

## Effects of Task Prompt Instructional Scaffolds on Secondary School Students' Achievement in Chemistry in Onitsha Education Zone

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### Abstract

The study investigated the effect task prompt instructional scaffolds on secondary school students' achievement in chemistry in Onitsha Education Zone. Two research questions guided the study and three hypotheses were tested. The design of the study was quasi-experimental. The population of the study was 1,823 senior secondary school year two (SS2) chemistry students, out of which 107 were selected. The instrument for data collection was Chemistry Achievement Test (CAT) validated by experts in the Faculty of Education, Nnamdi Azikiwe University, Awka. The reliability of the CAT was established using Kuder Richardson formula 20 to be 0.69. The finding of the study revealed that there was significant difference in the mean achievement scores of the students in favour of task prompt instructional scaffolds. The researchers recommended that workshops on the use of instructional scaffolds be organised by school heads for chemistry teachers to acquaint them with the use of the technique.

**Keywords:** Prompts, scaffolds, achievement, chemistry, bonding

### Introduction

The importance of chemistry has become very glaring in the face of the on-going pandemic ravaging the world. The dawn of COVID-19 disease have left the world with a wide search for an effective vaccine and drugs which could be used to prevent and cure the disease (Opejobi, 2020). Drugs are chemicals which can be obtained from organic matter or synthesised in the laboratory and they require advanced level of understanding in chemistry (Mattingly, Cain & Fink, 2010). Chemistry not only find application in nearly all fields of human endeavor such as in medicine and engineering but also forms a bridge across all science disciplines example biochemistry (Ababio, 2005). The importance of chemistry has made it an indispensable subject which requires foundational understanding from basic level of education. Chemistry is therefore studied at senior secondary level as a science subject requiring students to achieve a credit pass in order to be admitted into further science studies at the tertiary institution. Despite the importance of chemistry, students' achievement in the subject has been greeted with appalling remarks.

The Chief Examiner's Report from the West African Examination Council's (WAEC) angle expresses students' overall achievement in any subject area using raw mean scores and standard deviation. The approach by WAEC gives the public an idea not only of the students' average achievement but helps to compare students' achievement in each subject area across the years. The Chief Examiner's Reports from 2007 to 2018 in chemistry practical shows that students' average achievement has never exceeded 27.0. According to WAEC stanine, which is a grading system using students' percentile and which varies yearly, the benchmark for pass grade is D7 (45-49%), while failure grade is E8 (40-44%), where scores below the failure grade is indicated as F9.

Judging by the stanine standard therefore, the overall students' achievement in chemistry has remained below failure grade since 2007 to 2018. In the essay part of the examination, the highest raw mean score attained by the students was 47.00 in 2017. Again, judging by the stanine, students' overall achievement in chemistry essay is just at the pass grade. The state of the students' overall achievement in essay is made disturbing by the fact that apart from year 2017, students' raw mean score remained at failure grade, E8. The worst overall achievement ever, was noted in 2018 according to Chief Examiner's Report, when students had a raw mean score of 29.00. Such abysmal achievement have never been noted in chemistry until 2018 when it is expected that students ought to be improving their achievement given research studies and innovations in the teaching and learning of sciences.

The problem of poor achievement in chemistry has been attributed to a number of factors in literature such as lack of adequate practical activities (Enekwechi, Okeke, Nwanze & Chikwendu, 2019), poor usage of teaching materials (Emerhiona, Ajaja, Pius, Nwanze & Izuegbuna, 2018), dwindling interest in science studies (Izuegbunam, Osuafor, Nwanze, Emerhiona & Pius, 2018). The most implicated factor in literature however remains the instructional method used by chemistry teachers (Konyefa & Nwanze, 2020). Chemistry teachers often adopt the conventional method of teaching that is often teacher-centred and does not allow students to take full responsibility for their learning. The common use of teacher centred method according to Chikendu (2018) is due to the lack of the necessary resources for the adoption and application of innovative teaching methods in the teaching and learning of chemistry and the chemistry teachers' knowledge of them. There is the need therefore to investigate other innovative student-centred instructional strategies that may require fewer resources but allows students to take active role in their learning. One of such promising instructional techniques that has potentials for boosting academic achievement of students in chemistry in through the use of instructional scaffolds (Khairnar, 2015; Polman, Joseph & Pea, 1997).

