Journal of Positive Psychology & Wellbeing
2022, Vol. 6, No. 2, 1826 – 1837
http://journalppw.com
ISSN 2587-0130

Learning Chemistry through Interactive Demonstration: A Pedagogical Perspective

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Abstract-

This study was carried out to determine the achievement of school students in learning chemistry. Based on a quasi-experimental research strategy, this study looks at chemistry education at the secondary level. We chose three purposively selected public schools and six selected science teachers from those schools. A simple random sample was used to pick 120 students (57 females and 63 males). Generated data from CAT and CAS were examined manually and with IBM SPSS version -21. Pre-test results showed no significant differences in student performance by group or gender. Students in the experimental group performed well on the post-test, indicating that the interactive demonstration approach effectively taught chemistry. There was no need for students to act differently based on their gender, and they were all very supportive of each other's academic success. Most pupils struggle with understanding the concept of a chemical reaction. Overall, this study's findings imply that interactive demonstration substantially impacts student achievement and that gender does not play a role in student success. Thus, the interactive demonstration method (IDM) is advocated for use in the classroom to help students learn and understand the types of chemistry they will experience in their daily lives.

Keywords- Chemistry learning, Interactive demonstration, Science pedagogy, etc.

I. Introduction

Teaching high school chemistry is exciting and challenging (Valdez, Lomoljo, Dumrang, & Didatar, 2015). Students in school can understand the idea of chemistry if they are taught with suitable methods and materials. There are many ways to teach and learn chemistry that works well. Depending on the goals and nature of the chemical concept, the right way to prepare it can be chosen. Depending on the purpose and nature of the lesson, one or more teaching methods can be used in the same class (Pattnaik, Chakradeo, & Banerjee, 2015). Different ways of teaching help students learn other skills. So, the most effective way to teach chemistry is to choose and use the proper methods and activities. The suitable techniques and exercises make it easy to get a student excited about learning. To be an effective and efficient teacher, one needs to understand how the chemistry content relates to the different ways to teach a chemistry lesson. The Secondary School Science Curriculum (SSSC) has emphasized how students teach and learn chemistry through their activities. Some of the activity-based content areas listed in the SSSC are: showing electrolysis; telling the difference between electrolyte and non-electrolyte; telling the difference between alkali and base; showing how hydrogen, oxygen, carbon dioxide, nitrogen, and ammonia are made and what their properties are; showing that chemical reactions happen at different rates; making saturated and unsaturated solutions; and looking into the kin. The teacher shows the students how to do something as part of the demonstration strategy.

Such as how to make CO2 gas, a set of equipment, or an air tie. It is a way to teach people how to do things right. This method lets the teacher show the results found when elements, compounds, chemicals, and other materials are used in experiments. For example, what happens to a white piece of fabric could be shown when the blue dye is added to water. This method is one of the most valuable teaching methods (Oladejo et al., 2014). The strategy of showing people how to do something works well for both big and small groups. The more the students participate and use their senses, the better they learn. Here are some ways a teacher can improve how they use the demonstration method in the classroom (Newby et al., 2000). They say that teachers should encourage students to use more than one sense by giving them chances to see, hear, and maybe even feel. Ideas should also be presented to get people interested. If these safety measures aren't taken well, students might be unable to participate in the demonstration. Uhumuavbi and Mamudu (2009) said that teaching by example is sensitive to the issue of gender. They noted that showing students a demonstration strategy helped their male students perform better than female students. This is a claim that needs to be checked out. Gender is also a moderating variable in this study because it is essential to determine if the treatments are sensitive to gender. Instructional strategies are ways to achieve a set of goals and objectives. The level of how well students do on internal and external exams won't improve until teachers find the right ways to help students learn the knowledge and skills they need. According to research, different kinds of students benefit a lot from being able to interact with materials, participate in activities, and manipulate objects and equipment (Carrier, 2005; Prpric & Hadgraft, 2009). Students in high school classes have many chances to be actively involved in the learning process through lab demonstrations, educational games, simulations, field trips, and other hands-on activities (Blair, Schwartz, Biswas, & Leelawong, 2007).

