Original Research Article

IMPROVING STUDENTS' SCIENCE PROCESS SKILLS USING ARGUMENT-DRIVEN-INQUIRY (ADI) LABORATORY METHOD

Abstract:

This study aimed to determine the effects of the Argument-Driven-Inquiry (ADI) laboratory method on high school students' science process skills. The study further investigated the method's effect on students with different reasoning ability levels, namely the hypothetico-deductive, transitional, and empirical-inductive.

A mixed method employing both quantitative and qualitative procedures for gathering data was employed. An experimental study using a 2 x 3 factorial design was implemented where Reasoning Ability Level was the moderating variable. The study was conducted on two intact classes of fourth-year students at Iloilo National High School-Special Science Class enrolled in College Physics.

Quantitative data were gathered using Lawson's Classroom Test of Scientific Reasoning to categorize students according to their reasoning ability levels and Test for Integrated Process Skills II (TIPS II) to measure students' science process skills before and after the study. Mean, standard deviations, t-test for independent samples, and one-way analysis of variance were determined as part of the statistical analyses.

Results revealed that students in the two groups were comparable in terms of science process skills before the intervention was employed. However, exposure to the ADI method improved students' science process skills better than exposure to the traditional laboratory method. Further, the improvement of students' science process skills is deemed independent of the student's reasoning ability level but relies mainly on the type of laboratory instruction.

Keywords: *ADI, science process skills, scientific reasoning, TIPS II, laboratory method, concept cartoons*

Introduction:

One best venue where students would be able to acquire and improve their science process skills is through the conduct of laboratory activities. In recent years, science education research, both in local and international communities, stress the importance of inquiry-based instruction, particularly in the laboratory. Curricular reforms stress that students should be given opportunities where they would be able to design their investigations rather than simply follow a certain set of procedures and simply verify what they have learned in their lecture course.

Further, reports had shown that many benefits can be derived from inquiry laboratories such as better conceptual understanding, development of different skills, and even a more positive attitude towards science. Thus, inquiry laboratories can facilitate the development of students' process skills.

Statement of the Problem:

This study aimed to determine the effect of the revised Argument-Driven-Inquiry (ADI) Laboratory Method on high school students' science process skills. Specifically, this study aimed to: (1) determine the levels of students' science process skills before and after the implementation of the study, and (2) determine if there is a significant difference in the developed science process skills among students exposed to ADI and those exposed to the traditional laboratory when they are classified based on their reasoning ability levels?

Methodology:

Quantitative procedures for gathering data were employed. In addition, this investigation also utilized a quasi-experimental-pretest-post-test control group design employing a 2x3 factorial design with reasoning ability level as the moderating variable. The respondents of the study were the 4^{th} year students of INHS-SSC consisting of 2 sections; Sapphire with 26 students who served as the experimental group and Amethyst with the same number of students who served, on the other hand, as the control group. Students are further categorized as hypothetico-deductive (HD), Transitional (T), and empirical-inductive (EI) using Lawson's Classroom Test for Scientific Reasoning. A researcher-made ADI-laboratory guide for the experimental group and Physics Laboratory Manual by Silverio (2006) were employed in the study which includes selected activities such as Simple Circuit, Ohm's Law, Factors Affecting Resistance, and Series & Parallel Circuits.

In this study, the original ADI model proposed by Sampson, et al (2009) was adopted but revisions on some steps were done. Concept cartoons (Naylor & Keogh, 1999) were used in the first step as a stimulus for students to formulate their problem and plan their investigation to answer the problem. In addition, a possible replication of the investigation by another group as part of the peer-review was integrated in the model, although the actual replication was done only once in the whole semester due to time constraints. The distribution of the different steps was followed as those suggested by Walker, et al (2010).

