

Action research

Effects of ADDIE Model as an Instructional System Design for Senior High School Students in Natural Science through Alternative Delivery Learning

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Abstract: The nature of science learning is to teach students to be involved in the investigation. Investigations in science can help improve the performance and skills of students. The purpose of this study is to plan to design instructional strategies after crafting the Sustainability Action Plan in the school context. Specifically, it attempts to answer the following research objectives: (1) To determine the pre-test and post-test scores of the experimental group after their exposure to the ADDIE model in teaching natural science, and (2) To determine the significant improvement in the students' scores before and after exposure of the ADDIE model. Using a quasi-experimental design with non-probability sampling, the two experimental groups (n=30) per section taking up General Chemistry 2, and General Physics 2. The results revealed that the respondents obtained closer mean values of the pretest (M=10.80, M=9.03) but the mean value of the post-test for General Chemistry is greater than General Physics (M=23.00, M=12.27). Likewise, there is no significant difference in improvement between the means of General Physics ($t = 1.8959$; $p = 0.0630$) compared to General Chemistry which is significant ($t = 13.6640$; $p = 0.0001$) when tested at $\alpha 0.05$. The data suggest that students need a strong focus on the competencies taken from the modules on whatever modalities of learning are utilized. A parallel study is recommended to enhance the students' problem-solving skills at the junior high school level to establish the effectiveness of ADDIE Model.

Keywords: effectiveness, learning modality, science, ADDIE model

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1. Introduction

The nature of science learning is to teach students to be involved in the investigation. Investigations in science can help improve the performance and skills of students. They are carried out by discussing such conversations (as related to activities and direct observations designed to trigger students' curiosity, investigative science skills, observation, data recording, data analysis, and conclusion drawing. From the results of these investigations, Kurniawan et al. (2011) emphasized that there will be a learning desire for students so they can improve students critical thinking skills toward science subjects.

The study of Akerson et al. (2011) has shown that students do not have an adequate understanding of the nature of science (NOS) by the time they exit high school, there is also evidence that they have not received NOS instruction that would enable them to develop such understandings. In addition, Handrianto et al. (2021) pointed out the design of instructional strategies which is expected to build a relationship between learning theory and practice in the instructional system. Certainly, there are at least four basic elements in instructional strategies which include the characteristics of students, objectives, instructional design, and evaluation procedures.

Indeed, instructional design has played an integral role in the education and corporate sectors since its inception. Technology has greatly influenced various instructional design factors, including learners' and instructors' beliefs about knowledge, instruction, and learning. According to one industry trends report on instructional design, for instance, emerging technologies and concepts, such as gamification, virtual reality, and artificial intelligence continue to have an impact on the learning process (Bouchrika, 2023).

Hess and Greer (2016) used the ADDIE instructional design framework to build an iteration of a credit-bearing information literacy course. The phases of analysis, design, development, implementation, and evaluation were used to integrate current e-learning best practices and several of the colleges' and universities' high-impact practices to increase student engagement and make real-world applications. From the authors' experience, other academic librarians may find applications for instructional design constructs in their own teaching practices, both in online and face-to-face learning environments.

ADDIE model proved itself as a very useful instructional model in the preparation of materials for traditional teaching and there is a strong intention to use this model for electronic and online teaching materials. There is also an increase in student learning outcomes by looking at the comparison of pre-test and post-test results when the ADDIE Instructional Model was systematically used in developing a Production-based BPBL Model (Drljača et al., 2017; Adri et al., 2020).

According to participants' opinions about visual, sound, and interaction variables containing educational materials shows that; the ADDIE model is a suitable method for the produce e-learning materials and is an applicable method for adult education. Adult individuals have autonomy, so they want to be independent of the instructional materials (Gökkaya & Güner, 2014). Likewise, the effectiveness of this design has been measured, and results in both groups in this study were compared, the experimental group showed statistically significant in students' performances (Alnajdi, 2018).

Moreover, Almelhi (2021) examines the effectiveness of the ADDIE model as used in teaching online in the LMS of Blackboard® and its facilities such as discussion boards, forums, and blogs for improving the creative writing skills of EFL college students. Results demonstrated that there were statistically significant differences between the mean scores gained by the experimental group and those obtained by the control group writing performance post-testing to the good of the experimental group participants.