Duch et al. (2002) describe the demonstration strategy as an educational method that helps students "learn how to learn" by making them work together in groups to solve real-world problems. Prpic and Hadgraft (2009) discussed a demonstration strategy's essential parts. They said it shouldn't be confused with design projects or case studies, where the main focus is on using what is already known and putting it together. Teachers deal with classrooms where students have different academic and behavioral traits and are looking for more effective ways to teach and run the classroom (Tournaki & Criscitiello, 2003). As teachers are asked to do more and meet the needs of a broader range of students, research shows that schools may benefit from sitter-mediated interventions that consistently lead to academic gains (Ryan, Reid, & Epstein, 2004). Wenning (2011) made the Levels of Inquiry Model for teaching Science, and later, he explained the learning structures that go along with it. He said that by systematically addressing the different levels of inquiry learning, such as discovery learning, interactive demonstrations, inquiry lessons, inquiry labs, and hypothetical inquiry as to the inquiry spectrum (IS). One of the four stages of inquiry learning is the second stage of inquiry hierarchy, which is an interactive demonstration. So, Wenning added the idea of putting demonstrations into an activity based on the interaction that is still being made (Triayomi, 2019). Hassard and Dias (2005) explain that science education should be active, hands-on, constructivist, build on what students already know, and include group and cooperative work. Based on these instructions, a science teacher usually does an interactive demonstration by showing the activities as they say in the manual and then asking the students what they think will happen (Wenning & Khan, 2011). In an interactive demonstration model, students explain and make predictions, which allows the teacher to find, confront, and solve different ideas by addressing what the students already know (PK). So, I used an interactive demonstration as a method for classroom intervention in my study, based on Wenning (2005a). Interactive demonstrations involve students in activities that build on what they already know about a core idea. The action can be a classroom experiment, a survey, a simulation, or an analysis of secondary data. Interactive demonstrations introduce a carefully scripted activity and create a "time for telling" about classroom experiments. Because the action makes students think about what they already know about a core idea, they are ready to learn in the next interaction. Interactive demonstrations have the same three steps as other active learning methods. They are as follows;

Predict The Outcome of the Interactive Demonstration

The outcome of the demonstration is predicted individually, and then with a partner, students explain to each other which of the set of possible effects are most likely to occur. After the instructor describes the problem or shows the demonstration, students predict the result. In this step, students articulate their understanding, even if it is incorrect. Students explain their choice to a partner, changing their answers if they like. The instructor samples student answers without revealing which are correct.

Experience The Interactive Demonstration

For the experience of the demonstration, students are working in small groups. They conduct an experiment, take a survey, or work with data to determine whether their initial beliefs were confirmed or not. The demonstration can be a survey using student data, a simulation, an analysis of data from a secondary source, or a lab experiment. The demonstration may be conducted by the instructor in front of the class or by students in small groups.

Reflect on the Outcome of the Interactive Demonstration

The students think about why they held their initial belief and in what ways the demonstration confirmed or contradicted this belief. After comparing these thoughts with other students, they individually prepare a written product on what was learned. After the demonstration, the students record and report the results, identifying differences between what they predicted and what occurred in the demonstration. In the urgency to end a class meeting, it may be striking to skip the reflection step. However, research on learning shows that it is essential for students to think clearly about what they have learned, make connections to what they knew before, and identify what precisely has changed in their thinking. Also, to understand a concept deeply, students must practice using it in various contexts.