Moreover, Integrated Process Skills Test II (TIPS II) to test students' science process skills was also integrated. The process skills measured were the five (5) identified integrated process skills – identifying & controlling variables (ICV), generating hypothesis (GH), defining operationally (DO), interpreting data (ID), and experimenting (E). These process skills were described as Beginning (B), Developing (D), Advanced (A), and Exemplary (E). Further, the data were subjected to appropriate statistical treatment for the analysis.

Results and discussion

Results revealed that before the intervention, students' science process skills for both groups were already within the advanced level and even at the exemplary level for HD students. These data are reflected in Tables 1 and 2.

Table 1
Level of Students' Skills in the Five Integrated Science Processes of the Experimental Group before the Intervention

Skill	**no of items**	**HD**			**T**			**EI**			**WHOLE GROUP**		
		M	**SD**	**Level**	**M**	**SD**	**Level**	**M**	**SD**	**Level**	**M**	**SD**	**Level**
ICV	12	8.67	1.53	A	8.67	1.71	A	6.60	1.14	A	8.27	1.76	A
GH	9	7.33	0.58	A	5.33	1.71	A	4.80	0.84	A	5.46	1.63	A
DO	6	5.33	0.58	E	4.00	0.97	A	3.80	1.10	A	4.12	1.03	A
ID	6	5.00	1.00	E	4.67	0.69	E	4.40	0.89	A	4.65	0.75	E
E	3	3.00	0.00	E	2.33	0.91	E	2.00	0.71	A	2.37	0.85	E
Total	36	29.33	2.52	E	25.00	3.78	A	21.60	0.89	A	24.85	3.85	A

Table 2
Control Group's Level of Skills in the Five Integrated Science Processes before the Intervention

Skill	**no of items**	**HD**			**T**			**EI**			**WHOLE GROUP**		
		M	**SD**	**Level**	**M**	**SD**	**Level**	**M**	**SD**	**Level**	**M**	**SD**	**Level**
ICV	**12**	**9.00**	**0.00**	**A**	**8.00**	**2.03**	**A**	**8.00**	**2.53**	**A**	**8.1**	**2.01**	**A**

											2		
GH	**9**	**7.33**	**0.58**	**E**	**5.59**	**1.62**	**A**	**5.17**	**0.98**	**A**	**5.69**	**1.52**	**A**
DO	**6**	**5.00**	**1.00**	**E**	**4.59**	**1.23**	**E**	**3.83**	**1.94**	**A**	**4.46**	**1.39**	**A**
ID	**6**	**4.67**	**1.15**	**E**	**4.65**	**0.86**	**E**	**3.83**	**1.94**	**A**	**4.46**	**1.21**	**A**
E	**3**	**3.00**	**0.00**	**E**	**2.59**	**0.51**	**E**	**1.33**	**0.82**	**D**	**2.35**	**0.80**	**E**
Total	**36**	**29.00**	**2.65**	**E**	**25.41**	**3.76**	**A**	**22.17**	**6.08**	**A**	**25.08**	**4.58**	**A**

When the students' science process skills were compared, results showed that at the start of the intervention, the experimental group's HD students had significantly better science process skills compared to its EI students, but no significant differences were seen between the experimental group's HD and T students as well as its T and EI students. On the other hand, no significant differences lie among students in the control group when they are classified according to their reasoning ability levels. When taken as a whole, no significant difference was seen between the control and experimental group. Further, no significant difference exists between HD students, T students, and EI students of the two groups.

Tables 3 and 4 show the level of students' science process skills of the experimental group and control group, respectively, after the intervention. As can be observed, the experimental group students' skills in the five science processes were already at the exemplary level while students in the control group were still at the advanced level except for the HD students who were within the exemplary level.

