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SEAMLESS LEARNING THROUGH PROJECT ARDI IN RESEARCH BASED INSTRUCTION FOR SENIOR HIGH SCHOOL LEARNERS

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ABSTRACT

This study examined the effectiveness of Seamless Learning Approach through Project ARDI in enhancing the research competence and academic performance of senior high school learners in research-based instruction. Mixed methodology was used to assess the engagement, benefits, academic productivity, research attitude, and performance outcome of learners prior to and post implementation of the research intervention. Validated survey questionnaires, pretest and posttest results, and academic records were the sources of quantitative data, while learners' reflection and feedback for qualitative data. In analyzing the results of the research, descriptive statistics, paired sample t-test, correlation analysis, and thematic analysis were used. The findings indicated that learners exhibited relatively competent research skills, minimal research mastery, and adequate academic performance. However, with the implementation of Project ARDI, considerable improvement was seen in all aspects. Learners developed highly competent engagement, perception of benefits, and attitude towards research, as well as increased academic productivity. Moreover, a significant difference was found between the posttest and pretest scores with improved academic performance in the second quarter indicating that Project ARDI helped learners enhance their academic performance. Additionally, qualitative data revealed trends toward empowerment, enhanced confidence, improved cooperation, integration of formal and informal learning, and greater recognition of the importance of research. Overall, these findings indicated that Project ARDI successfully transitioned participants from initial research participation to mid-advanced level of research engagement, revealing the effectiveness of integrated learning, technology-enhanced learning, and project-based learning approaches in fostering productive learning, competency development, and positive academic outcomes among senior high school research subjects.

Keywords – Seamless Learning Approach, Project ARDI, Research Competence, Academic Performance, Learner Engagement

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Introduction

The integration of digital technologies into senior high schools has transformed teaching methods and learning environments. Developments in AI and mobile technologies have broadened the scope for students to acquire, manipulate, and utilize information in diverse settings. The learning process in an education environment does not solely take place inside the classroom setting; rather, it happens through informal and autonomous learning processes outside school premises. Zimmerman (2012) defined formal learning as systematic and curriculum-based learning, whereas informal learning was considered spontaneous and learner-led.

In this dynamic environment, seamless learning became an instructional approach where technology was effectively used to ensure continuity of learning from one setting to another. The approach allowed the learners to link their classroom learning with practical experience, thus improving their conceptual knowledge and skills (Fucio et al., 2022). Nevertheless, it was still difficult for senior high school teachers to apply evidence-based instructions that would help integrate these two learning environments and develop the learners' research competencies.

The theoretical underpinning for this study is rooted in the Technological Pedagogical and Content Knowledge (TPACK) model, which underscores the interactive nature of content knowledge, teaching approaches, and technology in the classroom setting. In a research-based learning environment, teachers must blend research content, inquiry-based pedagogies, and Artificial Intelligence technology in an integrated fashion to foster student independence and continuous involvement.

Although more educational technologies are now available, many senior high school students exhibited inadequate research skills, poor motivation, and lack of confidence in performing research activities. According to past studies, educational software driven by artificial intelligence focused on personalized instruction rather than collaboration, cross-curricular integration, and the acquisition of general research skills (Strielkowski et al., 2025). Consequently, students had difficulty extending their knowledge gained from research into practical inquiry and self-directed learning.

Moreover, the divide between classroom instruction and informal learning limited learners' chances to apply research skills in practical situations. This problem was especially pronounced in senior high schools, where learners were supposed to acquire sophisticated research skills to be ready for college-level courses and beyond. However, the absence of instructional models that allowed for effective integration of AI tools within research-oriented instruction emphasized the necessity for implementing an intervention aimed at overcoming cognitive and motivational obstacles in acquiring research skills.

With regard to tackling these problems, the current action research introduced the concept of Project ARDI, which is an AI-based application that can facilitate the process of analyzing the research data. The introduction of Project ARDI as a scaffolding tool helped learners go through the various phases of research analysis, including organization, analysis, and interpretation of the data. The use of the software simplified the computational process, thus enhancing learner motivation during the analysis phase.