Subsequently, several studies concluded that respondents' performance increased when ADDIE Model was introduced and employed. Asuncion (2016) affirms that student activities like multimedia projects shall continuously be provided to polish collaboration, creativity, curiosity, and sense of adventurism that would lead to students' holistic development and not deteriorate good learning qualities of the students. Notwithstanding, Sarkodie (2023) expanded the stages of the ADDIE Model to include the "reflection component". It has provided empirical evidence on the effect of reflection processes on students' academic performance and ex-panded the literature on hospitality education. Azimi (2015) reported that the studies trained by ADDIE model have high scores mean compared to the students learning Futsal by the traditional method of key skills.

On the other hand, the study of Ali (2021) indicated among others that students taught using Dick and Carey Model performed academically higher in Motor Vehicle Mechanics Work than their counterparts taught using the Addie Instructional Model. According to Quinn as cited in Chen (2016) the disadvantages of ADDIE include that the analysis step is not broad enough in the design process; the model is too linear and not flexible; and it does not encourage inspiration. Nevertheless, it provides structured guidance for design, serving as a valuable checklist to ensure a solid course design, and including a great focus on implementation and evaluation

Meanwhile, the Department of Education (DepEd) has reminded school heads that they are authorized to suspend in-person classes and implement alternative learning methods to ensure the safety of students, teachers, and non-teaching personnel amid the scorching heat. Head on the news of the country reported that DepEd issued a memo to public and private schools on April 20 reminding them that they are authorized to suspend face-to-face classes and shift to alternative delivery modes. Accordingly, the current DepEd spokesperson Michael Poa informed all citizens that schools have different situations. Thus, school heads should determine what learning mode is best for them (Malonzo, 2023; Ombay, 2023).

In the local setting, most of the secondary students in Don Sergio Osmeña Sr. Memorial National High School science classes are not exposed to instructional designs scientifically. Their Mean Percentage Score (MPS) from the third periodic performance falls on the below average to satisfactory level as reflected on the School Monitoring Evaluation and Adjustment (SMEA). Indeed, only one science teacher from the senior high school department had conducted action research on manipulative skills intended for STEM students only in the current school year. With the explosive technologies, traditional teaching could not be effective. Therefore, adopting and utilizing computer and communication technology in education became the most important to make learning more active in the new normal, but before utilizing

technology in education, teachers need to ensure of suiting the technology with the students' abilities and characteristics based on ADDIE Model.

For this purpose, the researchers plan to design instructional strategies after crafting the Sustainability Action Plan in the school context as it helps science teachers to analyze, design, develop, implement, and evaluate the teaching and learning activities to mitigate the poor performance of the students based on the results of the study.

This study aims to determine the effectiveness of the ADDIE Model through alternative delivery learning. Specifically, it attempts to answer the following research objectives:

1. To determine the pretest and post-test scores of the experimental group after their exposure to the ADDIE model in teaching natural science;
2. To determine the significant improvement in the students' scores before and after exposure to the ADDIE model in teaching natural science; and
3. To recommend a sustainable action plan based on the results of the study

Statement of Hypotheses concerns:

H1: There is no significant improvement in the Grade 11 STEM students' scores before and after exposure to the ADDIE model of teaching natural science

H2: There is no significant improvement in the Grade 12 STEM students' scores before and after exposure to the ADDIE model of teaching natural science

In this study, an interactive lesson was designed based on ADDIE Model. Students will be divided into two groups; the STEM classes from senior high school levels comprising Grade 11- Athena and Grade 12- Syzygy sections will be exposed as an experimental group with 30 students per section to evaluate the effectiveness of using the interactive lesson and its role in enhancing students' learning performance. The lesson had several stages; starting from having a useful design based on ADDIE Model, then providing a demo to the students to understand the knowledge. After that, the lesson will be presented in an interactive way, assistance hints provided to students during their learning process, and reviewing the initial demo are available for the whole lesson.