Instructional scaffolding as a teaching technique originates from Lev Vygotsky's 1978 sociocultural theory and his concept of the zone of proximal development (ZPD). The zone of proximal development according to Vygotsky (1978) is the distance between what children can do by themselves and the next learning that they can be helped to achieve with competent assistance. The activities provided in scaffolding instruction are just beyond the level of what the learner can do alone. An important aspect of scaffolding instruction is that the scaffolds are temporary (Nzewi & Ibeneme, 2011). As the learner's abilities increases, the scaffolding provided by the more knowledgeable teacher is progressively withdrawn. Finally, the learner is able to complete the task or master the concepts independently. Therefore, the goal of the teacher when using the scaffolding instructional technique such as task prompts is for the student to become an independent and self-regulating learner and problem solver with consequent development of positive attitude toward learning (D'Costa, Allison, Schlueter & Mark, 2013).

Prompts are auxiliary, extra or artificial stimuli that are presented immediately before or after the stimuli that will eventually cue the learner to display the behavior of interest at the appropriate time or in the relevant circumstance. Prompts are antecedent stimuli that controls a particular response or in getting response to occur (Berk & Winsler, 1995). They are instructions, gestures, demonstrations, touches or other things that we arrange ot (to) do to increase the likelihood that a learner make correct response (McClannahan & Krantz, 1999). The teachers' prompting during instruction can therefore be understood as an instructional technique used to help students make correct response until they learn to respond on their own to the stimuli that control their

behavior. Prompting procedures can be classified in a number of ways such as verbal cues, modeling, mainly gestural, manual, textural, tactile or task prompt (Brown & Green, 2015) however, classification is a matter of convenience.

Task prompts therefore could be seen as activity cues such as half-way solutions to problems, introductory demonstrations and step to step guides given by a teacher to support them in a task they could not have done alone. In the use of task prompts as instructional scaffolds, the teacher may write on the board, the reactants and ask the students to think and form the products. The students without the help of the teacher may not be able to do the task of forming the product, so the teacher may use their knowledge of valency to form one of the product as a task prompt type of scaffold, enabling them to form another product or more products without any further assistance. Another task prompt could be to do an atom count on the right-hand side when balancing chemical equations while the students do the atom count for the left-hand side and complete the balancing of the equation when the teacher support is removed. As these tasks are being performed by the students, the teacher may nod in affirmation when they are getting it right or use other body gesture as a task prompt to guide the students towards the right answer or solution to the tasks.

The use of task prompts could assist students irrespective of gender in such a way that they successfully complete task they may not have been able to complete. The teacher through the use of task prompt give male and female students equal assistance in completing any academic task. The importance of ensuring that students get help not minding their gender lies in the fact that science classes including chemistry classes are sometimes gender stereotyped (Akinwumi, 2017; Bosede, 2010). Also, cultural and social factors interact in different ways to influence teachers, parents and students' decision for learning science (Nakpodia, 2010). Science oriented subjects such as chemistry are sometime perceived as masculine as it is required for science studies. The need to further investigate the influence of gender on students' achievement in chemistry was also necessitated by the inconclusive results from studies (Emerhiona et al., 2018; Enekwechi et al., 2019; Izuegbunam et al., 2018; Konyefa & Nwanze, 2020) on the role of gender in achievement of students.

### **Purpose of Study**

The study investigated the effect task prompt instructional scaffolds on secondary school students' achievement in chemistry. Specifically, the study sought to find out:

1. The difference between the mean achievement scores of students taught chemistry using task prompt instructional scaffolds and those taught using conventional method.
2. The difference between the mean achievement scores of male and female students in chemistry.
3. The interaction effect of teaching method and gender on the achievement of students in chemistry.