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This intervention used a seamless learning strategy that combined formal classroom learning with informal learning through conducting independent research work, working with peers, and investigating issues outside the classroom. The strategy was based on the theory of project-based learning, which emphasized real-world research challenges, active participation, and learner independence (Zhang & Ma, 2023). Instructors were trained in ways to include Project ARDI in research classes in a manner consistent with educational standards.

Project ARDI was able to serve as both a technological instrument and an educational support structure through this intervention process. The purpose was to improve the research skills, engagement, and academic achievement of the students by allowing them to experience technology-enhanced research activities on a consistent basis.

Literature Review

Researchers point out educational inadequacies like inadequate technological framework and poor AI knowledge on the part of teachers, especially in places like Nigeria (Sidi & Chadirwe, 2026). This problem hampers the proper use of AI in education, hence reducing its impact on improving learning results (Kabir, 2025; Okunade, 2024).

This problem is made worse by the absence of appropriate instructional resources and best practice models on the use of AI in education, which constitute a major impediment according to teachers (Sanusi et al., 2021). This makes it extremely difficult to nurture research skills since both teachers and learners have a poor understanding of the benefits of using AI in academic research (Kabir, 2025).

This indicates the importance of having measures put in place and the design of user-friendly AI tools that will help fill these knowledge gaps in order to achieve an equal application of technology within the senior high school curriculum (Sambo-Magaji et al., 2025; Venzon & Venzon, 2025). It is crucial to equip students to face an AI-filled future by introducing new technologies such as AI in teaching strategies (Ayanwale et al., 2024).

Nevertheless, from the available literature, there appears to be an absence of research on the issue of AI education among K-12 students in Africa that would require an investigation of various stakeholders' views to facilitate the integration of AI within the curriculum (Sanusi et al., 2024). The deficiency is more prevalent in science education, where teachers' resistance to new innovations limits the use of AI within education (Nja et al., 2023).

Moreover, the absence of empirical data concerning the presence of Africa within AI literacy discourse in education, especially outside Western Africa, demands further geographical exploration in terms of teachers' opinions and the difficulties faced during instruction (Jatileni et al., 2023). The limited use of AI technology within education is due to insufficient infrastructure, along with the lack of formal training among educators, even as they recognize its teaching capabilities (Wahab et al., 2025).

Research Questions/Objectives

The main problem that was taken into consideration in this study through action research is the

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lack of integration between the two learning environments (formal and informal). This resulted in restrictions on the opportunities for students to use research-based skills through practical application. Therefore, a program called Project ARDI (Automated Research Data Interpreter), which uses Microsoft Excel as an educational platform, was developed to help implement this seamless learning process.

The project was assessed based on its success in enhancing the skills of the learners in research, increasing their level of participation, and improving learning results through an inquiry-based program using technology. The research questions were set up to establish whether the program made any difference in helping to form a unified learning framework in research for senior high school learners.

Specifically, this action research sought to answer the following questions:

1. What is the level of senior high school learners' research competence before and after the seamless learning approach through Project ARDI in research-based instruction in terms of:
   1.1. engagement;
   1.2. benefits;
   1.3. academic productivity; and
   1.4. attitudes towards research?
2. What is the level of the pretest and posttest performance of the senior high school learners in seamless learning approach in research-based instruction?
3. What is the level of academic performance of the senior high school learners before and after the seamless learning approach through Project ARDI in research-based instruction?
4. Is there a significant difference between the pretest and posttest performance of the senior high school learners before and after the implementation of seamless learning approach through Project ARDI in research-based instruction?
5. Is there a significant difference between the level of academic performance of the senior high school learners before and after the seamless learning approach through Project ARDI in research-based instruction?
6. Is there a significant relationship between the academic performance and the posttest performance of the senior high school learners after the implementation of seamless learning approach through Project ARDI in research-based instruction?
7. How do senior high school learners describe their perspectives towards research activities change after the implementation of seamless learning approach through Project ARDI in research-based instruction?

