

New Perspectives on Activity-Based Chemistry Learning through Meaningful Engagement: Mystical Improvement in Students' Achievement

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ABSTRACT

The study explored the effect of activity-based chemistry instructional techniques on the achievement of eighth-graders in public schools of Nepal. It focuses on activity-based teaching of the topic *filtration* compared to traditionally practiced chalk and talk methods. In this study, a pre-test, post-test control group, a quasi-experimental design was used. A Chemistry Achievement Test (CAT) was applied to eighty students of four basic level community schools located in Kirtipur, Kathmandu, Nepal. Three research questions and three research hypotheses were generated and tested at 0.05 level of significance. The data collected were analyzed using mean and standard deviation while independent t- test was used to test the hypotheses. To measure the reliability coefficient of CAT, Cronbach alpha was applied which was found 0.642. Results showed that students under the experimental group facilitated by activity-based chemistry instructional techniques performed significantly better than those taught by chalk and talk methods. It also showed that activity-based chemistry learning encourages students' independent and inquisitive learning by self-investigation and analysis of the situation. It is recommended from this study that activity-based learning is more beneficial for students' engagement in chemistry lessons in the community schools of Nepal.

Keywords: Activity-based learning, Engagement, Filtration, Chemistry achievement test.

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Highlights of this paper

- The study explored the effect of activity-based chemistry instructional techniques on the achievement of eighth-graders in public schools of Nepal.
- It focuses on activity-based teaching of the topic *filtration* compared to traditionally practiced chalk and talk methods.
- It is recommended from this study that activity-based learning is more beneficial for students' engagement in chemistry lessons in the community schools of Nepal.

1. BACKGROUND OF THE STUDY

The knowledge of chemical concept is important in increasing scientific literacy among the Nepalese citizen. General literacy is different from the scientific literacy in terms of modification of habit and behavior of people while working in the kitchen, choose healthy food items, healthy eating habits, adopt personal hygienic habits and to understand the general but important aspects of day to day life spheres. Connecting the views of scientific areas of understanding (Dale and Newman, 2005) argues that scientific literacy helps to meet the target of sustainable development goals by the behavior modification of the citizen after having the knowledge of basic chemical concepts. In relation to these facts, the curriculum development centre of science and environment subject under the Ministry of Education (MoE), Nepal made chemistry as a compulsory subject at the school level. Chemistry is made integrated with biology, physics, astronomy and geology in the basic level science course. According to the Ridwan *et al.* (2018) chemistry is an important subject for the school level students to develop scientific literacy. It is important to deliver the knowledge of chemical concepts among the learners to enable to make them scientifically literate citizen in the future that need to develop the skills and changes the attitude and behavior modification for healthy living. But it is difficult to transform the knowledge of basic chemical concepts from adoption the knowledge of chemistry to the knowledge generation in chemistry in new perspective.

Furthermore, Ridwan *et al.* (2018) argued that it is a challenge for teachers to transform the knowledge of chemistry for their learners. However, students in our school system are facing a number of problems to understand the chemical concepts through lecture method of teaching and book recitation in everyday classroom practices. Due to this factors the achievement of students in school level chemistry is very low (Acharya, 2017; Kousa *et al.*, 2018). This may be the disconnection between students' activities and chemistry curriculum in day to day life activities.

Many research studies claim that science teachers may have been poorly taught (Osefugbo, 1998; Fischer *et al.*, 2018). Another study found out that school science teachers have been poorly taught (Osefugbo, 1998). Researchers like Osefugbo strongly claim that the strong index that unqualified teachers may not be conversant with modern pedagogical approaches which may have contributed poor performance of school children in chemistry. Activity-based chemistry instructional technique is viewed as the use to gear up in chemistry in learning in order to facilitate students to understand the basic concept of chemistry. It might help by letting students to engage in activities for chemistry learning to understand the basic chemical concepts. Scientific achievement is the way to conceptualize the concept of chemistry through hands-on activities (Williams *et al.*, 2018). Connecting the views of Williams, Brule, Kelley, & Skinner and Nworgu, it is argued that a better performance of students may be due to upgrade the content of the curriculum, use of locally available instructional materials, and recruitment of qualified and committed science teachers with the recent methodological approaches, having the class and laboratory management skills.

