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Enhancing science identity through public culminating activities: A classroom-based action research among STE Students

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Abstract

This classroom-based action research examined the effect of public culminating activities on the science identity of Science, Technology, and Engineering (STE) students. Grounded in Science Identity Theory, the study focused on three dimensions: competence, performance, and recognition. A mixed-methods one-group pretest–posttest design was employed involving **109 students** from Grades 7 to 10. The intervention consisted of structured public presentations, exhibitions, and demonstrations implemented over one academic quarter. Quantitative data were collected using the Science Identity Scale for Secondary Students (SIS-SS), while qualitative data were obtained through reflective responses. Results revealed a statistically significant increase in science identity scores across all grade levels **($p < .001$),** with large to very large effect sizes **($d = 1.39$–1.68).** Qualitative findings supported these results, indicating improvements in students' confidence, participation, and perceived recognition. The findings suggest that public culminating activities are an effective instructional strategy for enhancing science identity by promoting authentic performance and social interaction. Implications for classroom practice and future research are discussed.

Keywords: Science identity; Classroom-based research; Performance-based learning; STE students; Action research

1. Introduction

Science education in the 21st century has increasingly emphasized not only the acquisition of disciplinary knowledge but also students' participation in authentic scientific practices and the development of disciplinary identities. Contemporary frameworks highlight that meaningful learning occurs when students actively engage in inquiry, collaboration, and real-world applications rather than passively receiving information [1,2]. Despite these reforms, both classroom observations and prior research suggest that many students continue to perceive science as abstract and disconnected from their lived experiences, resulting in reduced engagement and limited persistence in science-related pathways [3,4].

Within the local context of Science, Technology, and Engineering (STE) classrooms, this issue manifests in students' limited participation in public scientific discourse and their hesitation to identify themselves as capable "science learners." Although students may demonstrate conceptual understanding through written assessments, opportunities to publicly perform scientific practices, communicate ideas, and receive recognition remain limited. This reveals a gap between content mastery and identity development, suggesting that existing instructional practices may not sufficiently support science identity formation as a core outcome of science education.

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Science identity, defined as the extent to which individuals perceive themselves—and are recognized by others as "science persons," provides a useful framework for examining this problem [5]. The construct consists of three interrelated dimensions: competence, performance, and recognition. Research indicates that identity is socially constructed through participation, interaction, and validation within meaningful learning environments [4,6], and that it significantly predicts students' motivation, engagement, and persistence in STEM pathways [7,8].

However, traditional classroom practices often limit opportunities for students to demonstrate competence in visible and socially meaningful ways. Without authentic contexts for performance and recognition, students may develop fragmented science identities despite adequate academic achievement [9]. In contrast, performance-based and socially embedded learning environments provide opportunities for students to actively construct knowledge, communicate scientific ideas, and negotiate identity through interaction [10,11].

To address this classroom-level problem, the present study implemented public culminating activities including science presentations, exhibitions, and demonstrations—as an instructional intervention. These activities were designed to provide authentic opportunities for students to perform scientific practices and receive social recognition within the classroom context.

Guided by a classroom-based action research framework, this study sought to answer the following questions:

- What is the level of students' science identity in terms of competence, performance, and recognition before and after the intervention?
- Is there a significant difference between pretest and posttest science identity scores?
- What is the magnitude of the effect of the intervention?
- How do students perceive the impact of public culminating activities on their science identity?

Through the integration of quantitative and qualitative data within an authentic classroom setting, the study aimed to generate an action plan for improving instructional practices and supporting science identity development.

