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Design and Practice of Chemistry Teachers' Workshop Supported by Virtual Reality Technology

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Authors' contributions

This work was carried out in collaboration among all authors. Author YX designed the study. Author BX performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author SX managed the analyses of the study. Author CJSJ managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Introducing virtual reality technology into the chemistry teachers' workshops can motivate teachers immersion and participation in workshop, and promote the research effect of the workshops, which is beneficial the professional development of teachers. Based on the characteristic of chemistry subject, this paper focus on the scheme and effect of introduction virtual reality technology into teachers' workshop. A comparative experiment is used to discuss the practical effect of teachers' workshop. By designing a framework strategy, virtual reality technology is introduced in teachers' workshop, the experimental group (51) and the control group (58) was established for comparative study. Adopt the method of quantitative analysis to evaluate the quantitative and qualitative data of knowledge sharing. Particularly, by utilizing the Kappa value estimated the consistency of table that measures the quality of knowledge sharing. The experimental group is superior to the control group in terms of login frequency, average online time and quality of knowledge sharing content. It logged in 2.5 times a day for an average of 1.7 hours, however, the control group with an average of 0.9 hours. The experimental group average 1.38 posts were greater than the control group with average 0.78 posts which issued by each teacher. Then, the average score of "theme" in the

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experimental group was higher than the experimental group about 1.7344 point, in the quality of knowledge sharing. And, the average score of contribution in the experimental group was higher than the control group too. The experimental results show that the introduction of virtual reality technology in the workshop can effectively improve the enthusiasm and participation of teachers, the teachers' research effect in this designed workshop also was increased significantly.

Keywords: Virtual reality technology; chemistry teachers' workshop; virtual experiment; teacher professional development; knowledge sharing.

1. INTRODUCTION

Recently, the teachers' workshops have been attracted great attention to a multitudinous education specialists and displayed potential applications in teacher training, because of the excellent advantage in promoting the professional development of teachers [1,2]. Workshop generally used in education and psychology research. Educational psychology has been emerged with the closer integration of psychology and education. The teachers' workshops appeared when teachers' professional development becomes more demanding.

Teachers' workshop could be defined as a learning organization with the nature of a common guide, which presides over by an excellent teacher with teachers of different levels participated. In other words, teachers' workshop is a functional organization with research and communication for promoting the comprehensive quality and stimulating professional development of regional teachers, which is hosted by an outstanding owner and utilizer [3,4]. Currently, the development of teachers' workshops has been reached a balance in various fields of humanities. For example, teachers' workshops have been increasingly mature in the fields of language fields, psychology, and even training of class teacher.

In 2015, Soo Hyon Kim et al. investigated the issues of the English learners who study in the writers' workshop and proposed opinions of peer reviews [5]. In 2009, Roni Mualem and Bat-Sheva Eylon reported the exploration of science teachers in Israeli junior high-school and these teachers all improved in confidence and ability after participating in teacher' workshop [6]. In 2007, Howlin P et al. devised a teacher' workshop with the Picture Exchange Communication System (PECS) training for teachers of children with autism and proved the availability and practicability of this workshop [7]. In addition, Nwokolo et al. studied the greater need for the support of modern educational technology in special education [8]. However, in general, adaptability and usability are considered to be important factors that affect the study effectiveness. The common teachers' workshops could not meet the specificity of chemistry discipline in embodying the abstract, because of the relatively inflexible means in the part of technical support, particularly in the microscopic, abstract and experimental characteristics [9].

The increased development of computers and greater accessibility to the Internet have spurred the design and practice of chemistry teacher workshops with the technical support of high-performance computing, human-computer interaction technology and virtual reality technology [10,11]. Virtual reality technology is a part of emulation technique which merges interdisciplinary basis on computer graphics, computer simulation technology, human-machine interface technology, multimedia technology and sensing technology. VR (Virtual Reality) is a computer system which can establish a virtual world. The three-dimensional virtual world building by computer simulation providing users with visual, auditory, tactile and other sensory simulation as if be personally on the scene, for users can observe the three-dimensional space of things in a timely and unrestricted way [12]. Applications of virtual reality systems are divided into four categories: a) desktop virtual reality technology, b) immersive virtual reality technology, c) distributed virtual reality technology and d) hybrid virtual reality technology [13].