Participants

The main subjects of this action research project were senior high school students in the GAS strand who are taking Practical Research 2 classes for School Year 2025-2026. The other sources of data were research work produced by the learners, which includes research proposals, analyses of collected data, and their research paper outputs from using the software called Project ARDI. Additional sources of data were surveys made by the learners, observations taken from the

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classroom setting, and transcripts from the focus group discussion.

The study comprised around thirty (30) participants who were selected through purposive sampling. Purposive sampling was used in this study since the respondents were specifically chosen due to certain criteria related to the research goals. As described by Bisht (2024), purposive sampling is a sampling method that uses the selection of individuals who have qualities that relate to the research objectives. The participants in this study were selected because of the fact that they were enrolled in subjects involving research and had been exposed to Project ARDI intervention.

Methodology

Research Design

This research used a convergent parallel mixed methods design to assess the efficacy of Project ARDI in facilitating connections between formal and informal education in senior high school learners. Data were gathered simultaneously using quantitative and qualitative approaches and then analyzed individually before synthesis.

Quantitative data analysis involved the use of descriptive statistics, paired samples t-tests to analyze pre and post-test scores, and Pearson's correlation to determine relationships between academic achievement, post test scores, and self-perceived competence. Thematic analysis was applied to the qualitative data, which were coded and categorized based on the experiences of the learners.

Instruments

The research instruments, such as achievement tests, rubrics, checklists for observations, and interview guidelines, were validated by experts comprising three people (Educational Researcher, English Teacher, and Statistician) for content validation, clarity, and appropriateness in relation to the curriculum standards and study objectives. The pilot testing, involving 15 students not participating in the study, took place in July 2025 to evaluate the feasibility, understandability, and reliability of the research instruments. Internal consistency was measured through the use of Cronbach's alpha to yield a reliability coefficient of $\alpha=0.86$, suggesting good reliability and acceptable internal consistency of research instruments in educational studies (Taber, 2018).

Data Collection

To find out how effective Project ARDI is in establishing linkages between the formal and informal learning systems, the researchers used a mixed method data collection strategy as required by the action research design. The data was collected using pre-test and post-test tools, learners' research products, classroom observation, and focus group discussion.

The pre-tests and post-tests were conducted during Week 8 of the First Quarter and Week 8 of the Second Quarter (July-December 2025) to assess learners' research skills including their ability to formulate research questions and conduct data analysis and levels of motivation and self-efficacy. The instruments included researcher-made questionnaires which were conducted during

classroom sessions.

The learners' research outputs which include research proposals, data analysis, and final reports were collected during Weeks 4 and 8 of the First Quarter and Week 8 of the Second Quarter through Project ARDI. They were analyzed using rubrics based on the principles of project-based learning.

Observations of the classroom were carried out on a weekly basis throughout the research classes through the use of a structured observation checklist to note the engagement, collaboration, and participation of the learners. In addition, focus group discussions were also held involving six to eight learners in Week 8 of the First Quarter and Second Quarter beyond school hours in order to collect qualitative data regarding the learners' experiences and perceptions about the Project ARDI.

In terms of research instruments, a pretest-posttest questionnaire, scoring rubrics, observation checklist, and focus group discussion guide were utilized for data collection purposes. In order to ensure content validity and relevance, all research instruments were scrutinized by a committee of three experts who are an educational researcher, an English teacher, and a statistician. A pilot test was done in July 2025 involving twenty (20) learners from a non-participant class in order to establish reliability, clarity, and feasibility of the research instrument.

Data Analysis

The analysis of data involved the use of descriptive statistics, paired sample t-tests to establish any significant difference between means, and Pearson's correlation coefficient r to test the relationship between variables (Field, 2018). Likert scale rating items were considered interval scales of measurement, allowing for parametric analysis of data (Norman, 2010). The qualitative data were analyzed using thematic analysis by following the guidelines provided by Braun and Clarke (2006).

In addition to these considerations, ethical guidelines were strictly adhered to during the course of this research.