Since most students in the respective classrooms walked with a wide range of abilities, the researchers find ways to meet the needs of all students, including those with learning and thinking differences using the ADDIE model as an intervention. The Key takeaways (1) mapping out ideas using pictures and charts is especially effective with struggling students; (2) strategies that involve memorizing phrases help students remember concepts longer.; and (3) when students use all their senses, they remember the material better.

In Figure 1, the ADDIE Model helps researchers to design instructional strategies to apply in teaching-learning situations. It is a flexible guideline that allows teachers to get feedback from the students and provide continuous assessment

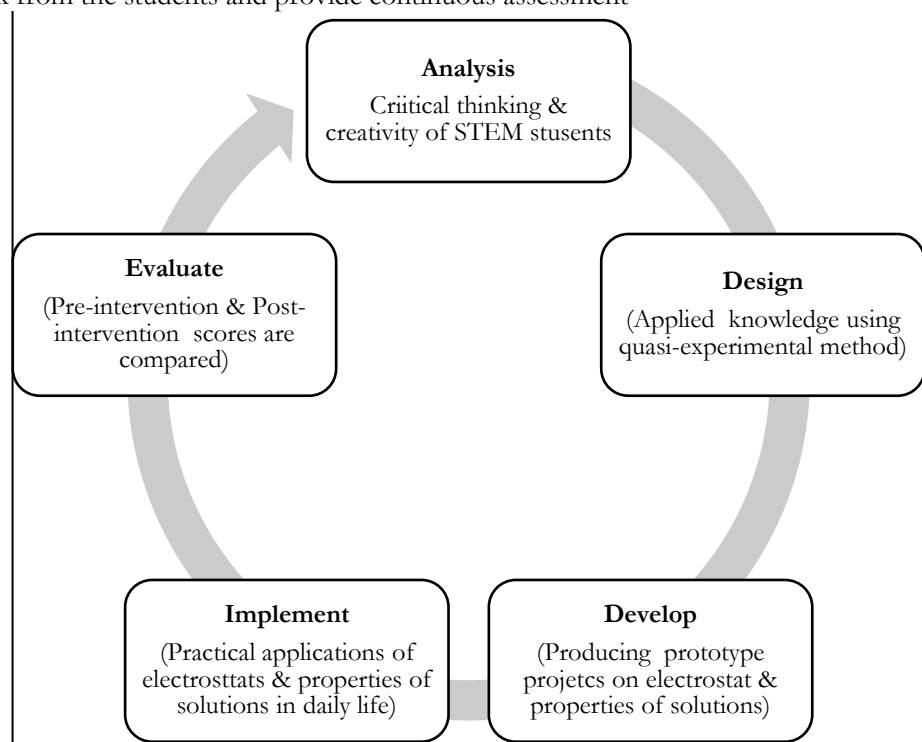


Figure 1. Framework of the Study

This model is an effective support tool to improve teaching competency among secondary school students. Through this model, teachers can analyze the learning needs of students in their classrooms (Hadrianto et al., 2021). In phase of analysis, teachers can investigate students, content, task, and several factors that can influence the instruction. In phase of design, teachers should be able to design teaching plans based on the students' needs. Teachers should address how the instructional goals and objectives to form strategies. In phase of development, teachers develop a tool process to create a new method and approach to deliver learning materials. In phase implementation, teachers do execution of the materials and create effective classroom management by involving students in learning activities. In phase evaluation, teachers can evaluate at what levels the students' understanding to their learning in formative and summative assessments. Based on the evaluation, teachers are allowed to revise an effective instructional strategy for future improvement. It is a part of the cycles of teaching competency of teachers by adapting ADDIE Model in the teaching-learning process.

Consultation and approval from the school research council, as well as the Learning and Development Coordinator, were sought since the planning, implementing, monitoring, and evaluating will be conducted during the In-service Training (INSET) and Learning Action Cell (LAC) sessions for two rounds once the creative investigation will be approved by the School Governance and Operations Division (SGOD) of the Division of Cebu City. The planning and research section gave the appropriate action as to its technical assistance and is able to implement sustainable programs and projects to help schools establish and manage a conducive learning environment and ensure learner readiness to learn.