Although the teachers' workshop has some advantages in developing professional development, the experimental and abstractness in the teachers' workshop still need to be studied due to specialty of chemistry. Virtual reality technology (VR) provides possibility to display chemistry characteristics in teachers' workshop of chemistry [14]. For increasing the simulate effect of the workshops, numerous modules have been introduced, such as virtual laboratory,

interactive exchange area and personal workshop, which not only enhance the sense of immersion but also improve the enthusiasm of participants. The chemistry teachers' workshop owns more advantages in making mini visual size experiment macroscopic, static thing dynamic, abstract knowledge visual, complicated technique concise and costs experiment simulated, by utilizing the virtual reality technology. Although, the teachers' workshops training has achieved remarkable effect, we conducted a more focused review of relevant literature and found that the interaction effect and immersion feeling of learning on professional characteristics have been given scarce attention [15].

2. METHODS

2.1 Design of Chemistry Teachers' Workshop

Chemistry is an experimental subject with the characteristics of experiment, microcosm, abstraction, etc. Teachers' workshop is a new model for promoting the professional development of teachers. Thus, the design of chemistry teachers' workshop have to break through three urgent issues of single distance learning, face to face teaching and self-study research. We have been introduced a module to solve two vital problem. Firstly, how do teachers explain the difficulty and abstract professional knowledge in chemistry. Secondly, how to control and teach complex chemical experiment. Therefore, the design of the workshop follows the principle of combining online learning and offline practice, subject study and independent elective course, experimental operation and theoretical basis, abstract concept and practical case analysis, expert doubt solving and team work, action research and Self-evaluation. Comparing with conventional workshop, VR technology provides remarkable support to solve issues which combines the experimental operation and basic theories, as well as the chemical abstract concept with the living case in the workshop [16].

2.2 Design the Module of Teachers' Workshop

The active elements in workshop mainly include several points: Learning subjects, learning goals, construction of community, learning tools, activity rules and so on. The learning subjects mean that members of the workshop, which consists of three parts, "participant", "moderator" and "facilitator". The learning goals constitute by the principle of gradual progress, which should consider with characteristics of discipline and learning subjects. The community construction refers to unit learning subjects and learning goals, the learning subjects should be strive for achieving goals. As technical factors, learning tools are the basic intermediary for teachers' workshop. Activity Rules manage evaluation and division of tasks for the orderly conduct of workshop activities. According to explications above, general workshops include training classrooms, topic studies, statistical management, training experiences, etc. Both of the members and operation in the workshop need special requirements, which should combine with characteristics of chemistry teacher's workshop, such as microscopic, abstract and experimental features. The basic module of the chemistry teacher workshop is shown in Fig. 1.

2.3 Characteristic Module of Teachers' Workshop

With the support of virtual reality technology, the characteristics of chemistry could be highlighted in the special module of chemistry teachers' workshop, which is designed in this paper, such as concreting the abstract concepts, converting the microcosmic knowledge to macroscopic, turning the plane theory into three-dimensional and simulating the hazard experiment.

2.3.1 Research classroom

As one of the main parts of the workshops, the research classroom mainly consists of two modules: Independent training classroom and virtual laboratory. The independent training class consists of the training guide, the video display of excellent teachers, micro lesson demonstration and the video of model lesson [17]. Advanced training classrooms include virtual reality support systems with immersive effect, namely virtual classrooms. The users can wear stereoscopic display helmets, data gloves and clothes, which make users to interact with computer generated 3D graphics and forming a virtual three-dimensional environment [18]. By using virtual classrooms, users can see, hear and even touch the 3D virtual laboratory apparatus, the authenticity of a feeling or effect similar to that of a person in a real environment.

