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Prototype learning activities: Road map to academic achievement

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Abstract.

The study of prototype learning activity has received significant attention to elevating students' academic performance. This study utilized the prototype learning design as a significant predictor of students' performance and the like. In addition, this study aimed to explore teachers' strategies for measuring students' creative growth utilizing authentic assessments. Moreover, this study used a survey to assess the perception of the students and teachers. The study used the quantitative inferential which provides the relationship between the two variables' effectiveness and perception of the prototype learning activities. The main instrument used to ascertain these parameters are the two survey questionnaires was researcher-made align with the Department of Education Science competency, the reliability and consistency were validated by the statistician. Results revealed that students' performance was at a high level when engaged in the prototype learning activity. Furthermore, the perception of the students and teachers in terms of ease of use, relevance, and comprehensibility indicates positive perception in relation to the student's performance. Finally, the prototype-based learning approach shows a promising effect on the performance of the student's and teachers' perceptions. Hence, enhancement training in developing a teacher's capacity to design meaningful learning that caters students' needs should be provided.

Keywords: Prototype learning; performance; academic achievement

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1. Introduction

The 21st-century education has become increasingly complex. The way educators teach and students learn is different from the classical context. However, the complexity of learning science the same in mathematics leads to poor performance. Yoon (2013) suggested that a core activity of learning science is to improve learning and implement these in real-world educational environments. Solomon (2017) emphasized that Chemistry being the branch of science is a very important course of study which does not only stand as a scientific study but also very essential for the development of any nation. Similarly, Nbina (2012) stated that the role of chemistry in the development of the scientific base of a country cannot be overemphasized. Aluko (2008) pointed out that chemistry as a branch of science is highly important in modern societies because of its requirement as a prerequisite to the study of many other science-oriented courses. A previous study of Adesoji an Olantubosun (2008) observed that within the context of science education, chemistry has been known and identified as very important subject that leads to the advancement of scientific development across the world. The scholars argued that effective teaching in science subjects could lead to advanced development. Simon (1996) addressed that designing a future is fundamentally different from describing and explaining the present. Consequently, it becomes important that success in chemistry and in science should generally be of high quality, thus the greatest challenge lies in the entire education system.

Poor output in chemistry as a field of science has, however, emerged considerably. Scholar Saage (2009) argued that it is surprising that the performance of the students in internal and external chemistry exams remained considerably low despite the relative importance of chemistry It also received little attention in chemistry education, despite the fact that design is a fundamental activity in the chemical discipline (Talanquer, 2013). However, design-based learning does include a much-needed approach to practical chemistry teaching (Sevian & Talanquer, 2014; Van Aalsvoort, 2000). Although, it was shown that Chemistry has significantly affected the development of our country. Nevertheless, the efforts made by teachers to enhance students' performance in chemistry and sciences, in general, are still low (Edomwonyi-Out & Avaa, 2011). In addition, the study of Muzah (2011) showed that poor performance in science subjects is a threat to education.

Moreover, education is facing great challenges in the Philippines today. One such obstacle relates to science education. Trends in Mathematics and Science Study, NCES (2013), out of 46 participants the Philippine students ranked 43rd in mathematics. This has been even more disturbing and deteriorating evidence about the growth of our nation. Several factors have been advanced to affect students'poor performance. Majo (2016) stated that there are lots of factors lead students' poor performance in science subjects (e.g., lack of teaching and learning materials, etc.). Several scholars also agree that teachers' factors contribute to students' performance such as inadequate instructional materials and poor teaching methods (Usman and Memeh, 2007). Additionally, Oladejo (2011) claimed that with appropriate instructional materials and Successful implementation will make the teaching of science subjects more relevant and efficient. Although teachers' ideas on teaching and learning are understood to influence the implementation of educational reforms (Jones & Carter, 2007; Van Driel, Beijaard, & Verloop, 2001), little is known about the views of Chemistry teachers on incorporating design practices into their subject matter. But influential scholars have found that design-based learning in chemistry education can enhance learners' comprehension of basic ideas in chemistry (Apedoe, Reynolds, Ellefson, & Schunn, 2008; Meijer, Bulte, & Pilot, 2009), and the real-world problem-solving abilities of students (Fortus, Krajcik, Dershimer, Marx, & Mamlok-Naaman, 2005).