### **Research Questions**

1. What are the mean achievement scores of students taught chemistry using task prompt instructional scaffolds and those taught using conventional method?
2. What are the mean achievement scores of male and female students in chemistry?

### **Hypotheses**

1. There is no significant difference between the mean achievement scores of students taught chemistry using task prompt instructional scaffolds and those taught using conventional method?
2. There is no significant difference between the mean achievement scores of male and female students in chemistry.
3. There is no significant interaction effect of teaching methods and gender on achievement of students in chemistry.

## Method

The design adopted for the study was quasi-experimental. The 2x3 factorial design was used. The study was conducted in Onitsha Education Zone of Anambra State. The population of the study was 1,823 SS2 chemistry students. The sample size for the study was 107 SS2 chemistry students obtained from two schools using a multi-stage sampling procedure. The instrument for data collection was Chemistry Achievement Test (CAT) designed on a four point response options lettered A-D. The 50 questions items were constructed using a table of specification on the concept of chemical combination (bonding). Chemistry Achievement Test was validated by experts from the Departments of Science Education and Educational Foundations, Faculty of Education, Nnamdi Azikiwe University, Awka. The reliability of CAT was established using Kuder-Richardson formula 20 to be 0.69.

The experiment was carried out in two phases. First, the regular chemistry teachers in the experimental schools who were used as research assistants were briefed within one week in three contacts. In the second phase, students were taught the chemical combination for six weeks using task prompt instructional scaffolds for the experimental group and conventional method for the control group. In the experimental classroom, the teacher implemented the use of task prompt instructional scaffold using the guide by the National Research Council (2004) which involved: motivating or enlisting the students' interest in relation to the task; simplify the task to make it more manageable and achievable for the students; provide some direction in order to help the students focus on achieving the goal; clearly indicating the difference between the students' work and the standard or desired solution, reducing frustration and risk; and modeling and clearly defining the expectations of the activities/tasks to be performed.

Data relating to the study was analysed using mean, standard deviation and analysis of covariance. The decision rule for accepting and rejecting the null hypotheses was that Pvalue less than or equal to 0.05 indicated acceptance whereas Pvalue greater than 0.05 indicated rejection.

## Results

**Research Question 1:** What are the mean achievement scores of students taught chemistry using task prompt instructional scaffolds and those taught using conventional method?

**Table 1: Pretest and Posttest Mean Achievement Scores of Students taught Chemistry using Task Prompt Instructional Scaffolding (TPIS) and Conventional Method (CM)**

Source of Variation	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Gain in Mean
TPIS	51	30.82	7.25	54.14	8.09	23.32
CM	56	33.27	8.94	48.34	7.50	15.07

Table 1 reveals that the students taught chemistry using task prompt instructional scaffolds has gain in mean achievement score of 23.32 while those taught using conventional method has gain in mean achievement score of 15.07. In the posttest, students taught using task prompt

instructional scaffolds had a less homogeneous score (8.09) than those taught using conventional method (7.50).

**Research Question 2:** What are the mean achievement scores of male and female students in chemistry?

**Table 2: Pretest and Posttest Mean Achievement Scores of Male and in Chemistry**

Source of Variation	Gender	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD	Gain in Mean
TPIS	Male	27	31.30	7.57	55.22	8.23	23.92
	Female	24	30.29	7.01	52.92	7.93	22.63
CM	Male	40	35.20	8.72	47.38	7.43	12.18
	Female	16	28.44	7.75	50.75	7.33	22.31

Table 2 shows that male students taught using task prompt instructional scaffolds has gain in mean achievement score of 23.92 while the females have gain in mean achievement score of 22.63 where the males taught using conventional method has gain in mean achievement score of 12.18 and the females a gain in mean achievement score of 22.31.

**Hypothesis 1:** There is no significant difference between the mean achievement scores of students taught chemistry using task prompt instructional scaffolds and those taught using conventional method.