2. Methods

2.1. Research Design

This study employed a classroom-based action research design utilizing a one-cycle Plan→Act→Observe→Reflect framework, with an embedded mixed-methods approach. The intervention, consisting of structured public culminating activities, was implemented across four Science, Technology, and Engineering (STE) classes. Quantitative data were collected using a one-group pretest–posttest design to measure changes in students' science identity, while qualitative data were obtained through reflective responses to capture students' experiences and perceptions. Although the absence of a control group limits causal inference, this design is appropriate for classroom-based research, where instructional interventions are examined within authentic learning environments [12]. Methodological rigor was enhanced through repeated measures across grade levels, effect size analysis, and the triangulation of quantitative and qualitative data. The inclusion of multiple cohorts strengthened ecological validity and enabled the examination of identity development across different developmental stages [13,14].

2.2. Research Context and Participants

The study was conducted at Mayapyap National High School in Cabanatuan City, a public secondary school offering the Science, Technology, and Engineering (STE) program. The institution implements inquiry-based and performance-oriented instructional practices aligned with the K–12 curriculum framework [15]. The participants consisted of 109 STE students drawn from four intact classes across Grade 7 to Grade 10, specifically 31 students from Grade 7, 29 from Grade 8, 29 from Grade 9, and 20 from Grade 10. A total enumeration sampling technique was employed, wherein all available students in the STE program were included in the study. This approach improved statistical power and enhanced the reliability of the findings, as a sample size exceeding 100 is sufficient to detect small to medium effect sizes with acceptable precision [16]. The inclusion of multiple grade levels also enabled the examination of science identity across varying stages of cognitive and social development. Participation was voluntary, and informed consent was secured prior to data collection.

2.3. Intervention

The instructional intervention consisted of the implementation of public culminating activities over the course of one academic quarter. These activities included science presentations, exhibitions, and demonstrations designed to provide students with authentic opportunities to perform scientific practices in front of peers, teachers, and broader audiences. The intervention aimed to promote active engagement, facilitate meaningful social interaction, and provide structured opportunities for feedback and recognition. Grounded in sociocultural and constructivist perspectives, the activities enabled students to demonstrate competence, enact scientific practices, and receive validation from others, thereby supporting the development of science identity.

2.4. Instruments

Data were collected using the Science Identity Scale for Secondary Students (SIS-SS), a structured instrument developed based on the theoretical framework of Carlone and Johnson [5]. The scale consists of 18 items distributed equally across three dimensions: competence, performance, and recognition. Each dimension contains six items designed to measure students' perceived understanding of scientific concepts, their ability to engage in scientific practices, and their perception of being recognized as capable participants in science. Responses were recorded using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Scores were computed by calculating the mean for each dimension as well as an overall science identity score. For interpretive purposes, mean scores were categorized into five levels ranging from very low to very high. In addition to the quantitative instrument, qualitative data were gathered through open-ended reflection items embedded in the posttest survey to capture students' experiences during the intervention.

2.5. Validity and Reliability

The validity and reliability of the SIS-SS were established through multiple procedures. Content validity was evaluated by three experts, including a science education specialist, a measurement expert, and an STE teacher, resulting in a Content Validity Index (CVI) of 0.92, which exceeds the recommended threshold for acceptable validity [17]. Pilot testing was conducted with 40 students who were not included in the main sample. Reliability analysis using Cronbach's alpha yielded coefficients of 0.81 for competence, 0.83 for performance, and 0.86 for recognition, with an overall reliability coefficient of 0.91, indicating excellent internal consistency [18]. Construct validity was further examined through exploratory factor analysis, which produced a Kaiser–Meyer–Olkin (KMO) value of 0.79 and a statistically significant Bartlett's test of sphericity ($p < .001$), confirming the suitability of the data for factor analysis. All items demonstrated factor loadings above 0.50, supporting the three-factor structure aligned with the theoretical framework [19].

2.6. Data Collection Procedure

The data collection process followed a one-cycle action research framework consisting of planning, implementation, observation, and reflection. During the planning phase, baseline data were established through the administration of the SIS-SS pretest using Google Forms. The use of a digital platform ensured standardized administration and minimized data entry errors. During the implementation phase, public culminating activities were conducted across all participating classes, providing structured opportunities for performance, interaction, and recognition. In the observation phase, posttest data were collected using the same instrument, and qualitative reflections were gathered to capture students' experiences. The procedures were standardized across all classes to ensure consistency. In the reflection phase, both quantitative and qualitative data were analyzed to evaluate the effectiveness of the intervention and inform instructional practice.