2. Materials and Methods

This study used a quasi-experimental design to establish a cause-and-effect relationship between an independent and dependent variable. This design involved selecting participants based on a specific cutoff point on a continuous variable, such as a test score. Participants on either side of the cutoff point are then compared to determine whether the intervention or event had an effect. The two experimental groups of senior high school students were exposed using the ADDIE model comprising 30 sample sizes from STEM for every section of students from Grade 11 Athena who are currently taking up General Chemistry 2 and Grade 12 Syzygy taking up General Physics 2. In other words, a non-probability sampling technique is used in this research to select individuals or groups of individuals that meet specific criteria relevant to the research question or objective.

Specifically, the researchers had selected the participants who are experts in a particular field or subject matter. Both heterogeneous groups were purposively sampled and subjected to pretest and posttest through ADDIE model as an intervention. This was administered starting May 2023 right after the third grading. The laborious participants are the senior high school students due to good evidence that they are representatives of the total sample of 60.

An instructional plan was utilized that covers the concepts of different subject areas with the adapted cognitive process dimensions with the use of descriptive statistics including mean, frequency, percentage, and ranking. The researcher a validation of the pretest with other classes that were not included in the study. This process determined if the pre-test administered to the participants was acceptable in content validation and its format. This was also examined by the master teachers and school principals in case they would suggest some revisions that would improve the validity of the assessment tool.

The data that were utilized in this action research are categorized into two. For Grade 11, the topics covered are properties of solutions, solubility, and the stoichiometry of reactions in solutions. The learners were able to use different ways of expressing the concentration of solutions: percent by mass, mole fraction, molarity, molality, percent by volume, percent by mass, ppm. The instructional materials to be used will be Module 3 Week 4 (n.d.) Properties of Solutions with a duration of 2 class periods / 120 minutes.

Furthermore, the Grade 12 were also exposed to ADDIE model in General Physics 2 covering the topic of Electrostatics and Coulomb's Law. The students were expected to use theoretical and experimental approaches to solve multi-concept and context-rich problems involving electricity. As a result, they will calculate the electric field due to a system of point charges using Coulomb's Law. The instructional materials to be utilized are the General Physics 2 Quarter 3 Week 1 Module 1: Electrostatics (DepEd) with a duration of two meetings / 12 hours (6 hours per meeting).

The respondents' scores from the administered pre-test and post-test were collected and treated using descriptive-inferential statistics. After computing its corresponding mean, the

following parameters were utilized: 90% and above (Outstanding), 85-89% (Very Satisfactory), 80-84% (Satisfactory), 75-79% (Fairly Satisfactory), and 74% and below (Did Not Meet Expectations). To establish if there is a significant improvement in students' achievement based on the pre-test and post-test of the correlated mean will be employed at α 0.05 level of significance.

The research subjects are free to choose to participate without any pressure or coercion. No personal identification details such as names and residential addresses were collected during the initial stages of the research. All participants can withdraw from, or leave, the study at any point without feeling an obligation to continue. There is no need to provide a reason for leaving the study. The researcher would let them know that their data will be kept confidential and that they are free to stop filling in the survey/questionnaire at any point for any reason. They can also withdraw their information by contacting their class adviser.

3. Results

The results of the present study are presented as per each hypothesis, followed by a short explanation.

Hypothesis One:

To verify the first hypothesis suggesting that "There is no significant improvement in the Grade 11 STEM students' scores before and after exposure to the ADDIE model of teaching natural science at the 0.05 level", a t-test for independent samples was used to compare the mean scores of the two groups on the skill of originality in the posttest.

Table 1. Grade 11 Students' Performance Using ADDIE Model in Teaching General Chemistry

Test	Mean	Standard Deviation	t- Value	P value	Degree of Freedom	Effect Size (η^2)
Pretest	9.03	3.11	13.6640*	0.0001	29	3.532**
Posttest	23.00	4.65				

* Significant at the 0.05 level ** Very large effect size

Table 1 shows that the calculated t-value (13.6640) is statistically significant at the 0.05 level of confidence. Therefore, it becomes evident that there is a significant improvement in the students' scores before and after exposure to the ADDIE model in teaching natural science. So, the first hypothesis is rejected. Furthermore, the effect size value was very large as $\eta^2 = 3.532$. Thus, the suggested strategy had a very large effect on the participants' performance.