However, the literature contains the greatest obstacle in the teachers' hands as to how to address this gap in education. Aluko (2008) the responsibility of teachers is to help students attain maximum achievement. For many years, researchers have been striving to find the right solutions to the problem. Several scholars such as Conlin et al. (2015) found out that design thinking using prototype learning activities could enhance learning especially to the low performer students. Bautista (2015) & Pappas (5015) found out that those students that experience prototype-based learning performed better and the significant relationship has been seen as a predictor of academic performance. While researchers have begun studying how to design effective learning activities play out in the classroom, there is still little research for K-12 students (Razzouk & Shute, 2012).

The promising effect of prototype learning activities to enhance student's academic performance is found significant based on the literature. However, to the best of our knowledge, there no studies thus far have specifically examined the promising effect of prototype-based learning in teaching a chemistry subject. In fact, very few studies (e.g., Bautista, 2015) have even investigated the learning impact of self-paced learning prototype in optimizing classroom instruction towards students' learning in Chemistry. Similarly, Evangelista et al. (2014) attempt to design a method to create prototype learning materials in teaching science subjects to enhance the academic performance of the students.

Thus, the researchers aim to investigate the performance of the students using prototype learning activities, and 2) Perceptions of teachers and students as to comprehensibility, ease of use, and relevance of the prototype learning activities. Addressing these important factors may contribute to improved effectiveness of our educational system.

Prototype Learning Activity

A prototype is a concrete model of a rough idea. According to Berglund & Leifer (2013) in both cases prototyping is an important enabler for the creation of iterative loops of new information through social networking and team-based communication. The deeper degree of cognitive attachments to prototyping offers an explicit connection between implicit embedded awareness and its consequences for objective learning. Malamed (2018) stated that through prototype learning activity you can communicate how something will work to others who have no idea what you are talking about. In addition, this design can be implemented as a tool for learners to gain awareness of the chemical content (Fortus et al., 2004). The importance of students creating design methods like identifying the problems' and finding solutions' have been gaining in popularity in the advent science education (NGSS, 2013). These chemistry curricula can also provide a few different reasons for involving Chemistry students in design thinking. In addition to the above views, design practices in chemistry education can also be found in the form of 'concept models' (e.g. Chang, Quintana, & Krajcik, 2010), and as teaching approaches to research, synthesis, and transformation practices (Sevian & Talanquer, 2014). Dam and Siang (2020) noted that prototyping is an important part of design thinking and user experience design in general, because it allows us to rapidly test our ideas and refine them in a timely manner. Moreover, research suggests that the process prototyping reframes failure as an opportunity for learning by minimizing the affective impact of mistakes or setbacks (Carroll et al., 2010; Gerber & Carroll, 2012; Sadler et al., 2000). According to Berglund and Leifer (2013) .The prototypes are designed, produced, presented and interpreted differently by individuals according to their understanding and framework. It is also transforming thoughts into concrete manifestations. In addition, prototypes activate mechanisms of cognitive association related to perception, prior knowledge, and interpersonal communication in ways that facilitate iterative learning among peers within the product development community. Edelman (2011) noted that prototypes are categorized differently between scholars, either using three dimensions: physical – tangible, analytical – virtual, and experiential – behavioral; or two-dimensional: physical and analytical (Ulrich & Epinger, 2007). The exception in experiential – behavioral simulations communicates behavioral representations that could disrupt conventional and defined behavioral patterns.

Based on the above discussions, we used to design and prototype-based learning for the following reasons. The first is to enhance the learning environment of teaching science. Second, previous literature has suggested that it promotes active and relevant interactions for students. Third, prototype-based learning promotes interactive learning that leads to effective learning.