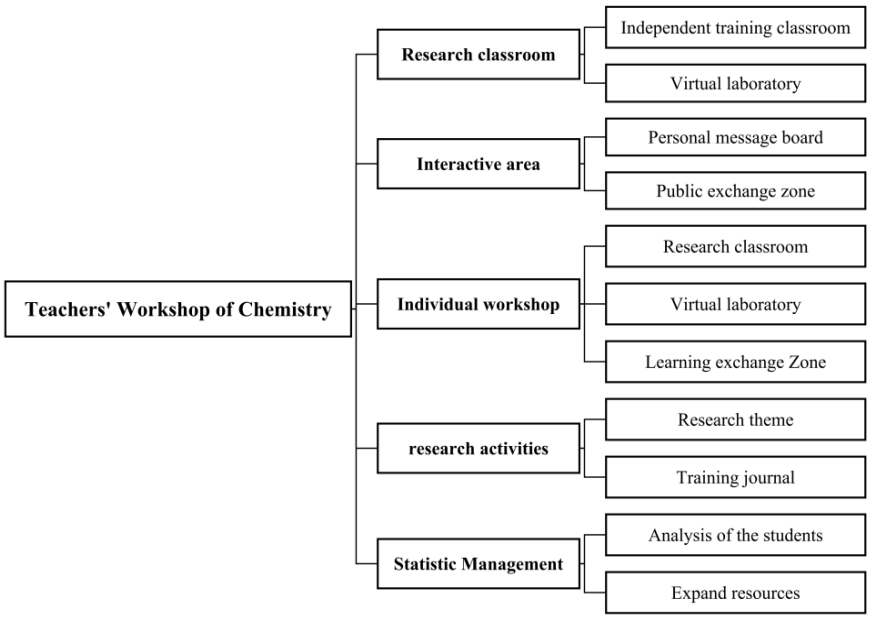

Fig. 1. The basic module of the chemistry teacher workshop

Virtual laboratory (including the virtual laboratory in the Individual workshop) is an emulational scenario of experiment based on computer technology, combined with simulation technology, computer graphics and image technology. Virtual reality system used in laboratory including immersion, desktop and distributed virtual reality system [19]. To adapt the characteristics of chemistry, more advanced virtual laboratory are designed and supported by hybrid virtual reality system. In virtual laboratory, the host and participants are teachers and users, respectively. The users can assemble experimental installations and study chemical properties of substance in the virtual laboratory. Supporting by hybrid virtual reality system, the virtual laboratories can transform the microscopic phenomena effectively to macroscopic during experiment. For instance, the microscopic invisible matter, such as molecular atom and ion can be magnified indefinitely by using the hybrid-virtual laboratory, and the motion and reaction of microparticles are presented in front of the users vividly, which makes it more easily to understand the relevant theoretical knowledge [20]. Moreover, the virtual laboratories can concrete the abstract concepts, such as simulating the thermodynamics and dynamics. For instance, by simulating iron burning in the air, users can observe the experimental phenomenon and feel the heat from burning. Making plane theory stereoscopic, simulating an accidental explosion in virtual laboratory to enhance the cognition and memory of users, by stimulating multi-senses including visual, auditory, and even tactile [21,22]. In addition, by using the virtual laboratory of the individual workshop, only through taking part in practice ourselves can users master the theoretical knowledge, promote scientific literacy and the ability of research [23].

2.3.2 Interactive area

The interactive area is a region where teachers report their feelings after each training class, in order to feedback the short of workshop and enhance the collective sense of the teachers in the workshop [24]. This section includes two parts: personal message board and public exchange area. The teachers' level of activity in the interactive area was also recorded in the evaluation of teacher training. Teachers can ask questions and answer others' doubts in this area, which not only enhances the awareness of cooperation but also promotes the capability of communication.

2.3.3 Individual workshop

An individual workshop is a chemistry workshop setting up by teachers who use the experience in teachers' workshop. This workshop set class as a unit, which contains research classroom, virtual laboratories and learning boards. In class

workshops, the host and participants are teachers and chemistry representatives, respectively. The chemistry representative is a person who could lead students studying chemistry and participating in the individual workshop.

2.4 Kappa Test

Kappa value is an indicator, which is used for checking the consistency of two testing methods. If kappa = -1, it shows that the two methods are completely inconsistent; if kappa = 0, it shows that the consistency of observation is caused entirely by accidental error; if kappa=1, it shows the true consistency after excluding opportunity consistency completely [25].