The NCF report says that for effective teaching and learning, there has been a focus on exploratory, interactive, and innovative activities. Priority has been given to teaching methods and local resources relevant to students' daily lives in their local environment. Co-curricular and extracurricular activities have been linked to improving teaching and learning, and problems with teaching and learning in Science have been taken care of. But our students don't do well in Science because they have to learn by rote memorization, and our schools haven't paid much attention to how students feel about learning and what problems they and their teachers face. So, teaching and learning have nothing to do with our everyday lives. In the same way, the research shows that the chemistry part of the Science test is more complex than physics and biology (Atagana & Engida, 2014). The students aren't interested in chemistry. They have trouble understanding chemical concepts because they don't get to talk to each other or do hands-on and mind-on experiments (Ali, 2012). Science is taught chiefly and learned through recitation and memorization by repetition. In middle and high school, it's a big problem that students don't do well in Science. So, it could be the cause of the teaching method. So, this study has tried to look at Learning Chemistry through Interactive Demonstrations: A Pedagogical Perspective as the study problem.

II. Materials and Methods

This study is based on the quantitative research methodology and is experimental (White & Sabarwal 2014). This study examines secondary school chemistry instruction through a quasi-experimental research design lens. We picked three public schools and six science educators purposively at those institutions. One hundred and twenty pupils were selected using a purely random method (57 females and 63 males). Both manual analysis and statistical analysis using IBM SPSS version 21 were applied to the concept achievement test (CAT) and chemistry attitude scale (CAS) output data. The data were analyzed using statistical tools like mean, standard deviation, Kolmogorov Simonov test, t-test, chi-square test, Charmers v, and regression.

III. Data Analysis and Interpretation

The data were tabulated and analyzed using IBM SPSS software version 21 consisting of mean, standard deviation, Kolmogorov Smirnov test, two-tailed t-test, chi-square test, charmers' v test, and regression analysis. The analysis of the Kolmogorov-Smirnov test for normality of achievement scores obtained by control and experimental group students in the chemistry of all schools are given below:

Table 1: *Analysis of Kolmogorov-Smirnov Test for Normality of Achievement Scores*

Achievements	**Kolmogorov-Smirnov[a]**			**Shapiro-Wilk**		
	Statistic	df.	Sig.	Statistic	df.	Sig.
	.101	240	.000	.970	240	.000

Note: a. Lilliefors significance correction

Analysis of the Kolmogorov-Smirnov test for normality of achievement scores was tabulated in table 5. This has degrees of freedom which equals the number of data points, namely 240. The p-value provided by SPSS (quoted under Sig. for Kolmogorov-Smirnov) is .000 (reported as $p < 0.05$). We, therefore, have significant evidence to reject the null hypothesis that the variable follows a normal distribution.

Table 2: *Analysis of Pre-test and Post-test Scores Obtained by Students Regarding Chemistry Content*

Test / Contents		**N**	**Minimum**	**Maximum**	**Maximum %**	**Mean**	**Std. Deviation**
Pre-test	Chemical Reaction	120	0	13	72.22	6.12	2.39
	Solubility	120	0	10	55.55	4.04	2.00
	Some Gases	120	0	8	57.14	3.62	1.68
Post-test	Chemical Reaction	120	3	16	88.88	8.50	3.01
	Solubility	120	1	11	61.11	6.01	2.13
	Some Gases	120	0	9	64.28	4.01	1.69

The pre-test and post-test scores obtained by students regarding Chemistry content are tabulated in table 2. It shows that the mean solubility and some gases were nearly equal, but the mean scores of chemical reactions were higher than that of the solubility and some gases in both tests. The mean scores of the post-test were more substantial than the Pretest.

Table 3: *Analysis of Pretest Scores Obtained by All Control and All Experimental Group Students*

Group	Sample size	Mean	S.D	Std. Error Mean	t-value	Remarks
Control	60	13.36	4.14	0.925	0.284	0.284>0.05
Experimental	60	14.18	3.32	0.750		

t 0.05, 118=0.284

Insignificant at 0.05 level of significance

Analysis of pre-test scores obtained by all control and all experimental Group students presented in the study table 3. This shows that there was no significant difference between the mean scores of control and experimental group students' in chemistry before treatment. It indicated that two groups were equivalent to the level of chemical concept and homogenous before the treatment. The students of both groups have to be found that the same level of prior knowledge on chemistry contents before the intervention in all schools.