2. Methods

3.1 Research Design

In quantitative-inferential, it aims to make judgments of the probability that an observed difference between groups is a dependable one or one that might have happened by chance in this study. Thus, we use quantitative-inferential to make inferences from our data to more general conditions; we use descriptive statistics simply to describe what's going on in our data (Trochim, 2020). This is an effective approach for evaluating the relationship between two variables and analyzing the learning behaviors and expectations of prototypes. In addition, both variables were given equal chances of being seen on the respondents and checked for sense with presence from the other. Pearson moment correlation "r" formula (Wersma, 2000) was used to analyze the data. All the statistical analysis was done at .05 level of significance and the effect size were also considered in the interpretation of the data results. Since the SAT scores were compared with the academic average of the aforementioned students and correlation does not necessarily allow more than 2 variables to be measured concurrently, each SAT score would be correlated to the academic average. Both variables were given equal chances of being seen on the students and checked with presence from the other for significance. Furthermore, the hypothesis is suggested: there is no significant difference between the perceptions of the two groups and the effectiveness of variables and no relationship between the perception of the students on effectiveness and results and the above-mentioned outcome variables.

3.2 Sampling and Instrument

The participants included 200 junior high school students and 2 teachers from public schools located in Southern Philippines. The school is also considered a big school and is a lead-school of the municipality of Consolacion where almost all of the events and contests both academic and non-academic in different subject areas are held. The only instrument used to ascertain these parameters are the two survey questionnaires for the end-users, two for the pupils, and one for the teachers. First, the questionnaire was researcher-made align with the Department of Education Science competency, the reliability, and consistency was validated by the statistician, with a Cronbach's alpha of 0.78. The second questionnaire was Secondary School Science Questionnaire was adopted from Kendzierski (1991) this instrument determines the perceptions of the students using prototype learning activities. The acceptability level was measured using a 4-point Likert Scale gauging the degree of agreement of the respondents on the indicators presented in the questionnaire. After the conduct of the study, data were then tallied, tabulated, and analyzed.

3. Results

Our report of results is organized into two sections. First addresses the research question (students' performance in second quarter competencies) and second addresses the (perceptions of the students and teachers).

Table 1. Students Performance Statistics (N=200)

Competency	Mean	Std. Deviation
Properties of metals in terms of their structure	4.00	0.70
Formation of ionic and covalent bonding	2.91	1.18
Mole Concept to express mass substance	3.22	0.99

The finding of the study, as presented in Table 1, shows that the respondents got outstanding results in 3 competencies. Properties of metals in terms of their structure recorded a mean score of 4.00 (SD=0.70), while the mean score of the mole concept to express mass substance was 3.22 (SD=0.99). In addition, the formation of ionic and covalent bonding recorded the lowest mean score of 2.91 (SD=1.18). Thus, this finding shows that prototype learning activities have a high impact on the students' performance with regards to the competencies.

Table 2. Prototype activities in terms of Comprehensibility

	Students		Teachers	
Perception	Mean	SD	Mean	SD
The activity gives teachers and students prescriptive and Sequential instruction.	3.51	0.84	4.00	1.03
Students have enough time to think about what they are doing.	3.23	0.73	3.50	1.02
The activity allows students to conduct their own investigation.	3.20	0.86	4.00	0.79
The activity is simple.	2.84	1.03	3.50	1.12
The activity is lively and fun.	3.36	0.92	4.00	1.09
The factors or concept of the activity are important to learn.	3.50	1.00	4.00	0.89
The students can understand and follow the procedure.	3.27	0.85	4.00	1.27
The procedure of the activity is not difficult to follow.	3.17	0.74	4.00	0.88
The activity helps the students to understand difficult concepts	3.15	0.93	4.00	0.87
Mean	3.25	0.87	3.89	1.00

In terms of comprehensibility, the results achieved a mean score of 3.25 (SD= 0.87) for the students and 3.89 (SD=1.00) for the teachers. Based on the data in table 2, all perceptions are at the high level. For the students, the lowest mean score fall in the "activity helps students to understand difficult concepts" which garnered 3.15 (SD=0.93), while teachers, on the other hand, three items where fall in the lowest mean score it includes "students have enough time to think about what they are doing, and the activity is simple" these garnered a mean score of 3.50 (SD= 1.02 & 1.12). Overall, the results show a positive influence on the students' performance.