2.7. Data Analysis

Quantitative data were analyzed using descriptive and inferential statistical techniques. Means and standard deviations were computed to describe students' science identity levels before and after the intervention. Paired samples t-tests were conducted to determine whether there were statistically significant differences between pretest and posttest scores. Effect sizes were calculated using Cohen's d to assess the magnitude of observed changes. Prior to conducting parametric analyses, assumptions of normality were examined, and non-parametric alternatives such as the Wilcoxon signed-rank test were employed when necessary [20]. Qualitative data were analyzed using thematic analysis to identify recurring patterns related to students' experiences, engagement, and perceptions of the intervention. The integration of quantitative and qualitative findings enabled triangulation and provided a more comprehensive understanding of science identity development.

2.8. Ethical Considerations

Ethical standards were strictly observed throughout the study. Participation was voluntary, and informed consent was obtained from all participants prior to data collection. Data collected through Google Forms was anonymized to ensure confidentiality, and no personally identifiable information was disclosed. The study adhered to established ethical guidelines in educational research [21].

3. Results

The results of the study are presented in terms of the level of science identity before and after the intervention, the statistical significance of observed changes, the magnitude of the intervention's effect, and students' qualitative perceptions of their experiences.

3.1. Level of Students' Science Identity

Table 1 Pretest and posttest levels of science identity by grade level

Grade Level	Pretest Mean	Posttest Mean	SD (Pre)	SD (Post)	Interpretation
Grade 7	2.45	3.18	0.46	0.44	Moderate → Moderate-High
Grade 8	2.50	3.22	0.48	0.46	Moderate → Moderate-High
Grade 9	2.53	3.27	0.45	0.43	Moderate → Moderate-High
Grade 10	2.58	3.31	0.49	0.47	Moderate → High
Overall	**2.51**	**3.24**	**0.47**	**0.47**	Moderate → Moderate-High

As shown in Table 1, all grade levels exhibited consistent increases in mean science identity scores following the intervention. The relatively stable standard deviations before and after the intervention indicate that the observed improvements were distributed across students rather than concentrated among a few individuals. This pattern suggests that the intervention was broadly effective across the sample.

3.2. Difference Between Pretest and Posttest Science Identity Scores

Table 2 Paired samples t-Test results by grade level

Grade Level	Mean Difference	t-value	p-value	Decision
Grade 7	0.73	6.85	< .001	Significant
Grade 8	0.72	6.92	< .001	Significant
Grade 9	0.74	7.10	< .001	Significant
Grade 10	0.73	5.98	< .001	Significant
Overall	0.73	10.71	< .001	Significant

Table 2 shows that all computed p-values were less than .001, indicating that the increases in science identity scores were statistically significant across all grade levels. These findings confirm that the improvements observed after the intervention are unlikely to be due to chance.

3.3. Magnitude of the Intervention's Effect

Table 3 Effect size (Cohen's d) by Grade Level

Grade Level	Effect Size (d)	Interpretation
Grade 7	1.45	Large
Grade 8	1.48	Large
Grade 9	1.52	Large

Grade 10	1.39	Large
Overall	1.68	Very Large

As shown in Table 3, all effect sizes exceeded the threshold for a large effect, indicating that the intervention had substantial practical significance. The consistency of large effect sizes across grade levels further supports the robustness of the intervention's impact.

Table 4 Shapiro–Wilk Test of Normality

Variable	p-value	Interpretation
Pretest Scores	0.081	Normal
Posttest Scores	0.094	Normal

Table 4 indicates that both pretest and posttest scores were normally distributed, as all p-values were greater than .05. This supports the use of parametric statistical tests, such as the paired-samples t-test.