Findings and Discussion

In this section, the results on the effectiveness seamless learning approach through Project ARDI in enhancing the research competencies of the learners will be shown and discussed. Quantitative data will be supported by qualitative observations to provide a thorough analysis of the observed improvements.

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Table 1: Senior High School Learners' Perceived Level of their Research Competence Before and After the Implementation of Seamless Learning Approach through Project ARDI in Research-Based Instruction

Indicators	Before			After		
	M	SD	VI	M	SD	VI
Engagement Levels	2.93	0.77	SWC	4.34	0.56	HC
Perceived Benefits	2.95	0.77	SWC	4.43	0.59	HC
Academic Productivity	2.70	0.84	SWC	4.19	0.65	C
Attitudes Towards Research	3.19	0.87	SWC	4.51	0.53	HC
Legend: 1.00-1.80 (NC-Not Competent); 1.81-2.60 (SC-Slightly Competent); 2.61-3.40 (SWC-Somewhat Competent) 3.41-4.20 (C-Competent); 421-5.00 (HC-Highly Competent)						

The above comparison reveals a definite and constant increase in the research competence among Senior High School learners as a result of the use of the Seamless Learning Approach as seen in Project ARDI. Before the implementation of the project, learners on all dimensions were assessed to have a developing competency in relation to their research knowledge and skills, showing that learners already had some skills and understanding which are still developing. After the implementation, major changes have occurred with regard to engagement in the learning process, benefits of research, achievement in academics, and attitudes towards research. It can be seen that after the use of the approach, learners became more engaged in the process, became more assured of the importance of research, and more competent in meeting research requirements in school.
Generally, the results suggest that Project ARDI was able to facilitate a shift from passive participation to confidence, competency, and value-based engagement in research. The results follow current research suggesting that technology-mediated learning environments foster continuous learning, enhance learner engagement, and produce significant developments in research competence and performance (Bond et al., 2020).

Table 2: Pretest and Posttest Performance

Test Performance	Pretest			Posttest		
	M	SD	VI	M	SD	VI
	26.80	3.74	MTM	39.63	4.44	M
Legend: 0-23 (Low Mastery), 24-36 (Moving Towards Mastery), 37-50 (Mastered)						

From the data presented in Table 2, it is evident that there were significant gains made by the subjects after the intervention because the pretest scores show low mastery levels, while the posttest scores demonstrate a move towards mastery level attainment. This implies that there was

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a positive effect made by the instructional or treatment aspect from the start of the assessment until the end, making it possible for the students to make progress in terms of gaining mastery of skills within the given period of time. This type of design, where there is a comparison between pretest and posttest scores, is common in educational studies where there is the measurement of any gain made by the subjects in terms of knowledge or competency acquisition due to the intervention made (Malicoban, 2025).

Moreover, existing literature underscores that pretesting can serve not only to benchmark initial competency levels but also to motivate learners and focus attention on targeted learning objectives, thus contributing to enhanced performance on subsequent assessments (Shek and Zhu, 2018).

Table 3: 1st and 2nd Quarter Academic Performance

Academic Performance	**1st Quarter**			**2nd Quarter**		
	M	SD	VI	M	SD	VI
	86.17	1.76	VS	90.23	2.227	O
Legend: 75-79 (Fairly Satisfactory), 80-84 (Satisfactory), 85-89 (Very Satisfactory), 90-100 (Outstanding)						

Performance data in comparison for the first and second quarters reveals some significant improvement in the performance of the students through time. In the first quarter, most of the learners were placed in the Very Satisfactory category, indicating their satisfactory but still developing understanding in learning expectations. The second quarter's performance, however, saw the emergence of more students with higher performance categorizations. The most prevalent performance among these students is in the Outstanding performance category. There seems to have been some positive change in the performance of the students during the first two quarters that may be credited to various improvements made in the process of learning. Among these could be improved learning conditions, increased involvement of the students in learning activities, and other pedagogic considerations done in order to increase student learning performance. All these performance trends reveal the multi-factorial nature of success in education (Alj & Bouayad, 2024).

