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Implementing a Target-Task Problem-Solving Approach in teaching electrochemistry to advanced level chemistry learners

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Abstract

The study investigated the effect of a Target-Task Approach on the performance of advanced level chemistry students in electrochemistry. The study adopted the quasi-experimental research design. Data were obtained from two advanced level chemistry classes from two high schools in Gweru, Zimbabwe. One of the two classes was assigned to be the experimental group, while the other class acted as the control group. The experimental group was taught electrochemistry using Target-Task Approach, while the conventional method was used to teach the control group. Analysis of covariance was used to analyse all the data generated from the study. The hypotheses formulated were all tested at the 5% level of significance. The results revealed that the difference in performance between the experimental and control group was statistically significant. The findings further show that the use of the Target-Task Approach greatly enhance the performance of low and medium scoring level students.

Key words: Electrochemistry, gender, problem-solving, scoring level, Target-Task Problem-Solving Model.

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1. Introduction

The role of science and technology to a nation's development is undeniable. Chemistry as a subject of the Zimbabwean secondary school curriculum has a critical role to play in the socio- economic and technological development of the nation. Among the vast number of topics in the chemistry curriculum is the topic electrochemistry. As noted by Abdulwahab, Oyelekan and Olorundare (2016), electrochemistry is a branch of chemistry dealing with the relationship between chemical reactions and electricity. It studies the chemical changes resulting from passing an electric current through a medium. The study of electrochemistry provides an understanding and application in a number of chemical phenomena and processes such as electrolyte solutions, electroplating and electro winning of metals, the corrosion and passivation of metals, batteries, bio electrochemistry and photo electrochemistry.

Despite its importance in everyday life, electrochemistry has been regarded as one of the difficult topics to study in chemistry (Ahmad & Che Lah, 2012; Amponsah & Ochonogor, 2016; Obamanu & Onuoha, 2012; Rollnick & Mavhunga, 2014; Sirhan, 2007). High school chemistry students in Zimbabwe also find this topic problematic (Kazembe & Musarandega, 2012). Students also find examination questions on electrochemistry challenging as attested by the Zimbabwe Schools Examinations Council (ZIMSEC) examiners reports (2009, 2012, 2014). Previous studies have shown that the topic is difficult to teach because of its abstract nature involving the macroscopic, sub microscopic and symbolic levels (Lee & Kamisah, 2014). As further noted by Brandriet and Bretz (2014), the difficulties, students have in electrochemistry, arise from lack of conceptual understanding of the concepts of oxidation and reduction. Sen, Yilmaz and Geban (2016) highlight that the conceptual difficulties students encounter in as far as electron transfer is concerned stem from the need for oxidation and reduction to occur simultaneously as a result students fail to differentiate between the two concepts.

Bong and Lee (2016) further opine that electrochemistry is abstract to students and the fact that electron movement is invisible; this makes it difficult for students to visualise the movement of electrons. Consequently, if students cannot visualise the movement of electrons and ions during electrochemical processes, it then becomes difficult for them to translate the electrochemical processes into chemical formulae and equations (Lee & Kamisah, 2014). It is also important to note that some misconceptions students have in electrochemistry emanate from their teachers. A study by Yilmaz and Bayrakceken (2015) revealed that teachers' understandings of electrochemistry were inadequate and there were many misconceptions that they held. These misconceptions can be passed on to students during teaching and learning.

The difficulties, students have in electrochemistry and chemistry in general, can be attributed to the use of ineffective and unproductive instructional strategies used by chemistry teachers (Abdulwahab et al., 2016). There is, therefore, need for chemistry educators to implement alternative instructional strategies that can address student difficulties and misconceptions resulting in overall improvement student performance. One of the teaching methods that can help to address students' difficulties and alternative conceptions in electrochemistry is the Target-Task Problem-Solving Model. This model as noted by Olaniyan and Omosewo (2015) is a step-by-step approach comprising of six key stages which are described as follows:

1. **Pre-task:** this stage involves the introduction and a detailed explanation of the topic by teacher to make sure that the learners have an adequate understanding of what they are to accomplish at the task stage.
2. **Task:** The students are engaged in addressing the given task either in pairs or in groups, at the same time, the teacher will be monitoring the students and offering encouragement.

3. **Planning:** At the end of the activity, the students prepare a written report on what they experienced during the task in their groups.
4. **Report:** The students submit their reports to the teacher for the assessment. The teacher then returns the report back to the students after having made necessary corrections.
5. **Analysis:** The teacher will highlight the relevant parts of the learning on the board.
6. **Practise:** The teacher then gives more problems of practise for the students.