The formula is as follows:

$$K = \frac{p_0 - p_e}{1 - p_e}$$

P_0 is the observed agreement, the formula is:

$$P_0 = \frac{1}{n}\sum_i 0(ii)$$

P_e is the agreement by chance, the formula is:

$$P_e = \frac{1}{n}\sum_i O_1(i)O_2(i) \Big/ n$$

$$\sum_i O_1(i)O_2(i)$$

means the theoretical count value of two methods, which is determined by the two researchers independently. Landis and Koch recommended the range of statistical acceptance is showed in the following table.

Table 1. Inter-rater, coefficient of internal consistency

Kappa	Consistency degree
<0	Absolutely poor
0.00-0.20	Considerably poor
0.21-0.40	Poor
0.41-0.60	Moderate
0.61-0.80	Good
0.81-1.00	Perfect

We discuss the case in which a fixed set of two observers tested the same *N* experimental subjects, giving the results in Tables 2, 3. Let K denote the number of categories for a categorical response, and denote two observers by R and S. In the population of subjects of inspection, choosing i as the experimental subject, let $O_{irs,jk}$ (R = j, S = k) denote the number that observer R classifies in category j and observer B classifies in category *k*, (j,k = 1, ... , k). Let $O_{irs\ ,\ j+}$ denote the total number of lines and $O_{irs\ ,\ +k}$ denote the total number of columns [26].

Table 2. The measurement results of R&S

Observer		Observer S			
R	1	2	.....	k	Tote
1	$O_{irs,11}$	$O_{irs,12}$	.....	$O_{irs,1k}$	$O_{irs,1+}$
2	$O_{irs,21}$	$O_{irs,22}$	....	$O_{irs,2k}$	$O_{irs,2+}$
...	.....	....	.....	.....	.....
k	$O_{irs,k1}$	O_{irs}	.....	$O_{irs,kk}$	$O_{irs,k+}$
Tote	$O_{irs,+1}$	$O_{irs,+2}$	.....	$O_{irs,+k}$	n

3. RESULTS AND DISCUSSION

In this paper, we design a chemistry teachers' workshop, which combines the principle teachers' workshop and the research on activity elements. The chemistry teachers' workshop not only highlights the characteristic module of chemistry but also promotes the immersion and enthusiasm of the teachers who participate in workshop. For researching the initiative of teachers in the workshop, the topic of 'how to attract students' attention in chemistry classroom was designed and published (All have the experience of network training). The experimental group and the control group were established for comparative study. The positive conclusion was evaluated by referring to the average online time, the average number of login, as well as, the quantity and quality of knowledge sharing of teachers in the workshop.

3.1 Average Number of Login and Average Online Time

This paper adopts the method of quantitative analysis to evaluate the quantitative and qualitative data of knowledge sharing. The topic of 'how to concentrate students' attention in class' was designed and published for assessing above issue. And this part was evaluated by counting the quantity posts and investigating the quality of posts, which teachers sent and replied to the topic.

Table 3. Knowledge-sharing quality assessment scale

Dimension	Code	Score	Explanation	Case
IM1:Relevance of the post to the theme	IM11	0	The post is irrelevant to the subject.	How to upload homework?
	IM12	1	The post is a little of relevance to the theme.	Teachers should have passion, loud voice and humor in class.
	IM13	2	The post is a rough correlation with the theme.	We can connect chemistry with students' life, design some interesting experiments to attract students' attention, and make students feel that chemistry is useful.
	IM14	3	The post is completely relevant to the theme.	As a chemistry teacher, we should be passionate in our classes to stimulate students' interest in learning, and we should establish the valid teaching scenario, introduce vivid stories, demonstrate experiments, and guide students do the experiments.
IM2:Contribution of the post to the theme	IM21	0	The post makes no contribution to the topic.	
	IM22	1	The post can only justify themselves but can not deeply discussed. (they may not be relevant to the subject matter.)	We should eliminate the interference of irrelevant factors and cultivate good study habits for students.
	IM23	2	A deep discussion of the topic. (the problem solution, how to do it, etc.)	Teachers should be humorous and witty, give out personality charm, quote many examples of chemistry in life, and arouse students' interest in chemistry.
	IM24	3	To discuss the subject at the theoretical level and promote the divergent discussion of the subject, put question and think about the point of view by other teachers.	We should fully excavate the teaching material, enrich the content, increase the interest of the teaching, enhance the appeal and affinity of the teaching language, carefully design the interaction of the game, arouse students fully participate.
IM3:Continuity of the posts	IM31	1	The length of the posting is 1-3 short sentences.	(Breaking sentences only using Comma.)
	IM32	2	The length of the posting is 4-6 short sentences.	
	IM33	3	The length of the posting is 4-6 short sentences.	
	IM34	4	More than 10 short sentences.	