Table 4: Significant Difference Between the Pretest and Posttest Performance of the Senior High School Learners Before and After the Implementation of Seamless Learning Approach Through Project ARDI in Research-Based Instruction

		t-value	**p-value**	**Degree of Significance**	**Decision**
Pretest	Posttest	-16.620	0.000	Significant	Null Hypothesis is Rejected
$p<0.05$					

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The improvement shown by Table 4 above is statistically significant, implying the effectiveness of the intervention in improving the measured constructs. The t-value is calculated at –16.620, with a p-value of 0.000, indicating a statistically significant difference in the mean score between the pretest and posttest ($p<0.05$). Therefore, the null hypothesis can be rejected based on these findings, thereby establishing that the intervention led to an increase in posttest scores compared to the pretest. These results are in agreement with the existing literature in educational measurement. Specifically, when measuring the effects of an educational or instructional intervention, researchers apply a paired sample t-test, which generates statistically significant differences, including significant values of t and insignificant values of p. These results are consistent with those reported in high-indexed articles, in which a statistically significant pre-post score increase occurred following an intervention (Arrieta-Cohen et al., 2024).

Table 5: Significant Difference Between the Academic Performances of the Senior High School Learners Before and After the Implementation of Seamless Learning Approach Through Project ARDI in Research-Based Instruction

		t-value	p-value	Degree of Significance	Decision
1st Quarter Period	2nd Quarter Period	-15.627	0.000	Significant	Null Hypothesis is Rejected
p<0.05					

There is a statistically significant difference between the 1st Quarter Grade and the 2nd Quarter Grade, as shown by Table 5. The negative t-value demonstrates an immense improvement from the performance in the 2nd Quarter. This implies the success of the intervention carried out since the results were favorable. With a p-value of 0.000, which is less than the usual standard level of significance (0.05), there exists enough evidence to dismiss the null hypothesis. The conclusion that can be drawn from this analysis is that there is an intervention effect as demonstrated by improved performance during the second quarter. The results obtained are consistent with other scholarly works, stating that academic interventions lead to improved academic performance (Hung et al., 2025).

Table 6: Significant Relationship Between the Academic Performance and the Posttest Performance of the Senior High School Learners After the Implementation of Seamless Learning Approach Through Project ARDI in Research-Based Instruction

		r-value	p-value	Degree of Significance	Analysis	Decision
2nd Quarter's Academic Performance	Posttest Performance	-0.023	0.451	Not Significant	Very Weak Negative Correlation	Null Hypothesis is Accepted
p<0.05						

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As shown on Table 6, there is no significant relationship between the 2nd quarter academic performances of the senior high school learners and their posttest performances after the use of the Seamless Learning Approach via Project ARDI. The obtained r-value of –0.023 represents a very weak negative correlation, whereas the value of p (0.451) exceeds the 0.05 significance level. Therefore, the null hypothesis stands, signifying that the improvements in academic performances are not closely correlated with previous posttest. This result is aligned with the findings of recent studies showing that instruction methods like interventions based on project-based and seamless learning approach can make a difference to learners' performances regardless of previous academic performances (Cheng et al., 2023).

Table 5: Summary of Themes from the Learners' Reflections and Feedback on the Implementation of Project ARDI

Category	Themes	Top 5 Codes
Project ARDI as a tool for data interpretation and organization	Transformation in Research Competence	Clarity of research Complexity of concept Simplicity of analysis Change of confidence Confidence
	Empowerment through Structured Guidance	Structured Guidance Systematic Methodology Organized Data Research Importance Analysis with Meaning
	User-Friendly Research Experience	Usability for new users Novice Friendly Organizational capabilities Clear and understandable Minimizes user stress
	Empowerment through Research Tools	Improved Research Skills Boosting Confidence Levels Conducting Personal Research Building Communication Confidence Increased Motivation
	Effectiveness of Project ARDI in Enhancing Research Skills	Positive Tone Project Strength Skill Building Practical Example Learning Impact

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Transformation in Research Competence

It is possible to state that there was a significant change in the level of research competency achieved by the participants considering the substantial progress in knowledge and skills acquisition and development after working on Project ARDI. One of the main codes that can be pointed out is that of the clarity of research. The first participant mentioned that the project helped:

"I understand the steps better."

thus facilitating the clarification and structuring of the research process and increasing its comprehensibility. In such a way, it can be assumed that the process was simplified for the participants.