Table 3. Prototype activities in terms of Ease of Use

	Students		Teachers	
Perception	Mean	SD	Mean	SD
The activity provides opportunities for class discussion.	3.47	0.93	4.00	1.03
Students get excited about what they do.	3.08	0.97	4.00	0.88
Students are curious about the activity they do.	3.27	1.04	3.50	0.97

Students get bored.	2.23	1.09	1.00	0.96
Students don't understand the activity they do.	2.01	1.23	1.00	1.06
It deals with things that students are concerns with.	3.06	1.03	4.00	0.98
The activity is enjoyable in general.	3.23	0.83	4.00	.936
It caters for individual differences	2.98	1.21	4.00	1.24
It facilitates scientific inquiry.	3.09	.920	4.00	1.10
It demonstrates experiment.	3.10	1.31	3.50	1.04
The materials of the activity are readily available.	3.12	0.93	4.00	1.15
The activity is time bounded.	3.04	0.83	4.00	0.97
The activity is safe.	3.51	0.82	4.00	1.21
Mean	3.01	1.01	3.36	1.04

The second factor that measures the effectiveness of the prototype learning activities is the ease of use. Table 3 shows the data analysis of the ease of use in the prototype learning activity. The findings show that ease of use got an overall mean score of 3.01 (SD=1.01) for the students and 3.36 (SD=1.04) for the teachers. The data shows that all perceptions are also at the high level. For the students in the statement of "students get bored" it garnered with a mean score of 2.01 (SD=1.23), which describe as disagree. While teachers got a mean score of 1.00 (SD= 0.96) which indicates strongly disagree. For the statement "the activity provides opportunities for class discussion got the highest mean score 3.47 (SD=0.93) for the students, teachers side got a mean score of 4.00 (SD=1.03). Overall, the results show a positive influence on the students' performance.

Table 4. Prototype activities in terms of Relevance

Perception	Students		Teachers	
	Mean	SD	Mean	SD
The activity allows the students to work in groups.	3.42	0.72	4.00	0.78
Students find the activity so easy.	2.69	1.03	2.50	0.72
Students find the activity so challenging.	3.11	1.12	3.50	1.21
Students think the activity is too hard.	2.58	0.98	2.00	1.02
The activity is relevant to students' future.	3.11	0.90	4.00	0.89
The activity relates scientific content to students everyday life.	3.23	0.92	3.50	0.88
It incorporates technology.	2.88	0.86	3.50	1.12
It incorporates practical work.	3.04	1.00	3.50	0.94
The activity provides a good foundation for HL.	3.46	0.80	4.00	0.83
The activity is aligned to the LC in the second quarter.	3.15	0.69	4.00	0.92
The activity reinforces the learning of the students.	3.23	0.76	4.00	1.03
The activity is something new to the students.	3.20	1.12	3.50	0.86
Mean	3.10	0.91	3.56	1.00

Table 4 reflects in terms of relevance, the results achieved a mean score of 3.10 (SD= 0.91) for the students and 3.56 (SD=1.00) for the teachers. Based on the data in table 4, all perceptions are at the high level. For the students, the perception of "the activity is too hard" got a mean score of 2.58 (0.98) which disagrees with the statement, while teachers got a means score of 2.00 (SD=1.02). Table 4 also shows, the activity reinforces the learning of the students, with a mean score for the students 3.23 (SD=0.76) and 4.00 (1.03) for the teachers. Overall, the results show a positive influence on the students' performance.

Table 5. Differences between Students and Teachers' Perception

Population Sample	Sample Size	Sample Mean	Population Standard Dev.	Z-test	Two-Tail Test Lower Critical Value	Two-Tail Test Upper Critical Value	p-value
1	2	3.52	3.95	0.1396	-1.96	1.96	0.889
2	200	3.13	1.33				
Dif. Of Sample Mean		0.39					

Table 5 shows the differences in students' and teachers' perceptions of the effectiveness of the learning activities. The computed mean for teachers which is 3.52 and 3.13 for students revealed that both group respondents found the activities to be comprehensible, useful, and relevant. As shown in the intermediate calculations for the two population sample sizes the Z-test statistic result for the p-value which is 0.889 is higher than the level of significance which is 0.05. Therefore, accept the null hypothesis that is there is no significant difference in the views of the two classes of respondents of the above variables.