3.1.1 Number of the posts and replies

The number of teachers' knowledge sharing exhibits the enthusiasm of teachers in the process of learning. According to the statistics of teachers' posts, the result shows that whole experimental group contains 51 teachers, and 42 of them participated in the experimental group in the discussion of publishing questions. And 58 posts were issued, in which including 34 first posts (issuing at the first time) and 24 replies. The first posts received 15 in favour and 0 against, average 1.38 posts were issued by each teacher. The control group contains 58 teachers, and 41 of them participated in the discussion on the same topic. And 32 posts were issued, in which including 27 first posts (issuing at the first time) and 5 replies. The first posts received 21 in favour and 0 against, average 0.78 posts were issued by each teacher. According to the statistical data above, both number of the first posts and the average issuing posts in the experimental group are higher than that in the control group. Significantly, the replies number of the first posts in the experimental group is almost five times of the control group. The results

indicate that teachers in the experimental group thought more actively about the research theme and communicated with others.

3.1.2 Quality of the posts and replies

Although the number of posts reflects the degree of knowledge sharing, the quality of posts, in a sense, plays a more essential role in reflecting the degree of knowledge sharing, which could analyze the degree of knowledge sharing with many aspects of teacher workshops [27]. In this work, we employ the quality assessment analysing the quality of teachers' posts in workshops [28]. According to the quality assessment forms of knowledge sharing in the process with the participating and interactive knowledge construction proposed by Y. K. Avc and Yücel, and the activity characteristics of teachers' workshop, we designed a simplified version, short and easily evaluation sheet [29]. A quality assessment scale for teacher knowledge sharing in teacher workshops was established through communication and discussion with experts (show in Table 1). The table evaluates teachers' first posts and replies in three dimensions, the continuity of the posts, the relevance and contribution of the posts to themes, respectively, and the detailed explanation and example description will be divide with each dimension.

The evaluation scale is used to evaluate the quality of knowledge sharing of teachers' posts. To avoid the subjectivity of individual assessment, we use the two-person assessment to evaluate the quality of knowledge sharing of teachers' posts. The two observers evaluated the quality of whole posts from the experimental group [30]. The consistency of the assessment results shown in Table 2. It shows that the reliability of above table is pretty good and the kappa value is between the reasonable value of 0.4-0.75. It is noteworthy that the evaluation of the control group posts was completed by one person. The posting in three dimensions by two reviewers and the quality assessment of consistency between the two observers were showed in following Tables.

Table 4. Relevance of the post

Observer	Observer 1				
2	0	1	2	3	Tote
0	0	2	0	0	2
1	0	14	0	0	14
2	0	5	11	3	19
3	0	1	3	19	23
Tote	0	22	14	22	58

Table 5. Contribution of the post

Observer	Observer 1				
2	0	1	2	3	Tote
0	0	0	0	0	0
1	0	7	1	0	8
2	0	1	12	2	15
3	0	1	2	32	35
Tote	0	9	15	34	58

Table 6. Continuity of the posts

Observer	Observer 1				
2	0	1	2	3	Tote
0	0	0	0	0	0
1	0	23	0	0	23
2	0	0	25	0	25
3	0	0	0	10	10
Tote	0	23	25	10	58