The above model can be seen as an adaptation of the guided discovery approach (Olaniyan & Omosewo, 2015) emerging on the basis of the benefits of constructivism, where students are actively engaged in creating, structuring and understanding their own knowledge. The Target-Task Problem-Solving Approach is a student-centred teaching methodology that supports students' active participation in the learning process. In this method, students learn in small groups through inquiry and engage in specially designed tasks to achieve the goals of the curriculum. The approach incorporates the aspect of cooperative learning where students are involved in activities in a peer-led guided inquiry learning environment.

The teacher's role in the Target-Task Problem-Solving Model is that of facilitator of student learning. The teachers do not directly intervene in groups but only become involved in group discussions when offering assistance and encouragement to ensure that the scientific concepts are appropriately structured and represented by students.

A review of the literature shows that there are a number of studies relating to the Target-Task approach. The studies were conducted in chemistry (Nbina, 2011) and physics (Olaniyan & Omosewo, 2015). The use of the Target-Task Approach in teaching physical chemistry enhanced the performance of students in the experimental group in comparison to those taught with expository lecture method (Nbina, 2011). The study by Olaniyan and Omosewo (2015) investigated the Effects of a Target-Task Problem-Solving Model on Senior Secondary School Students' Performance in Physics. The study found that that students taught with the Target-Task Problem-Solving Model significantly did well in a current electricity achievement test than those exposed to the lecture method.

1.1. Aim of the study

The study aimed at determining the effects of the Target-Task Approach on the achievement of advanced level chemistry students in electrochemistry. The objectives of the study were to:

i. Determine the effect of the Target-Task Approach on the achievement of advanced level chemistry students in electrochemistry;
ii. Determine the influence of gender on advanced level chemistry students' achievement in electrochemistry when taught using the Target-Task Approach.

1.2. Research questions

The study was guided by the following research questions:

1. How do advanced level chemistry learners exposed to Target-Task Approach and those exposed to the conventional method perform in an electrochemistry achievement test?
2. How does gender influence the performance advanced level chemistry learners exposed to the Target-Task Approach?
3. How is achievement in the electrochemistry test influenced by the scoring level of the students?

1.3. Research hypotheses

The study tested the following research hypotheses:

HO_1: There is no significant difference in the performance of students taught using the Target-Task Approach and those taught using lecture method.

HO_2: Gender does not significantly influence the performance of advanced level students in an electrochemistry test.

HO_3: The scoring level of students exposed to the Target-Task Approach does not significantly influence achievement in an electrochemistry achievement test.

2. Methodology

In this study, the quasi-experimental research design was utilised. The design employed a non-equivalent control group involving pre-test and post-test measures. The research utilised the quasi-experimental design since it was not possible to randomly assign the participants to groups hence intact classes were used. The target population of the study consisted of all advanced level chemistry students in Gweru urban district. The sample consisted of 110 advanced level chemistry students who were purposively selected from two high schools. One schools constituted the experimental group (50 students), while the other school comprised the control group (60 students). The selected schools had qualified chemistry teachers with more than 3 years of teaching experience at advanced level. For collecting data in the study, the researchers utilised an achievement test and an instructional package on electrochemistry. The instructional package on the Target-Task Model was used to teach the experimental group, while the lecture method was used to teach the control group. The achievement test on electrochemistry contained items drawn from concepts on electrochemistry. The reliability coefficient of the text was determined using Kudder Richardson formula—21. The reliability index was found to be 0.86. The test items were validated using content and face validity.

2.1. Collection procedures

The data for the study were collected for a period of 4 weeks. During the 1st week of the study, a number of activities were conducted which included the training of the chemistry teachers by the researcher, collection of terminal results used to group students into scoring level and administering of the pre-test. The pre-test was administered to determine the level of understanding of the students of the selected concepts in electrochemistry before teaching them. The teacher of the treatment group was trained on how to use the Target-Task Problem-Solving Approach in teaching electrochemistry, while the teacher of the control group did not receive any training and used the conventional lecture method to teach electrochemistry. The treatment period lasted for 2 weeks in which concepts in electrochemistry were taught to the advanced level chemistry leaners. The researcher visited the schools during the duration of the implementation of the intervention to ensure that the instructional package was appropriately used. In the 4th week, both the experimental and control group were post-tested. The data that were generated from the achievement tests were analysed using analysis of covariance (ANCOVA). The ANCOVA was performed on the Statistical Package for Social Sciences version 20.0. In conducting the ANCOVA analysis, the pre-test scores were set as the covariate, and this adjusted for initial group differences.