Table 3

Experimental Group's Level of Skills in the Five Integrated Science Processes after the Intervention

SPS	**no of items**	**HD**			**T**			**EI**			**WHOLE GROUP**		
		M	**SD**	**leve**	**M**	**SD**	**leve**	**M**	**SD**	**leve**	**M**	**SD**	**leve**

				l			l			l			l
ICV	12	9.67	0.58	E	10.61	1.75	E	9.00	2.45	A	10.19	1.88	E
GH	9	8.00	0.00	E	7.06	1.51	E	7.20	0.84	E	7.19	1.33	E
DO	6	5.67	0.58	E	5.11	0.76	E	4.60	1.52	E	5.08	0.93	E
ID	6	6.00	0.00	E	5.22	0.73	E	5.20	0.84	E	5.31	0.74	E
E	3	2.67	0.58	E	2.50	0.62	E	2.00	1.00	A	2.42	0.70	E
Total	36	32.00	1.00	E	30.56	3.58	E	27.80	4.55	E	30.19	3.71	E

Table 4

Control Group's Level of Skills in the Five Integrated Science Processes after the Intervention

SPS	**no of items**	**HD**			**T**			**EI**			**WHOLE GROUP**		
		M	**SD**	**level**	**M**	**SD**	**level**	**M**	**SD**	**level**	**M**	**SD**	**level**
ICV	12	10.67	1.15	E	8.76	2.19	A	7.33	1.97	A	8.65	2.21	A
GH	9	8.00	0.00	E	6.59	1.70	A	4.67	1.63	A	6.31	1.85	A
DO	6	4.67	1.15	E	4.76	0.75	E	3.67	1.03	A	4.50	0.95	A
ID	6	5.33	1.15	E	4.47	1.37	A	3.67	1.51	A	4.38	1.42	A
E	3	2.33	1.15	E	2.29	0.69	E	2.17	0.98	A	2.27	0.78	E
Total	36	31.00	2.00	E	26.88	4.72	A	21.50	4.46	A	26.12	5.19	A

When comparing students' gains in their science process skills after the intervention, T and EI students in the experimental group showed better gains in their science process skills compared to their counterparts in the control group while HD students had comparable gains. When taken as a whole, students in the experimental group had better gains in science process skills than those in the control group. In addition, no significant differences were seen in the gains among students of different reasoning ability levels belonging to the same group.

The results of this study support those reports by Basaga et al (1994), Brickman et al, (2009), Ergül et al (2011), Lati et al (2012), Myers, et al (2003) and Walker et al (2010) that inquiry-based laboratories, promote the development of science process skills. This is in consonance with the findings of Siahaan, et al (2019) who reported that the ADI method is effective in developing students' generic science skills.

Conclusions

The findings of the study imply that the Argument-Driven-Inquiry Laboratory Method is more effective in promoting students' development of science process skills compared to the Traditional Laboratory Method. Since the ADI method requires students to formulate a hypothesis to explain the concept cartoon, test this hypothesis by performing a well-planned experiment and evaluate their explanation based on their data, thus, science process skills are promoted. The absence of such opportunities in the traditional laboratory method may have hindered the improvement in students' skill development. The study had also shown that regardless of students' reasoning ability level, all students benefit from the ADI method.

Recommendations

It is recommended that science teachers utilize the ADI Laboratory Method especially in performing laboratory activities. The present K+12 Basic Science curriculum encourages the use of inquiry-based activities as well as performing scientific investigations and this study had shown that the ADI Laboratory Method is a very good strategy that can be used to materialize these objectives. It is, therefore, recommended that the ADI Laboratory Method be implemented in any regular DepEd science class, especially for the STEM strand as well as Introductory Science laboratory courses at the college level. Teacher training and seminars in the use of different inquiry-based approaches such as the ADI Laboratory Method are further recommended to empower science teachers.

Different research can also be done related to this study. It is suggested that the effectiveness of the ADI Laboratory Method be examined on students of different learning styles as well as its effect on students' argumentation skills, attitude towards science, and social skills. It is also recommended that different group compositions (such as heterogeneous, homogenous, and friend-based groups) and group sizes be tested to determine which group composition and size would best facilitate cooperative learning.

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