Table 7. The quality assessment of consistency between the two observers

Dimension	Relativity	Contribution	Continuity
Kappa	0.6445	0.7837	1.0000

Based on the Table 8, the following conclusions have been drawn. Counting the total score, it is obviously that the total quality of the experimental group teachers who participated in knowledge sharing is relatively high, and the posts of knowledge exchange keep to the point with the published topic. From the relevance of the theme, the topic of the experimental group are basically related to the theme, they focused this theme deeply and shared ideas and their experience in teaching. The total score of the control group teachers who participated in

Table 8. Results of teachers' posting quality score

Dimension	Relativity	Contribution	Continuity
Total score of experimental group	237	284	206
Average score of the experimental group	2.0431	2.4483	1.7759
Total score of control group	111	123	74
Average score of control group	1.7344	1.9219	1.1563

knowledge sharing showed that they are mostly perfunctory in the discussion, their posts are not highly related to the theme and could not attached enough importance to the theme.

From a contribution perspective of posts to the theme, the teachers in the experimental group contributed to the subject study, and could deeply reflect on the theme and express views. However, the theme and posts can only arouse some teachers of the control group approval, could not introduce further the divergent discussion on theme and posts. Therefore, it is necessary to take some measures to promote the divergent discussion. In terms of continuity scores, most of the posts in the experimental group were more than 4-6 sentences describing about the topic, it shows that a great number of teachers were involved actively in the topic study. The score of the control group shows that the content of the teachers' posts are mostly within three sentences, and there is no deep discussion on the subject. It is show that the average number of posts in the experimental group is higher than 0.6 posts in the control group. There was no absolute advantage in the average number of posts in the experimental group. However, in the quality of knowledge sharing, the average score of "theme" in the experimental group was higher than that in the experimental group about 1.7344 point of each posts. And, the average score of contribution in the experimental group was higher than that in the control group about 1.9219 point of each posts, the knowledge sharing quality in the experimental group was much higher than that in the experimental group, and the average score of posting continuity was only higher than that in the experimental group about 1.1563 point of each posts. The above phenomenon probably owing to, on the one hand, the length of the post in the experimental group was higher than that in the control group, and the logic and ideas to be expressed could be completed in one or two statements. On the other hand, the experimental group teachers are addicted to other characteristic modules in the chemistry teachers' workshop, couldn't research on the "theme" in-depth.

4. CONCLUSION

By utilizing the support of virtual reality technology, teachers' workshop of chemistry can better highlight the characteristics of chemistry, such as, making the abstract concept concrete, making macroscopic knowledge macroscopic and making plane theory three-dimensional. From investigations of cases, whether from examining the average logon times or online time in the workshops, our experimental group was higher than control group. It is proved that there is a irreplaceable superiority of increasing the enthusiasm of users who participate in teachers' workshops which are supported by virtual reality technology, especially in the aspect of knowledge sharing. It is worth mentioning that the characteristic module of virtual experiment attracting aroused great concern from chemical teachers. Comparing with general laboratories, virtual laboratories possess advantages that improving the ability and independent inquiry of users, saving cost, simulating the hazard experiment and strengthen the memory of participants. Teachers play a role of students in the teachers' workshops, teacher's return to management roles in the individual workshop conversely, which improves the management ability of teachers in modern technology. The evaluation of teacher training in the interactive area including innovative questions and answers which not only enhances the awareness of cooperation, but also promoted the capability of communication. According to the investigation of cases, the teachers' workshops supported by virtual reality technology are more than ordinary teachers' workshops to enhance the sense of immersion and improve the enthusiasm of participants. Particularly, we employed the Kappa test to checkout the consistency of tables for knowledge quality, for improving the objectivity of results of the study. It reminds that we should increase the support of virtual experiment technology to chemistry teachers' workshops in the future, extending its advantages to all aspects of workshops to improve teachers' participation and enthusiasm. The development of teachers' workshops combine with modern educational technology would be benefited to enrich the approach of teachers' online interaction and correspond with characteristics of the chemistry, which would be a significant role to promote the direction of teacher professional development. Predictably, it is a new strategy which combining the virtual reality technology with teachers' workshop of chemistry, and it will be a change to promote the professional development of chemistry teachers.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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