2.2. Implementing the intervention

The intervention was implemented following the Target-Task Problem-Solving Model. The model is composed of six stages. As outlined by Harmer (2007), the stages are: Pre-task, Task, Planning, Report, Analysis and Practise.

1. **Pre-task:** This stage requires the teacher to introduce the topic under study (electrochemistry) and the concepts involved. The teacher then breaks down the topic into units of instruction and explains to the students what they will cover in each unit. The teacher will outline the objectives of each unit of instruction, and give a clear explanation of the theoretical aspects behind each concept

and problems, but does not solve any of the problems. The teacher may recall any relevant information that can assist the students during the task. On the other hand, students are engaged in note taking and spend some time in preparation for the task. At the pre-task stage, the teacher may demonstrate to the students what they are expected to do during the task. The teacher also divides the students into pairs or small groups of four depending on the class size. The last part of this stage is for the students to take notes and get prepared for the task. The teacher may also play a video recording of learners performing the task, thus giving the learners a clearer picture of what is expected of them as they engage in the task.

2. **Task:** At this stage, the students complete or work on the given task together with other peers either as pairs or as groups. In completing the task, they utilise the electrochemistry knowledge and resources acquired during the pre-task stage. The teacher's role will be to monitor and offer encouragement. Students are engaged in solving both mathematical and non-mathematical problems in a peer-led learning environment, in cooperation by combining knowledge of the group members, thus making it possible through peer learning for learners to dispense with their alternative conceptions. Through cooperative learning in groups, the students help to explain the right scientific concepts to students with alternative concepts leading to conceptual change.
3. **Planning and Presentation:** Students prepare a clearly written report of the problems they worked on during the task and share with the rest of the class/peers the experiences gained during their engagement with the task. The leader of each group will then present the solution to the entire class at the same time members from other groups make constructive contributions on the work presented.
4. **Report:** The students will present their reports with solutions to the teacher for assessment. The teacher will look at the reports, corrects them and give feedback to the groups. After getting the feedback, the students are able to see their mistakes and misconceptions. Students who have worked on similar tasks will get the chance to compare their work. This enables them to reflect on how they carried out the task as well as identifying some areas which were problematic about the task. Thus, they learn on how best the task can be or could have been performed (Buyukkarci, 2009).
5. **Analysis:** The analysis involves the teacher focusing on certain electrochemistry concepts or issues related to the tasks that students are addressing. This may be based on some of the errors or misconceptions the teacher has noted down while monitoring the students' work. The teacher highlights major points of the lesson on the board, clarifies students' misconceptions and summarises the lesson. The summary includes all activities undertaken in the class during the period (Abraham, 2015).
6. **Practise:** The teacher selects areas of practise and assignments for the students. In selecting the assignments, the teacher has to consider the needs of the learners that will have emanated from the tasks and the reports given by the students. This may be in the form of definitions or calculations on aspect relevant to the topic discussed during the lesson. The students are expected to practise and solve the problems by performing the task, do the planning and present their reports (Frost, 2006). The practise problems are meant to increase the self-confidence of students.

3. Results

The results of the study are presented based on the research questions and research hypotheses formulated. All hypotheses were tested at 0.05 level of significance.

Research question 1: *How do Advanced level chemistry learners exposed to Target-Task Approach and those exposed to the conventional method perform in an electrochemistry achievement test?*

The effect of using the Target-Task Problem-Solving Model on teaching electrochemistry to advanced level was determined by computing the mean performance test scores. The data are shown in Table 1.

Table 1. Students' mean scores in an electrochemistry achievement test

Treatment	Mean score	Pre-test scores	Post-test scores	Mean gain scores
Target-Task Model	Mean	44.02	68.66	24.64
	N	50	50	
	Standard deviation	4.58	5.23	
Conventional	Mean	42.44	44.78	2.34
	N	60	60	
	Standard deviation	6.34	7.24	

Table 1 shows the mean scores of students in the experimental and control groups. At the pre-test stage, the experimental group obtained a mean score of 44.02 and standard deviation of 4.58, while the control group obtained a mean score of 42.44 and standard deviation of 6.34. At the post-test stage, the experimental group obtained a mean score of 68.66 and standard deviation of 5.23, while the control group obtained 44.88 as the mean score and 7.24 as the standard deviation. The mean gain difference between students exposed to the Target-Task Model and lecture method is 22.30. It can be concluded from the outcome that students taught using the Target-Task Model performed better than those taught using the conventional lecture method.