Table 4: *Analysis of Pretest Scores Obtained by sex regarding all Schools*

Group	Sample size	Mean	S.D	Std. Error Mean	t-value	Remarks
Male	63	13.21	3.99	0.877	0.391	0.391>0.05
Female	57	14.49	3.59	0.813		

t 0.05, 118=0.391

Insignificant at 0.05 level of significance

The data in table 4 shows that the pre-test scores obtained by sex in all schools.

This shows that there was no significant difference between the mean scores of male and female students' in chemistry before treatment. It indicated that both male and female students were equivalent to the level of chemical concept and homogenous before the treatment. The students of both males and females have to be found that the same level of prior knowledge on chemistry contents before the intervention in all schools.

Table 5: *Cross Tab. Analysis of Chi-square Value on Pre-test Achievement Regarding sex*

Achievement	Sex		Total	Deg. of Freedom	Chi-square value	Asymp. sig.
	Male	Female				

7	1	0	1			
9	1	1	2			
10	2	0	2			
11	4	1	5			
12	0	1	1			
13	4	3	7			
14	2	1	3			
15	1	4	5	13	11.43	0.575
16	3	1	4			
17	3	1	4			
18	1	1	2			
19	0	1	1			
20	1	1	2			
25	0	1	1			
Total	23	17	40			

The level of the association on achievement scores between male and female students was measured by a cross tab. analysis of chi-square value on pre-test achievement regarding sex in school "A" is tabulated in table 5. This shows that there was no significant difference between the mean scores of male and female students' in chemistry before treatment. It indicated that there is an association between mean scores of male and female students on learning of chemical concepts.

Table 6: *Analysis of Cramer's "V" for the association on pre-test achievement regarding sex*

Sex	N	Chi-square	K	Cramer's V
Male	23	11.43	2	0.60
Female	17			

To find out the degree of the association on achievement scores between male and female students measured by analysis of Cramer's "V" for the association on pre-test achievement regarding sex in school "A" is tabulated in table 6. It indicated that there is a very strong association between mean scores of male and female students on learning of chemical concepts.

Table 7: *Analysis of Posttest Scores Obtained by All Control and All Experimental Group Students*

Group	Sample size	Mean	S.D	Std. Error	t-value	Remarks

				Mean		
Control	60	13.91	2.28	0.512	0.00	0.00<0.05
Experimental	60	21.60	3.66	0.819		

t 0.05, 118=0.00 Significant at 0.05 level of significance

Analysis of post-test scores obtained by all control and all experimental Group students presented in the study table 7. This shows that there was a significant difference between the mean scores of control and experimental group students' in chemistry due to the treatment given to the experimental group. It indicated that the students of experimental groups achieve better than the control group on learning chemical concepts in all schools.

Table 8: *Analysis of Posttest Scores Obtained by sex regarding all Schools*

Group	Sample size	Mean	S.D	Std. Error Mean	t-value	Remarks
Male	63	17.19	5.00	1.15	0.275	0.275>0.05
Female	57	18.64	4.58	1.02		

t 0.05, 118=0.275 Insignificant at 0.05 level of significance

The data in table 8 shows that the post-test scores obtained by sex in all schools. This shows that there was no significant difference between the mean scores of male and female students' on learning chemistry in the post-test. It indicated that both male and female students were equivalent to the level of learning chemical concepts in all schools.

Table 9: *Cross Tab. Analysis of Chi-square Value on Post-test Achievement Regarding sex*

Achievement	Sex		Total	Deg. of Freedom	Chi-square value	Asymp. sig.
	Male	Female				

8	1	0	1			
12	1	0	1			
13	0	3	3			
14	2	1	3			
15	1	0	1			
16	1	0	1			
17	0	3	3			
18	1	3	4			
19	0	2	2			
20	3	0	3			
21	1	1	2	19	26.11	0.127
22	0	1	1			
23	1	2	3			
24	2	1	3			
25	0	1	1			
26	1	0	1			
28	0	1	1			
29	0	1	1			
30	3	1	4			
31	0	1	1			
Total	18	22	40			

The degree of the association on achievement scores between male and female students was measured by cross tab table 9. This shows that there was no significant difference between the mean scores of male and female students in learning chemical concepts. It indicated that there is an association between mean scores of male and female students' performance on learning of chemical concepts in school "B".