In this research study, the term institution position means the location of basic level community schools within the study locality. Some schools are in the properly located in the city areas whereas two are in the rural areas. But, both are in located in the Kirtipur municipality of Kathmandu valley. The role of gender is also one of the important variables considered in this study. In the context of newly Federal Nepal, gender has become an immerging issue

some years back. As Nepalese parents are in the stage of sending their daughters in the school, gender is now became a new and focus for the researchers to uplift their socio-economic, educational and livelihood status. As a researcher, my assumption is the role of school girls is most to understand the chemical concepts for the overall development of the family and the community. It ultimately starts from the classrooms. Connecting this scenario, [Kang et al. \(2019\)](#) advocated that difference in sex and how the quality of life affects their personalities and perception towards being and academic achievement. Gender disparity is one of an important and common problem in classrooms. To favour this line, [Jimoh \(2004\)](#) suggests that boys are performing better than girls in reasoning and thinking skills development. It indicates that the bond between gender and their learnability is strongly associated. [Cheung \(2009\)](#) conducted a comprehensive review of the literature regarding gender issues related to chemistry education. The finding of the study suggests that girls had a more favourable attitude towards studying chemistry than boys. However, the study done by the [Subagia and Wiratma \(2017\)](#) shows that there is no significant difference in chemistry achievement between boys and girls in chemistry. I hope that this research study will certainly, authenticate the reliability of the assertions of these researchers.

Research carried out by [Acharya \(2019\)](#) showed that instructional techniques have great roles for a significant outcome of education if students are employed on hand-on activities followed by mind-on inquiry approaches in chemistry classrooms. Chemistry teachers are expected to make chemistry more relevant, enjoyable, easy and meaningful to students in order to make the students creative and technologically inclined ([Jack, 2017](#)). Understanding poorly in chemical concepts is the result of the application of chalk and talk method of chemistry instruction. It is supposed by the finding of [Nwosu \(2010\)](#) and [Acharya \(2016\)](#) who said that teaching of chemistry can only be outcome oriented if pupil are favourably exposed to an appropriate instructional techniques like learning by doing ([Jack, 2017; Acharya, 2018](#)).

2. PROBLEM STATEMENT

Most of the school children in Nepal are facing problems in chemistry learning. They do not understand the basic chemical concepts as the orientation of teaching and learning is traditional that is based on chalk and talk method of teaching. The overall achievement of science is below the policy expectation ([Acharya, 2017](#)). Experts of science education in Nepal are worried that students performed poorly in chemistry. Most of them leave to answer the chemistry portion in their examination. They experienced that chemistry is a volatile subject as they forget it within a week when the class is over. It is due to the lacking of connection of chemical concepts to daily life activities. Low chemistry achievement among school children is became the indicator that the learning of chemistry in Nepal is profusely disappointing. As a result, the teaching and learning of chemistry have become a difficult job to science teachers from the history of the Nepalese education system. It results in the decline in the pass rate of students in Secondary Education Examination (SEE) in science subject on the one hand and low enrollment of students in science and technology education in the university level studies on another.

This study attempts to progress the academic achievement in school level chemistry by applying the activity-based instruction and suggesting policymakers and curriculum designers to incorporate the techniques of hands-on activities while teaching chemistry. In the connection of this statement, [Achimugu \(2018\)](#) argued that student-centered instructional techniques for improving chemistry learning will ensure quality education to enable students to meet with scientific and technological literacy to challenges the 21st century skills. The main concern is that, the use of outdated and conventional chalk and talk method of teaching chemistry has not been able to address the low academic achievement of students. As the student of science education and a researcher, I raised a question in this position would the use of activity-based instructional technique has any positive effect on students' academic

achievement in chemistry? This is the gap that this study intends to find empirically among the basic level community school students in Kirtipur municipality of Kathmandu valley, Nepal.

I limited this research within the eighth graders of four community schools by using an activity-based pedagogical approach in the teaching topic 'filtration' filtration from the chemistry portion of science curriculum. process. The findings of this study will be useful to design the chemistry curriculum for the school level integrated science, chemistry teachers to adopt activity-based pedagogical approach and students to improve the academic achievement in chemistry subject. It will ultimately help to uplift the scientific literacy of school children by understanding the basic concept of chemistry.

3. RESEARCH OBJECTIVES

To find out the effectiveness of activity-based instruction of students of grade eight in chemistry achievement. To determine the mean achievement scores taught by activity-based and chalk and talk method of instruction.

To compare the mean achievement score of boys and girls in chemistry taught by activity-based instruction and the chalk and talk approach of teaching.