The ANCOVA test was performed to determine if the difference in performance between the two groups in the post-test was statistically significant. The findings are presented in Table 2.

Table 2ANCOVA of post-test scores of the treatment group and control group using the pre-test as covariate

Source	Sum of Squares	df	Mean square	*F*	Sig.
Corrected model	9832.254[a]	2	4786.556	128.330	0.002
Intercept	2687.519	1	2698.382	73.276	0.001
Pre-test	5215.174	1	5231.085	141.197	0.001
Treatment	23.012	1	23.012	0.598	0.019
Error	1463.155	107	36.417		
Total	101876.000	110			
Corrected total	13133.280	109			

An examination of Table 2 reveals that an F (2, 109) = 0.598, p = 0.019, which is less than 0.05 (i.e., p-value < α-value), suggesting that the main effect (treatment) was significant. The results indicate that the Target-Task Problem-Solving Approach greatly influenced the post-test scores after the effect of the covariate had been controlled. Thus, the treatment using the Target-Task Model and conventional method accounted for the difference in the post-test achievement score of the students, and the difference is significant.

Research question 2: *How does gender influence the performance of students taught using the Target-Task Approach?*

Table 3. Mean scores of male and female students taught using Target-Task Approach

Gender	Mean	Pre-test	Post-test	Mean gain score
Female	Mean	44.02	57.95	13.93
	N	20		
	Standard deviation	3.53	4.26	
Male	Mean	45.02	59.65	14.63
	N	30		
	Standard deviation	3.46	4.23	

In Table 3, the mean gains displayed are 14.63 and 13.93, respectively, for the male and female students taught using the Target-Task method. It indicates that the male students obtained higher mean scores in the pre-test and post-test of the electrochemistry achievement test than the female students. The Table 3 also indicates that both the scores for the male and female students in the post-test were higher than the pre-test results for the two groups. In order to check significance of difference in achievement in electrochemistry of the boys and girls taught through the Target-Task Approach, ANCOVA test was applied. The obtained values are shown in Table 4.

Table 4. Analysis of covariance on the post-test scores of male and female students taught using the Target-Task Problem-Solving Model

Source	Sum of squares	df	Mean square	*F*	Sig.
Corrected model	2932.254[a]	2	1436.556	38.330	0.000
Intercept	1298.519	1	1298.382	33.876	0.000
Pre-test	2835.174	1	2816.085	73.197	0.000
Gender	.162	1	.162	.005	.0845
Error	2163.155	47	36.632		
Total	72076.000	50			
Corrected total	5133.200	49			

Based on hypothesis 2, which says that there is no significant difference between the mean achievement scores of male and female students taught chemistry using the Target-Task method, Table 4 shows that the calculated *p* value (0.845) is greater than p alpha level of 0.05, ($p > 0.050$), therefore, we do not reject the null hypothesis. It can, therefore, be concluded that male and female students taught using the Target-Task Approach perform equally the same in an electrochemistry achievement test.

Research question 3: *How is achievement in the electrochemistry test influenced by the scoring level of the students?*

Table 5. Mean scores of high, medium and low scoring level students taught using Target-Task Problem-Solving Model

Category	Mean	Pre-test	Post-test	Mean gain score
High scoring	Mean	48.16	69.32	21.16
	N	18		
	Standard deviation	3.242	2.913	
Medium scoring	Mean	36.34	59.41	23.07
	N	22		
	Standard deviation	1.434	0.974	
Low scoring	Mean	25.57	49.86	24.29
	N	10		
	Standard deviation	0.572	0.545	

Table 5 shows that high scoring students had a mean gain of 21.16, while medium scoring students had a mean gain score of 23.07 and the low scorers had a mean of 22.29. From Table 5, it can be seen that the highest mean gain was obtained by the high scorers followed by the medium scores then lastly the low scorers. Thus, there is a difference in the performance of students taught using the Target-Task Approach based on the scoring level. In order to determine whether the difference in the performance of students (taught with Target-Task Approach) based on scoring was significant, the third hypothesis was tested at 0.05 level of significance. The results are shown in Table 6.