Table 6. Regression analysis comprehensibility

	Coef	*Std Error*	*t Stat*	*P.value*
Intercept	23.16832048	2.182814674	10.61396588	4.01519E-21
Comprehensibility	-0.183440106	0.665469343	-0.27565523	0.783100355

Table 6 shows that there is weak positive correlation (r -value = 0.042). Moreover, the relationship is not significant (p-value = 0.55). The comprehensibility and performance were independent from each other.

Table 7. Regression analysis Ease of use

	Coef	*Std Error*	*t Stat*	*P.value*
Intercept	29.21126285	2.647768659	11.03240751	2.27905E-22
Ease of use	-2.187387392	0.868849619	-2.517567303	0.012609262

Table 7 reflects that there is weak positive correlation (r -value = 0.042), the relationship is significant (p-value = 0.0126) and the ease of use and performance were independent from each other.

Table 8. Regression analysis Relevance

	Coef	*Std Error*	*t Stat*	*P.value*
Intercept	29.37118239	2.397202833	12.25227252	4.69674E-26
Relevance	2.187722702	0.767650263	-2.84989507	0.004836092

Table 8 shows that there is weak positive correlation (r -value = 0.045) , the relationship is highly significant (p-value = 0.0048) and the relevance and performance were independent from each other.

4. Discussions

With reference to the analysis above, the data shows that the association between the experience of the students with their results about the effectiveness of the prototype learning activities was a poor positive correlation. It has been proved by the regression analysis test, where the r-value is 0.042. This means that even if one of the variables increases (the perception of students) but there is a lower likelihood of there being a relationship with the second variable (students' achievement). Furthermore, with reference to the p-value which is 0.55, it shows that it was above the significant level, 0.05. This means that the null hypothesis that there is no correlation between the students' perception of effectiveness and performance and the aforementioned variables of effectiveness was accepted. It can be concluded that the students' perception of the effectiveness of the prototype learning activities did not affect their performance. Even though the value of the mean for each variable of effectiveness shows that the students' perception was in satisfactory category, it does not mean that their performance would also increase. Students' perceptions of the prototype learning activities and students' performance were independent of each other.

Moreover, the perception of the students on the effectiveness of the prototype learning design is on a higher level. The majority of the students agreed that the learning activities are comprehensible, useful, and relevant to their day-today living. The students' success in all skills reached a satisfactory stage. Results showed that there is no significant difference in the expectations of the two groups of respondents of the above-listed effectiveness variables. But students and teachers both agreed that the activities are highly relevant to their future which provides a good foundation of higher learning. In addition, there is no important correlation between the interpretation of the students and their performance. Kardash and Wallace (2001) claimed that when teachers plan activities that encourage student comprehension and learning by manipulations and group engagement, high cooperation and active participation could be interpreted as suggesting that students consider their teachers to be implementing techniques that enhance learning for students. In addition, Bernardo et al. (2008) reported that science classes that incorporate learning activities that encourage curiosity and analytical skills in the science process make learning more relevant to the students. However, successful student-centered activities would result to students' progress in their performance.

5. Conclusions

Based on the research findings, prototype learning experiences shows important outcomes in the field of science education. It showed that were no significant difference in the views of the two respondent groups. In addition, students considered the activity to be important to their future and daily life as evident in their responses with a highly significant outcome. This further suggested that interactive practice would be more effective in making students more receptive to the teacher.

6. Recommendations

Our finding revealed that students got an outstanding performance when engaging in prototype design learning activity. Moreover, the perception of the students and teachers in terms of ease of use, relevance, and comprehensibility of the perception shows positive perception in relation to the performance of the students. The results of the study support the study of several scholars such as Conlin et al. (2015) found out that design thinking using prototype learning activities could enhance learning especially to the low performer students. Bautista (2015) & Pappas (5015) found out that those students that experience prototype-based learning performed better and the significant relationship has been seen as a predictor of academic performance. Therefore, strategies in meeting the needs of the students must be addressed. Prototype learning activity must be recognized and utilized in order to elevate the student's performance.

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