Table 10: *Analysis of Cramer's "V" for the association on post-test achievement regarding sex*

Sex	**N**	**Chi-square**	**K**	**Cramer's V**
Male	18	26.11	2	0.80
Female	22			

To find out the degree of the association on achievement scores between male and female students measured by analysis of Cramer's "V" for the association on post-test achievement regarding sex in school "B" is tabulated in table 10. It indicated that there is a very strong association between mean scores of male and female students on learning of chemical concepts.

Table 11: *Analysis of Coefficients for Multiple Regressions Coefficients*

Model	**Unstandardized coefficients**		**Standardized coefficients**	**T**	**Sig.**
	B	Standard Error	Beta		
Constant	5.661	3.103		1.824	.071
Attitude	-.588	.604	-.057	-.918	.361
Sex	1.693	.663	.160	2.554	.012
Group	7.859	.667	.743	11.791	.000

a. Dependent variable: Achievements

An analysis of the statistical significance of the independent variables is given in table 11. Given that, the t-value and corresponding p-value are in the "t" and "Sig." tests tell us that the sex concerning p (.012) <0.05 and group of students' p (.000) <0.05 are significant. The predicated variables' effect on the dependent variable was found to be 5.661 achievement scores if all independent variables, attitude = 0, sex = 0, and group of students =0. That is, we would expect the average achievement scores of students were affected by 5.661 scores in the test when all predictor variables were taken to be the value 0. The unstandardized coefficients were present in the above table of the coefficient for group and sex was found to be 7.859 and 1.693 respectively. This means for every unit increase in groups, there was a 7.859 and 1.693 scores increase in achievement scores of students in the test. The beta weight measures the outcome variable increases in standard deviations when the predictor variable is increased by one standard deviation assuming other variables in the model are held constant. Hence, in this case, groups of students are the highest contributing (.743) was the predictor to explain scores in the test. The analysis of data shows that the interactive demonstration helps to enhance the achievement in chemistry contents.

IV. Result and Discussion

The interpretation carried out in terms of students' achievement in chemistry through interactive demonstration, and gender-wise achievement in chemistry.

Interactive Demonstration and Students Achievements

The t- value and chi-square value analysis of pre-test scores show that both groups were homogenous regarding group and sex before the intervention (Quantitative analysis). The determination of prior conceptions of students from the Pre-test is conceded to the theoretical literature of the constructivist learning theory. Similarly, Phillips (1995) argues that this prior knowledge affects what new knowledge of an individual will construct as the new learning experiences. Based on students' preconceptions in chemistry, an interactive demonstration manual is prepared on chemical reaction, solubility, and some gases of chemistry content of science subject. The interactive demonstration manual was based on the three components. Based on Merritts, Walter, and MacKay (2018), they are predicting the outcome of demonstrations, experiencing the demonstration, and reflecting on the outcomes. It was implemented in the experimental group and the control group intervention by the traditional method in the community school. The post-test was conducted after the experimental session of each school. Analysis of post-test scores shows that the experimental groups of each school perform better than the control group. It indicated that the interactive demonstration method was better than the lecture method. This teaching method is supportive of the students learning in the chemistry sector of science.