In turn, Participant 5 stressed that there used to be a complexity of concept that was overcome with the help of Project ARDI, the learner mentioned that the intervention helped:

"Helped me understand research concepts that were hard for me before."

Hence, it is possible to claim that there used to be some difficulties in terms of abstract and complicated research concepts that were eliminated.

Moreover, there was a code called the simplicity of analysis, the third participant noted that the project helped:

"The tool explained the process in a simpler way"

while the second participant indicated that able:

" I learned how to properly analyze data."

Thus, one can conclude that data analysis became easier and less difficult because of some clear instructions and guidelines.

Lastly, there was an obvious change in confidence, as noted by the fourth participant who said that the project enabled:

" I can now interpret results more confidently."

Consequently, there was a significant increase in confidence regarding research conduct and interpretation.

Empowerment through Structured Guidance

The participants' answers show an empowering theme of structured guidance which allows Project ARDI to help students learn to analyze research data in an organized way. First, a prominent code is structured guidance since Participant 1 says,

“The tool guided me step by step, especially in organizing my data into tables and interpreting the results.”

Here, the program offered clear step-by-step guidance, helping students to perform research according to the step-by-step plan.

The next closely connected code is systematic methodology expressed in Participant 3's answer:

"Project ARDI showed me how to move from raw data to proper analysis."

The tool provided a step-by-step process which allowed moving from unprocessed data to proper analysis.

Organized data is another code in the answers from Participant 5:

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"ARDI helped us with organizing data in tables and presentations efficiently."

The participants appreciated the possibility of organizing and analyzing data better and faster thanks to the program's instructions.

Another important finding concerns the importance of research which was seen in Participant 2's answer:

"It helped me understand what my data means instead of just putting numbers in a table."

Students stopped seeing data simply as numerical values and learned to understand their meanings.

A code found in the answers is analysis with meaning. Participant 4,

"I did not feel lost because the instructions were clear when analyzing data."

This shows how clear instructions allowed students to conduct analyses meaningfully without feeling uncertain.

As a result, Project ARDI empowered students to conduct research using a systematic methodology with step-by-step instructions.

User-Friendly Research Experience

Consequently, the theme user-friendly research experience provided through Project ARDI's support for the learners in terms of easy-access and usability. Participant 1:

" Project ARDI was easy to use and not confusing even for beginners like me."

This idea is supported by Participant 5:

"It was user-friendly and suitable for senior high school students."

Organizational capabilities is another aspect discussed. Participant 2 expressed:

" The structure helped me focus on one part of the research at a time."

The code of clear and understandable, which is also mentioned in the interviews, Participant 3 says,

"The instructions were simple and easy to follow."

Participants mention that the aspect of minimizing user stress is reflected in the statement made by Participant 4:

"I liked how the tool was organized because it made research less stressful."

Hence, the results prove that Project ARDI ensures a user-friendly research experience, that it remains accessible to novices, clearly organized and instructed, and minimizes user stress.

Empowerment through Research Tool

The responses of the participants emerge a theme, empowerment through research tools, emphasizing how Project ARDI enhanced learners' confidence, independence, and engagement in research. One of the main codes, for instance, is boosting confidence levels. Participant 1:

"I became more confident in doing research on my own."

The response indicates that the use of the tool boosted learners' self-confidence in performing the assigned tasks. Such a conclusion can also be drawn from the responses provided by Participants 3 and 5.

Another key code is building communication confidence. Participant 5 says,

"I am now more confident when discussing our research findings."

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Thus, ARDI improved learners' communication skills apart from other skills required to accomplish a particular assignment.

Increased motivation represents another code that has been revealed. Participant 2 says,

"I felt more motivated to finish my research because I understood what I was doing."