4. HYPOTHESES

Following hypotheses were formulated to test at 0.05 level of significance:

HO₁: There is no significant difference in the mean achievement scores of eighth-graders in the experimental and control group.

HO₂: There is no significant difference in the mean achievement scores of boys and girls in the control and experimental group.

5. METHODOLOGY

The design of the study is pretest-posttest non-randomized control group design (quasi-experimental). The study was carried out in four selected basic level community schools in Kirtipur municipality of Kathmandu valley, Nepal. To carry this study, eighty students studying in grade eight selected randomly among the total schools within the municipality.

The sample consists of eighty students which were selected randomly from the four sampled basic level community schools. The main tool to collect the data was the Chemistry Achievement Test (CAT). CAT was designed the multiple choice questions with a statement and four distractors with only one correct answer. To ensure the validity of the CAT, the content of the filtration of grade eight is checked by matching with the curriculum through content analysis.

To test the reliability of the measuring tool conducted using a trial testing, piloting it on one of the community school located at Kirtipur in the similar setting of the sampled schools.

The instrument reliability coefficient gotten through the use of Cronback's alpha was 0.642 and ensures the internal consistency of the instrument used. Thus, the instrument was deemed reliable for use in this present study.

5.1. Data Collection

Eighty achievement test papers on Chemistry Achievement Test (CAT) items were administered at grade eight of four (twenty from each) community schools. CAT items were collected by myself and administered to input data on SPSS tabulation during pre-test and post-test examinations. The data collected were analyzed using the statistical tools of mean scores, standard deviations and independent t-test.

6. RESULTS

The result of the study is based on the objectives of the study in sequence. The objective is to determine the mean achievement scores taught by activity-based and chalk and talk method of instruction.

Table-1. Achievement scores of effectiveness of activity-based instruction in experimental and control groups.

	Experimental group			Control group			
	N	\bar{x}	SD	N	\bar{x}	SD	
Pretest	20	12.30	3.42	Pretest	20	8.11	2.14
Posttest	20	18.59	4.69	Posttest	20	9.27	2.78

Source: Field data $t_{0.05, 18} = 2.101$ 0.05 level of significance.

Table 1 shows that students in experimental group obtained a mean score of 12.30 in the pretest and 18.59 in posttest. On the other hand, the students in the control group had the mean scores of 8.11 and 9.27 as pretest and posttest respectively. This underscored that the students in the experimental group achieved higher than those in the control group in the chemistry achievement test.

The third objective is to compare the mean achievement score of boys and girls in chemistry taught by activity-based instruction and chalk and talk approach to teaching.

Table-2. Achievement scores of effectiveness of activity-based instruction in experimental and control groups of boys.

	Experimental group (Boys)			Control group (Boys)			
	N	\bar{x}	SD	N	\bar{x}	SD	
Pretest	20	10.47	2.53	Pretest	20	6.90	1.58
Posttest	20	15.45	3.89	Posttest	20	8.39	2.65

Source: Field data, $t_{0.05, 18} = 2.101$ 0.05 level of significance.

Table-3. Achievement scores of effectiveness of activity-based instruction in experimental and control groups of girls.

	Experimental group (Girls)			Control group (Girls)			
	N	\bar{x}	SD	N	\bar{x}	SD	
Pretest	20	12.41	3.36	Pretest	20	8.90	3.01
Posttest	20	18.10	4.73	Posttest	20	11.31	3.27

Source: Field data, $t_{0.05, 18} = 2.101$ 0.05 level of significance.

Data in Table 2 showed that boys in the control group obtained a mean score of 6.90 in the pretest and 8.39 in the posttest. Similarly, in the experimental group, pretest mean score of boys was 10.47 and that of the posttest was 15.45. On the other hand, the girls in the Table 3 shows good achievement mean scores than boys in both the pretest and posttest of control and experimental groups. The highest mean scores of girls in the posttest was 18.10 out of the total score of 20. These Table 2 and Table 3 clearly show that girls performed higher than their boys in the experimental and the control group in the chemistry achievement test.

The first objective is to find out the effectiveness of activity-based instruction of students of grade eight in chemistry achievement. The analysis of the data clearly shows that activity-based science teaching and learning by the engagement of students in doing activities during the chemistry learning is far better than that of chalk and talk method of teaching.