Table 6. Analysis of covariance on the post-test scores of male and female students taught using the Target-Task Problem-Solving Model

Source	Sum of squares	df	Mean square	*F*	Sig.
Corrected model	4427.164[a]	3	1446.136	108.215	0.000
Intercept	2588.439	1	2588.439	189.327	0.000
Pre-test	305.238	1	305.238	21.108	0.000
Scoring level	1345.362	2	694.223	49.331	0.015

Error	798.527	46	15.324
Total	71986.879	50	
Corrected total	5101.600	49	

Considering hypothesis 3 which stated that the scoring level of students exposed to the Target-Task Approach does not significantly influence the achievement in an electrochemistry test, the results of the ANCOVA analysis in Table 6 show that F (1, 46) = 49.331, and $p < 0.05$. The results are statistically significant since $p < 0.05$. It can be concluded that the scoring level of students significantly influences the achievement of students taught electrochemistry using the Target-Task Approach. The implication is that differences exist in the performance of high, medium and low scoring level students hence the null hypothesis 3 was rejected.

The difference in the performance of high, medium and low scorers was further observed using a post-hoc comparison. The results are shown in Table 7. A Tukey HSD test indicated that the mean score for high scorers (M = 69.32, SD = 2.91) was significantly different from medium scorers (M = 59.41, SD = 0.97) and low scorers with (M = 49.86, SD = 0.55) when p = 0.000. Hence, the null hypothesis was rejected.

Table 7. Post-hoc comparison of the mean scores obtained from Target-Task strategy-based scoring levels

I(scoring l)	j(scoring l)	Mean difference Scoring l (I-J)	Std. error	Sig.
High	Medium	9.91	3.21	0.000
	Low	19.46	2.18	0.000
Medium	High	−9.91	3.21	0.000
	Low	9.55	2.45	0.000
Low	High	-19.46	2.18	0.000
	Medium	-9.55	2.45	0.000

4. Discussion

This study aimed to investigate the effects of the Target-Task Problem-Solving Model on advanced level chemistry students' achievement in electrochemistry. The results of the study showed that students who were taught using the Target-Task Approach performed better than those taught using the lecture method. It was hypothesised that the difference in achievement between students taught using the Target-Task Approach and those exposed to the conventional method was significant. The finding was in agreement with Olaniyan and Omosewo (2015) who found that the Target-Task Approach was more effective in teaching current electricity concepts in physics than the lecture method. The finding is also consistent with Acar Sesen and Tarhan (2013) who found that students exposed to instruction based on inquiry-based laboratory activities performed significantly better in electrochemistry than those exposed to the traditional methods. It was also in agreement with Sen, Yilmaz and Geban (2016) who found that students exposed to Process Oriented Guided Inquiry Learning performed better in electrochemistry concepts than those exposed to conventional teaching methods. The finding was also in line with Gunter and Alpat (2017) who noted that if students are taught using the problem-based learning strategy they are better able to understand electrochemistry concepts than those who are taught with the lecture method.

The study found that the performance of male and female students exposed to the Target-Task Approach was equally the same and not significantly different. Thus, students regardless of their gender benefited from the use of the Target-Task Approach. The findings are consistent with Abdulwahab et al. (2016) who found out that gender had no significant effect in the achievement of students taught electrochemistry using cooperative instructional strategy. The findings are also in line with Akpoghol, Ezeudu, Adzape and Otor (2016) who found that there was no statistically significant main effect of gender on students' achievement in electrochemistry.

The findings of the study further revealed that there was a statistically significant difference in the achievement of students taught using the Target-Task Approach on the basis of scoring levels. The use of the Target-Task Approach had a greater influence on the low and medium scorers than the high scorers. This is because the high scoring students maintained their high scores after they have been exposed to treatment but the low and medium scoring students gained more from this strategy as they scored closer to the high scoring students. This supports earlier findings by Lamidi, Oyelekan and Olorundare (2015) who found that low scoring level students had the highest mean gain score in a mole concept achievement test. This finding further confirms the efficacy of the Target-Task Approach, in bridging the achievement gaps among learners of various abilities and scoring levels. Thus, the Target-Task Approach has the potential of levelling up the achievements of learners across various ability groups.

5. Conclusion

It can be concluded from this study that the students had enhanced performance when taught electrochemistry using the Target-Task Approach than when taught using the conventional method. The Target-Task Approach also bridged the achievement gap between the low, medium and high scorers. Furthermore, gender did not influence students' achievement when the Target-Task Approach was used to teach electrochemistry.

6. Recommendations

Based on the findings from this study, the following recommendations are made:

Pre-service chemistry teachers should be exposed to problem-solving models during their training in order to learn how to implement effectively problem-solving instruction in their classes.

Chemistry teachers are strongly recommended to use the Target-Task Approach during teaching and learning of chemistry in high schools to facilitate students' performance and enhance better performance of chemistry concepts.

The writers and publishers of chemistry textbooks need to integrate the problem-solving models of chemistry teaching as they write new editions so that both teachers and learners may benefit.

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