It means that procedural clarification motivated learners to perform their tasks better.

The code improved research skills emphasized by Participant 4 stated,

"I became more engaged in research activities because it was easier to follow."

Moreover, Participant 3 say,

"It made it easier for me to do data analysis without fear."

The results reveal that Project ARDI improves students' researching abilities, builds up their self-confidence, fosters independence, improves communication skills, and motivates them to do better research.

Effectiveness of Project ARDI in Enhancing Research Skills

The effectiveness of Project ARDI in enhancing research skills, demonstrated significant results in terms of the development of the learners and their experience of researching. Participant 1 expresses:

"Project ARDI is effective because it really helped improve my research skills."

A stance is confirmed by the project's strength, Participant 4 states:

"It helped me a lot, especially in data analysis, which is usually difficult."

The code skill building, provided by the learners who noticed improvements in their research skills thanks to the implementation of the project, especially in data analysis. However, Participant 2 proposes a way to improve the tool with the help of a practical example:

"It is helpful, but adding more examples would make it better."

Notably, including additional examples can positively affect the learning process of the students involved.

Finally, the code learning impact can be traced from the responses of Participants 3 and 5:

"I think Project ARDI should continue to be used in research subjects" and

"It is suitable for those who just started with research subjects."

Generally, the findings show that Project ARDI is highly effective in enhancing research skills, particularly in complex areas, while also emphasizing the value of adding more practical examples to further enhance its learning impact.

Implications

From the results presented above, the implementation of the proposed Seamless Learning Approach using Project ARDI can be considered an appropriate method to enhance research skills and academic achievements of Senior High School learners participating in research-oriented instruction. Positive changes in learners before and after the experiment prove that technology-driven, collaborative, and project-oriented learning environments may improve learners' participation and research skills development.

Moreover, it is also evident from the current study that incorporating seamless learning in

teaching research skills can go a long way towards solving the learners' problems regarding conducting research owing to their constant availability and guidance for authentic learning experiences outside the traditional classroom environment. Additionally, it can be seen from the findings of the current study that the project ARDI can be adopted by the teachers and school administration to enhance learners' academic productivity.

More importantly, this study makes a contribution to the expanding literature on technology integration and seamless learning by demonstrating how innovative teaching methods can lead to effective learning and produce well-prepared students who are capable of conducting research.

Conclusion

From the findings presented above, one can deduce that there was a marked improvement in the level of research competence among Senior High School learners as a result of the Seamless Learning Approach, which was carried out through Project ARDI. In terms of pre-test results, the subjects only showed moderately competent levels in terms of engagement in research, benefits associated with doing research, productivity during research and their overall attitude towards research, suggesting that although they already possessed basic research skills and knowledge, there were constraints as far as confidence, understanding and intrinsic motivation towards research were concerned.

After the adoption of the Project ARDI program, remarkable progress was seen for all the variables used. High competence was shown in the areas of engagement, benefit perceptions, and attitudes towards research. Competence was also attained in academic productivity. The posttest and academic performance findings showed considerable improvement, thus indicating the effectiveness of the program in improving learners' understanding, skills, and readiness in research. Further analysis showed that the difference between pretest and posttest scores, and first and second quarter academic performances was significant, thus failing to uphold the null hypotheses.

The qualitative results indicated that Project ARDI enabled empowerment via increased engagement, heightened confidence, better collaboration, effective incorporation of formal and informal education, and increased recognition of relevance in research. Thus, this study shows that a smooth integration of learning supported by technology and carried out within a project framework can help convert passive learners into self-confident and research-oriented people.

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Declarations

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5. Ethics, Consent to Participate, and Consent to Publish declarations. This study was reviewed and approved by the Sta. Catalina Integrated National High School Research Ethics Committee in accordance with institutional ethical guidelines and principles. Informed consent was obtained from all participants involved in the study. For participants under 18 years old, informed consent was obtained from their parents or legal guardians prior to participation. The author consents to the publication of this manuscript and all accompanying materials.

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Bionote:

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