The scores of both the boys and girls were found better in the posttests but the value of the posttest in the experimental setting was dramatically increased in all the cases. It clearly indicates that involving students in hands-on activities in the filtration process from the very beginning of the process such as the collection of sand particles, mud, filter papers, funnel, tripod stand, beakers and glass rods help to understand the process of filtration. Students learnt the basic level chemical concepts by meaningfully engaging in the activities in groups.

The research hypothesis of the study was also tested in both the groups among boys and girls. The first hypothesis was that there is no significant difference in the mean achievement scores of eighth-graders in the experimental and control group.

Table-4. t-value between the experimental and control groups.

Instructional techniques	N	\bar{x}	SD	t-value
Experimental group	20	18.59	4.69	3.42
Control group	20	9.27	2.78	

Source: Field data, $p < 0.05$; $df = 39$; critical value 1.69.

Table 4 clearly shows us that the calculated t- value (3.42) which is greater than the critical value (1.69), the null hypothesis is thus rejected. Therefore, there is a significant difference in the mean achievement scores in chemistry taught by chalk and talk method and activity-based instruction.

The second hypothesis was that there is no significant difference in the mean achievement scores of boys and girls in control and experimental group.

Table-5. t-value between the experimental and control groups.

Instructional techniques	N	\bar{x}	SD	t-value
Experimental group	20	15.45	3.89	2.17
Control group	20	8.39	2.65	

Source: Field data $p < 0.05$; $df = 39$; critical value 1.69.

This Table 5 clearly shows us that the calculated t- value (2.17) which is greater than the critical value (1.69), the null hypothesis is thus rejected. Therefore, there is a significant difference in the mean achievement scores in chemistry taught by chalk and talk method and activity-based instruction among boys.

Table-6. t-value between the experimental and control groups.

Instructional techniques	N	\bar{x}	SD	t-value
Experimental group	20	18.10	4.73	2.01
Control group	20	11.31	3.27	

Source: Field data $p < 0.05$; $df = 39$; critical value 1.69.

This Table 6 clearly shows us that the calculated t- value (2.01) which is greater than the critical value (1.69), the null hypothesis is thus rejected. Therefore, there is a significant difference in the mean achievement scores in chemistry taught by chalk and talk method and activity-based instruction among girls.

7. RESULT SUMMARY

Major findings of the study are the applications of activity-based instructional techniques have positive effects on the mean achievement score of students in basic level community school chemistry learning. Another interesting result is related to the gender in which girls in the community schools are more active than boys during the chemistry practical activities which improve their learning achievements.

It indicates that the role of gender is one of the important variables under study throughout Nepal to improve chemistry achievement. Encouraging students to do physical and mental activities in the learning process help to develop the skills with the gaining of information. Knowledge obtained through personal experiences by hands-on activities makes the learning meaningful.

Activity-based chemistry learning encourages students independent and inquisitive by self-investigation and analysis of the situation. Students in this research while doing activities in the filtration process develop the habit of thinking independently, critically based on their own experiences. It improves their learning achievement.

Working students in groups support social qualities such as cooperation, team works and social skills. It ultimately improves the social life of the community people. Activity-based science learning encourages students with the opportunity to express what they understood through the act of doing.

8. DISCUSSIONS AND CONCLUSION

Mean achievement scores of the effectiveness of activity-based instruction in experimental and control groups among 8th graders experimental group obtained a mean score of 12.30 in the pretest and 18.59 in the posttest. On the other hands, the students in the control group had the mean scores of 8.11 and 9.27 as pretest and posttest respectively. This underscored that the students in the experimental group achieved higher than those in the control group in the chemistry achievement test.

Since the calculated t- value is greater than the critical value statistically it is clear that the null hypothesis is thus rejected. Therefore, there is a significant difference in the mean achievement scores of chemistry students taught by using activity-based chemistry instruction in filtration process. The result of this study is related to the study done by [Achimugu \(2018\)](#) who found that less achievement score in chemistry is the result of using the lecture method of teaching.

This finding is also in line with the work of [Nwosu \(2010\)](#); [Acharya \(2019\)](#) and [Acharya et al. \(2018\)](#) agreed that the teaching-learning activities in science can only be the result oriented when students are favourably exposed to suitable instructional methods in school level chemistry learning.

Data in [Table 2](#) shows that boys in the control group obtained a mean score of 6.90 in the pretest and 8.39 in posttest. Similarly, in the experimental group, the pretest mean score of boys was 10.47 and that of the posttest was 15.45. On the other hand, the girls in the [Table 3](#) shows good achievement mean scores than boys in both the pretest and posttest of control and experimental groups. The highest mean scores of girls in the posttest were 18.10 out of the total score of 20.