This result is conceded to Milne and Otieno (2007). They argued that the interactive demonstrations in science provide the beginning point for experience, intending questions, suggesting patterns, and testing those questions and patterns with specific content. It also provides the structure for interactions that focuses on support to student learning in chemistry. Similarly, Interactive demonstration is one of the stages of inquiry hierarchy from the four stages of inquiry learning. In this study, an interactive demonstration is a variable to be applied in the experimental group of students (Wenning, 2005 a). Similarly, an interactive demonstration is generally implemented by a teacher in the science classroom teaching by demonstrating the teaching activities according to the manual and then asking questions about what will happen (Wenning and Khan, 2011). Interactive demonstrations are not only used as laboratory activities but can be used as part of inquiry teaching. It introduced the implementation of demonstrations into an interactive-based activity that is currently being developed by Wenning (Triayomi, 2019). They state that students significantly understand the material better when traditional learning is combined with interactive demonstrations (Sokoloff and Thornton 1997). Based on the result mentioned by the study, I used to solve the problem by applying interactive demonstration methods in the students in chemistry learning. It enhances the better achievements of students in the chemistry sector of science subjects in the post-test.

Students Achievements in Terms of Sex

The pre-test scores obtained by sex regarding all schools show that the mean scores of the male and female students in chemistry were 13.21 and 14.49 respectively. The calculated p-value was found to be 0.391 which is greater than the 0.05 level of significance using an independent sample of a two-tailed t-test. This shows that there was no significant difference between the mean scores of male and female students' in chemistry before treatment. It indicated that both male and female students were equivalent to the level of chemical concept and homogenous before the treatment. The students of, both males and females, were found to have the same level of prior knowledge of chemistry content before the intervention in all schools. The cross tab analysis of chi-square value on pre-test measures the association level on achievement scores between male and female students. The calculated p-value was more significant than the 0.05 level of significance. This shows no significant difference between male and female students' mean scores in chemistry. It indicated an association between the mean scores of male and female students in learning chemical concepts. The study result of Demircioglu and Norman (1999) is also similar to the outcome of this study. But in contrast result insight by Chambers & Andre (1997) is the effect of gender on students'. Conceptual understanding might be attributed to the differences in prior experience, interest, and knowledge.

The degree of the association on achievement scores between male and female students was measured by analysis of Cramer's "V" for the association on pre-test achievement regarding sex in school. The calculated Cramer's V value was found to be 0.71, with the value of K is equal to 2. It indicated that there is a very strong association between the mean scores of male and female students in the learning of chemical concepts in all schools. In post-test scores were obtained by sex regarding all schools, and the calculated p-value is more significant than the 0.05 level of significance using an independent sample of a two-tailed t-test. It shows no significant difference between the mean scores of male and female students in learning chemistry in the post-test. It indicated that male and female students were equivalent in the level of learning chemical concepts in all schools. A similar result was observed by Adekoyal and Olatoye (2011) in part on the gender issue of their study. My teaching-learning and field experience also shows no different results existed between students' achievement in learning chemistry and gender status. But in contrast, the result is inlighted by the study of Cetin et al. (2009) and Bunce & Gabel (2002) for the favor of male and female students in learning chemistry.

Similarly, the cross tab measures the level of the association on achievement scores between male and female students. Analysis of the chi-square value on post-test achievement regarding sex shows that the calculated p-value was found to be 0.399, which is greater than the 0.05 level of significance of the chi-square test. The null hypothesis was accepted. It shows no significant difference between the mean scores of male and female students in learning chemical concepts. It indicated an association between mean scores of male and female students' performance in learning chemical concepts. The degree of the association in achievement scores between male and female students was measured by analysis of Cramer's "V". The association in post-test achievement regarding sex shows a strong association in gender status. There is no significant effect of gender status on students' chemistry achievement.

V. Conclusion

The data from the pre-test demonstrate that both the experimental and control groups had similar levels of chemical knowledge before treatment. A post-test given to both groups of students indicates that the experimental group benefited from the interactive demonstration method used to teach chemistry. Therefore, the interactive demonstration method is effective for learning chemistry. There was no difference in students' performance depending on gender among either male or female students. Chemical reactions as a concept are widely understood by students and do well on tests. To help students who are having trouble learning chemistry, teachers should employ interactive demonstration methods, recognize and address students' concerns about the subject's complexity, and use appropriate teaching resources.

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