virtual reality should follow the rules supported by evidence

The results of this study indicate that the design features of virtual reality are an important factor affecting student empathy,so designing virtual reality teaching should follow the objective laws found in existing research.Firstly,based on the comprehensive subgroup analysis and cumulative meta-analysis results,it can be seen that the duration of empathetic teaching experience based on virtual reality should be 10 to 20 minutes per session,and teaching below 10 minutes may have poor effectiveness.Secondly,it is better for students to learn from the third person perspective.The intuitive connection between self and others and more environmental information that can be provided by the third person perspective are crucial to eliciting empathy among students.Finally,teachers should pay attention to controlling the level of interaction in virtual reality programs.The interactivity and exploratory nature of virtual reality are important reasons for its ability to provide a high sense of presence.Designing virtual reality teaching can retain interactive functions but should be carefully considered.The principle is that the addition of interactivity should not undermine students'focus on the scene,and avoid students viewing virtual reality empathy teaching with a playful attitude.

Finally,this study has the following limitations:firstly,the included literature is randomized controlled trials,but most studies do not explicitly report on randomized methods and allocation concealment,which reduces the quality of the final literature. Secondly,the limited number of studies included in the analysis limits the examination of potential moderating variables such as cultural regions,empathy scales,and virtual reality devices. Thirdly,most of the included studies were single short-term interventions,with insufficient long-term follow-up studies,making it difficult for researchers to assess the long-term stability of the impact of virtual reality on student empathy.

5 Conclusion

This study included 19 randomized controlled experiments to conduct a meta-analysis of the effect of virtual reality on eliciting student empathy compared to traditional teaching methods. Compared to traditional teaching methods,virtual reality can enable students to develop higher empathy.1)Virtual reality teaching has a better teaching effect on students'empathy compared to face-to-face teaching,but there is no significant difference in teaching effect compared to 2D and 3D videos;2)Knowledge learning and public welfare experiential virtual reality teaching can better trigger student empathy,with knowledge learning having a greater amount of empathy effect,but public welfare experiential teaching is more widely used,and disease perception virtual reality teaching has no significant effect compared to traditional teaching methods;3)The virtual reality program design should be run from the third person perspective,not interactive,and 10-20 minutes of virtual reality teaching will lead to better results of empathy among students. Unlike technology that has almost always created barriers and hindered empathy in the past,virtual reality provides technology that supports the development of empathy.This may indicate the bridging of the gap between technology and humanity,but we still need to be vigilant about the results of technology.On the one hand,it has not yet been determined whether the ultimate empathy object of participants in virtual reality intervention is virtual people and objects presented in three-dimensional surround sound and 3D ultra clear images,or the real world associated with the virtual world.There are essential differences between them.If the generated empathy is limited to the virtual world,then virtual reality technology will reduce people's empathy ability for the real world,because the virtual world is often more exciting.On the other hand,excessive emotional experiences may lead to empathy fatigue and avoidance,but virtual reality programming always pursues the inclusion of more sensory stimuli in a shorter period of time,which sometimes hinders the generation of empathy.In summary,virtual reality does not provide a shortcut for enhancing student empathy,and more research and sustained efforts are needed to systematically explore this field.

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