**Table 3: ANCOVA on test of Significant Difference in the Mean Achievement Score of Students taught Chemistry TPIS and CM**

Source of variation	SS	Df	MS	F	P-value	Decision
Corrected Model	2659.335 <sup>a</sup>	4	664.834	14.727	.000	
Intercept	8111.989	1	8111.989	179.697	.000	
Pretest	1564.341	1	1564.341	34.653	.000	
Method	727.884	1	727.884	16.124	.000	S
Gender	135.896	1	135.896	3.010	.086	NS
Method * Gender	422.542	1	422.542	9.360	.003	S
Error	4604.534	102	45.142			
Total	286694.000	107				
Corrected Total	7263.869	106				

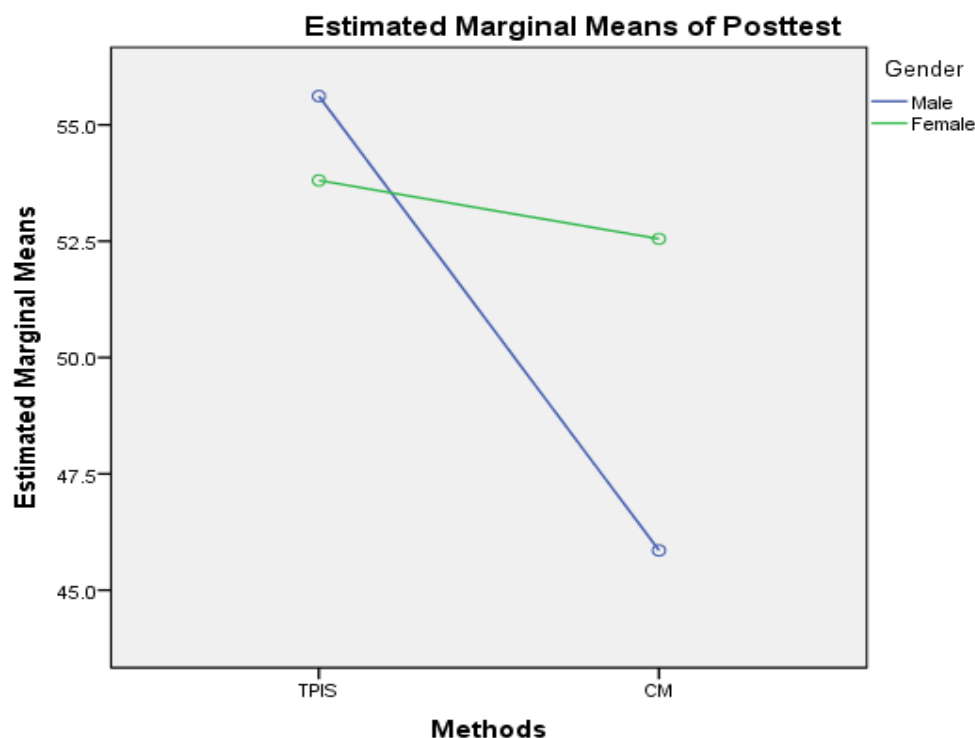
Table 3 shows that at 0.05 level of significance, 1df numerator and 106df denominator, there was a significant main effect of the treatment on students' achievement in chemistry  $F(1,106) = 16.124$ . Therefore, the null hypothesis was rejected. Thus, there is a significant difference between the mean achievement scores of students taught chemistry using task prompt instructional scaffolds and those taught using conventional method in favour of task prompt instructional scaffolds.

**Hypothesis 2:** There is no significant difference between the mean achievement scores of male and female students in chemistry.

Table 3 also shows that at 0.05 level of significance, 1df numerator and 106df denominator, there was no significant main effect of gender on students' achievement in chemistry  $F(1,106) = 3.010$ . Therefore, the null hypothesis was not rejected. Thus, there is no significant difference between the mean achievement scores of male and female students in chemistry.

**Hypothesis 3:** There is no significant interaction effect of teaching methods and gender on achievement of students in chemistry.