These [Table 2](#) and [3](#) clearly shows us that girls performed higher than their boys in the experimental and the control group in the chemistry achievement test. Since the calculated t- value is greater than the critical value, the null hypothesis is thus rejected. Therefore, there is a significant difference in the mean achievement scores of boys and girls in the experimental group.

To connect the finding of the study, the result explored by [Cheung \(2009\)](#); [Acharya \(2018\)](#) and [Acharya et al. \(2019\)](#) advocated that girl students have a positive attitude towards learning chemistry than boy students. Both these result show that the girls have the positive attitude than boys to learn chemistry by hands-on activities and attitude as also a determining factor of good achievement in school level chemistry.

From the findings of the study, it is concluded that activity-based chemistry learning has facilitated students' achievement in basic level community schools in Nepal. Students who were facilitated using activity-based chemistry instructional technique achieved significantly higher than those who were taught with chalk and talk methods of teaching.

This certainly predicts that the students in the experimental group had a better grasp of the basic chemical concepts than the teaching students simply by using the chalk and talk approach. For this reason it is important to apply activity-based chemistry instructional techniques to improve the achievement scores in chemistry in the community school education in Nepal.

9. IMPLICATIONS OF THE STUDY

The results of this study have numerous implications for the field of science education to reform and transform the quality of chemistry education in teaching and learning in the community schools of Nepal. Overall, the results show that the applications of hands-on activities through students' meaningful engagement have the positive effect to improve the achievement scores. Second, results suggest the transformation of science teachers' activities in the classroom from chalk and talk method to activity-based approaches to teaching chemistry.

To catch the current movement/issue of learning by gender in the context of Nepal can also be addressed by this study. In relation with this issue, the study suggests that to design practical activities for chemistry learning by motivating boys for the school level teaching and learning. The finding of this study illustrates an important issue in the continuing discourse over the influence of transformation in chemistry learning on students learning. More researchers have been published and supported for the ineffective of transformation in school level learning, notably Irani *et al.* (2001), Tobin (2011), Reigeluth (2004). However, Widodo *et al.* (2019) argued that unsuitably discovery learning with controlled inquiry methods that actually include guidance from the teacher.

10. RECOMMENDATIONS

On the basis of the findings, I would suggest the followings for the recommendation for the transformation of learning chemistry in the school education in Nepal. Activity-based chemistry instructional technique should be employed by engaging students in hands-on activities.

The tradition of chalk and talk method of learning does not encourage chemistry learning. So, students need to be encouraged by arranging simple experiments to provide the basic chemical concepts of chemistry. It is also recommended that the teachers' professional development packages need to be designed by giving priority for hands-on activities and to engage students throughout the lecture hours.

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REFERENCES

- Acharya, K.P., 2016. Fostering critical thinking practices at primary science classrooms in Nepal. *Research in Pedagogy*, 6(2): 1-7. Available at: <https://doi.org/10.17810/2015.30>.
- Acharya, K.P., 2017. Science teachers' information processing behaviours in Nepal: A reflective comparative study. *Research in Pedagogy*, 7(1): 1-6. Available at: <https://doi.org/10.17810/2015.43>.
- Acharya, K.P., 2017. Exploring critical thinking for secondary level students in chemistry: From insight to practice. *Journal of Advanced College of Engineering and Management*, 3(1): 31-39. Available at: <https://doi.org/10.3126/jacem.v3i0.18812>.
- Acharya, K.P., 2018. Hands-on, minds-on and hearts-on activities in high school science teaching: A comparison between public and private schools in Nepal. *The Online Journal of New Horizons in Education*, 8(2): 51-57.