Hypothesis Two:

It was proposed that there was no significant improvement in the Grade 12 STEM students' scores before and after exposure to the ADDIE model of teaching natural science in the skill of accuracy at 0.05 level. To verify this hypothesis, t-test for independent samples was used to compare the mean scores of the two groups on the skill of accuracy in the post-test.

Table 2: Grade 12 Students' Performance Using ADDIE Model in Teaching General Physics

Test	Mean	Standard Deviation	t- Value	P value	Degree of Freedom	Effect Size (η^2)
Pretest	10.80	2.43	1.8959*	0.0630	29	0.491**
Posttest	12.27	3.47				

* Significant at the 0.05 level ** Moderate effect size

Table 2 shows that the calculated t-value (1.8959) is statistically not significant at the 0.05 level of significance. Therefore, it becomes evident that there is no significant difference between the means of the scores obtained by the participants based on their pretest and post-test scores. Hence, the second hypothesis is confirmed. Furthermore, the effect size value

was identified as moderate where $\eta^2 = 0.491$. Thus, the ADDIE model design in the senior high school STEM academic strand has moderate effect on the participants' performance in natural science.

4. Discussion

The obtained scores of the Grade 11 students showed significance in describing how Coulomb's Law can be used to solve electrostatics problems as well as displaying independence and collaboration with their classmates when answering activities and assignments. As applied in daily life, electrostatics has many practical applications, such as in the functioning of electronic devices, electrostatic painting, and electrostatic discharge protection. This concept is aligned with the study of Asuncion (2016) who affirms that student activities like multimedia projects shall continuously be provided to polish collaboration, creativity, curiosity, and sense of adventurism that would lead to students' holistic development and not deteriorate good learning qualities of the students. In addition, electrostatics also has many medical applications, such as in electrostatic precipitators for removing pollutants from air and in electrostatic cell separation techniques for isolating specific cells. Finally, electrostatics is widely used in industry for various applications, such as in electrostatic dust collectors, electrostatic oil cleaners, and electrostatic printing.

On the other hand, the Grade 12 students obtained scores resulting in no significant difference when they were exposed to ADDIE model. Thereupon, they had moderate effect sizes when the two treatments (pre-test and post-test) were administered and demonstrated minor understanding of the properties of solutions, solubility, and the stoichiometry of reactions in solutions. Quinn as cited in Chen (2016) confirmed the disadvantages of ADDIE include that the analysis step is not broad enough in the design process; the model is too linear and not flexible; and it does not encourage inspiration. Based on the performance of the students and through observation of the conduct of the lesson, the researchers proved a less effective utilization on the effectiveness of the model as an instructional design. Stoichiometry is one of the most fundamental topics in senior high school STEM courses, but it is also one of the most challenging concepts for students to master. As with any abstract concept, activities that encourage conceptual thinking tend to promote a deeper level of understanding.

5. Conclusions

The statistical analysis demonstrated that the ADDIE model applied in alternative delivery of learning proved to be effective for teaching natural science subjects to Grade 11 students who improved significantly in favor of the post-test in the overall test at the 0.05 level of significance. Results of the study indicated that the use of the weblog as a medium of projecting students' displaying independence and collaboration with their classmates when answering activities and assignments in the instructional design of the ADDIE model functioned as an effective teaching and learning tool supportive of the process of creative writing.

Similarly, the amount of growth between the pre-test and post-test was not significant in overall Grade 12 group students. Some factors related to the suggested strategy and the implemented teaching/learning methodology seem to account for the registered progress in their overall understanding of the properties of solutions, solubility, and the stoichiometry of reactions in solutions skills.

Pedagogically, the findings from this study suggest that science teachers should be mindful of the significance of e-learning resources and strategies inherent in the full utilization of alternative learning delivery and discussion boards as teaching and learning tools for enhancing students' problem-solving performance compared to the conventional method. Despite its successful application in two settings, ADDIE is not a guarantee for successful and effective instruction. This means instructional solutions cannot guarantee desired learning outcomes, which is very different from the causal relationship in a science rule.

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