Table 3 further shows that at 0.05 level of significance, 1df numerator and 106df denominator, there was a significant interaction effect of teaching methods and gender on achievement of students in chemistry  $F(1,106) = 9.360$ . Therefore, the null hypothesis was rejected. Thus, there is no significant interaction effect of teaching methods and gender on achievement of students in chemistry. The plot of interaction is shown in Figure 1.



Covariates appearing in the model are evaluated at the following values: Pretest = 32.10

**Figure 1: Plot of interaction effect of teaching methods and gender on students' achievement in chemistry**

The plot of the interaction effect of teaching methods and gender was not significant and disordinal.

### Discussion

The finding of the study showed that the use of task prompt instructional scaffolds significantly improved achievement in chemistry more than conventional method. The significant improvement in the students' achievement in chemistry could be attributed to support which assisted the students in accomplishing new tasks and concepts they could not typically achieve on their own. The supportive learning environment resulting from the use of task prompts which were in the form of physical and verbal cues made the students free to ask questions, provide feedback and support their peers in learning new materials. The incentive arising from the use of the scaffold motivated the students to take active role in their own learning and shared the responsibility of teaching as well as learning through the scaffolds. The whole process of learning therefore resulted in an in-depth understanding of the concept of bonding.

The activities relating to the learning bonding such as the tasking of drawing structural examples of different types of chemical combination was made attainable through the use of example and



charts on bonding. The body movements by the teachers such as nodding heading and verbal cues such as ‘keeping going and you will arrive there’ assured students of the possibility of achieving the goal of instruction through the help of those scaffolds. The interaction with the teachers over the learning materials enabled the students to take ownership of the learning event when scaffolds are removed and ensured mastery after several task. The teachers by building the students’ learning of chemical combination on such concepts such as valency and electronic configuration through the use of scaffold created an effective medium for students to recall previous knowledge with much ease and to link it to the learning of the new concept of chemical combination.

The finding of the study is in line with the findings of Nsikak-Abasi, King, Onweh (2014) that scaffolding instructional technique was a better teaching method than conventional instructional method. The finding of the study also supports the finding of Nzewi and Ibeneme (2011) that scaffolds significantly improved achievement more than the conventional method. The finding of Nonye and Nwosu (2011) and Alake and Ognuseemi (2013) that instructional scaffolding method was superior to the conventional method in improving the achievement supported the finding of the present study.

The study also revealed that gender has no significant influence on the achievement of the students. A significant disordinal interaction effect of teaching method and gender on achievement in chemistry was observed. Instructional scaffold provide support for all students male or female and help them better understand the underlying structure of subject matter improving achievement in such areas as comprehension and recall of instructional contents. The finding of the study supported the finding of Nwankwo (2020) that gender has no significant main influence of students’ achievement. The finding of the study also supported the finding of Izuegbunam, Osuafor, Nwanze, Pius and Emerhiona (2018) that gender did not significantly influence the achievement of students in chemistry. The finding of the study however contrasted the finding of Nonye and Nwosu (2011), Omiko (2015) and Enebechi (2016) that there was no significant interaction effect of teaching methods and gender on the achievement of the students. The finding of the study lend credence to the finding of Emerhiona, Ajaja, Pius, Nwanze and Izuegbunam (2018) that the interaction of teaching method and gender on students’ achievement was significant and disordinal.

## Conclusion

It can be concluded based on the findings of the study that adopting task prompt instructional scaffolds during chemistry learning is an effective way of improving students’ achievement. The use of task prompts as instructional scaffold increase cognitive process thereby facilitating proper conceptualization of the concepts taught leading to improved achievement.

## Recommendations

It is recommended based on the findings that:

1. Orientation and workshops on the use of task prompts as instructional scaffolds during chemistry learning should be organised for chemistry teachers by school heads and educational stakeholders.
2. Abstract chemistry concepts or such concepts as students may find difficult to learn should be taught using instructional scaffolds such as task prompts.

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