- Acharya, K.P., 2019. Inquiry-based science learning through school gardening activities: Wonderful experience through participatory action research. *International Journal of Elementary Education*, 7(3): 40-45. Available at: <https://doi.org/10.11648/j.ijeeedu.20180703.11>.
- Acharya, K.P., B. Devkota, C.B. Budhathoki and A.P.B. Bjonness, 2018. Relevance of learning science through inquiry based participatory action research in basic public schools of Nepal: A proposal. *The Online Journal of New Horizons in Education*, 8(4): 87-97.
- Acharya, K.P., R. Rajbhandary and M. Acharya, 2019. (Im) possibility of learning science through livelihood activities at community schools in Nepal. *Asian Social Science*, 15(6): 88-95. Available at: <https://doi.org/10.5539/ass.v15n6p88>
- Achimugu, L., 2018. Effectiveness of enriched demonstration and lecture instructional strategies on senior secondary school students' achievement in chemistry. *Journal of Contemporary Educational Research*, 2(1): 1-9. Available at: <https://doi.org/10.26689/jcer.v2i1.246>.
- Cheung, D., 2009. Students attitudes toward chemistry lessons: The interaction effect between grade level and gender. *Research in Science Education*, 39(1): 75-91. Available at: <https://doi.org/10.1007/s11165-007-9075-4>.
- Dale, A. and L. Newman, 2005. Sustainable development, education and literacy. *International Journal of Sustainability in Higher Education*, 6(4): 351-362.
- Fischer, C., B. Fishman, C. Dede, A. Eisenkraft, K. Frumin, B. Foster, F. Lawrenz, A.J. Levy and A. McCoy, 2018. Investigating relationships between school context, teacher professional development, teaching practices, and student achievement in response to a nationwide science reform. *Teaching and Teacher Education*, 72: 107-121. Available at: <https://doi.org/10.1016/j.tate.2018.02.011>.
- Irani, Z., A.M. Sharif and P.E. Love, 2001. Transforming failure into success through organisational learning: An analysis of a manufacturing information system. *European Journal of Information Systems*, 10(1): 55-66. Available at: <https://doi.org/10.1057/palgrave.ejis.3000384>.
- Jack, G.U., 2017. The effect of learning cycle constructivist-based approach on students academic achievement and attitude towards chemistry in secondary schools in North-Eastern part of Nigeria. *Educational Research and Reviews*, 12(7): 456-466.
- Jimoh, A.T., 2004. Influence of gender difference of students achievement in chemistry. Available from <http://www.Unilorin.edu.ng/ejournas> [Accessed June 20, 2011].
- Kang, H., A. Calabrese Barton, E. Tan, S.D. Simpkins, H.-y. Rhee and C. Turner, 2019. How do middle school girls of color develop STEM identities? Middle school girls participation in science activities and identification with STEM careers. *Science Education*, 103(2): 418-439. Available at: <https://doi.org/10.1002/sce.21492>.
- Kousa, P., R. Kavonius and M. Aksela, 2018. Low-achieving students' attitudes towards learning chemistry and chemistry teaching methods. *Chemistry Education Research and Practice*, 19(2): 431-441. Available at: <https://doi.org/10.1039/c7rp00226b>.
- Nwosu, A.C., 2010. Causes of poor academic performance of chemistry students. *Nigerian Journal of Issues in Science Education*, 1(1): 35-37.
- Osefugbo, I., 1998. The correlation between students' performance in mock and GCE ordinary level examination in science subjects in some selected senior secondary schools in Kano metropolis. Unpublished B. Ed Thesis, A. B. U, Zaria.
- Reigeluth, C.M., 2004. Chaos theory and the sciences of complexity: Foundations for transforming education. In *Annual Meeting of the American Educational Research Association*, San Diego, CA.
- Ridwan, A., Y. Rahmawati and T. Hadinugrahaningsih, 2018. STEAM integration in chemistry learning for developing 21st century skills. *MIER Journal of Educational Studies, Trends and Practices*, 7(2).

- Subagia, I.W. and I.G.L. Wiratma, 2017. The quality of chemistry learning process viewed from learning outcome indicators and process of teaching. In 2nd International Conference on Innovative Research Across Disciplines (ICIRAD 2017). Atlantis Press. Available from: <https://doi.org/10.2991/icirad-17.2017.25>.
- Tobin, K., 2011. Global reproduction and transformation of science education. *Cultural Studies of Science Education*, 6(1): 127-142. Available at: <https://doi.org/10.1007/s11422-010-9293-3>.
- Widodo, R.P.A., L. Lisdiana and M. Nuswowati, 2019. Development of teaching materials based on discovery learning on science lessons with addictive and psychotropic themes in middle school. *Journal of Innovative Science Education*, 8(1): 184-194.
- Williams, D.R., H. Brule, S.S. Kelley and E.A. Skinner, 2018. Science in the learning gardens (SciLG): A study of students motivation, achievement, and science identity in low-income middle schools. *International Journal of STEM Education*, 5(1): 8. Available at: <https://doi.org/10.1186/s40594-018-0104-9>.

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