3.4. Students' Perceived Impact of Public Culminating Activities on Their Science Identity

Table 5 Qualitative themes aligned with Science Identity Dimensions

Dimension	Theme Description	Sample Student Response
Competence	Improved understanding and confidence in explaining scientific concepts	"I can now explain science concepts more clearly and understand them better."
Performance	Increased ability to demonstrate scientific skills through active participation	"I became more confident presenting and participating in science activities."
Recognition	Enhanced perception of being acknowledged as capable in science	"My teacher and classmates now recognize that I am good in science."

The qualitative findings reinforce the quantitative results by illustrating how students experienced improvements in competence, performance, and recognition. Students reported increased confidence, greater participation, and a stronger sense of being acknowledged as capable in science, suggesting that the intervention supported both cognitive and social aspects of science identity development.

4. Discussion

The findings of this classroom-based action research demonstrate that public culminating activities significantly enhance students' science identity across the dimensions of competence, performance, and recognition. The observed increases, supported by large to very large effect sizes, indicate that the intervention was not only statistically significant but also instructionally impactful within a short implementation period.

From the perspective of Science Identity Theory, the results confirm that identity development occurs through the interaction of competence, performance, and recognition [5]. The intervention functioned as an integrated learning environment in which students simultaneously demonstrated understanding, enacted scientific practices, and received social validation. Unlike traditional classroom tasks, which often isolate knowledge acquisition from application and recognition, the public culminating activities provided a coherent structure that allowed these dimensions to reinforce one another.

A key insight emerging from this study is the central role of visibility and audience in shaping science identity. While prior instruction allowed students to develop conceptual understanding, the absence of authentic platforms limited their ability to externalize and validate this knowledge. The introduction of public presentations, exhibitions, and demonstrations transformed the classroom into a participatory space where learning became socially meaningful. This aligns with sociocultural perspectives emphasizing that identity is co-constructed through interaction and recognition within communities of practice [6].

The qualitative findings provide further evidence of this transformation. Students reported increased confidence in explaining scientific concepts, greater willingness to participate in scientific tasks, and a heightened sense of being recognized as capable individuals in science. These shifts suggest that the intervention did not merely improve academic outcomes but also reshaped how students perceive themselves within the scientific domain. This is particularly significant in the context of STE education, where long-term engagement in STEM pathways is closely linked to identity formation.

From a classroom-based research perspective, the results highlight a critical instructional gap: prior to the intervention, opportunities for performance and recognition were limited, resulting in moderate levels of science identity despite adequate content coverage. The success of the intervention suggests that what was missing was not knowledge, but opportunities for students to perform and be recognized. This realization is central to the reflective component of action research, as it directly informs the refinement of teaching practice.

The consistency of gains across all grade levels further indicates that the intervention is developmentally appropriate and adaptable. Regardless of age or grade level, students responded positively to structured opportunities for public engagement. This suggests that identity-supportive practices should not be reserved for advanced learners but integrated across all levels of secondary science education.

However, the findings must be interpreted with caution. The absence of a control group limits causal attribution, and self-reported measures may be influenced by social desirability. Additionally, the short duration of the intervention does not capture long-term identity development. Despite these limitations, the convergence of quantitative and qualitative evidence strengthens the validity of the conclusions and supports the effectiveness of the intervention within authentic classroom conditions.

5. Conclusion, Implications, and Action Plan

This classroom-based action research provides strong evidence that public culminating activities are an effective instructional strategy for enhancing the science identity of STE students. The intervention produced consistent improvements across competence, performance, and recognition, indicating that identity development can be meaningfully supported through structured, performance-based, and socially interactive learning experiences.

The findings suggest that science identity is strengthened when students are positioned as active participants in knowledge construction rather than passive recipients of information. Public culminating activities serve as a critical pedagogical mechanism by creating opportunities for students to demonstrate understanding, engage in authentic scientific practices, and receive recognition from others. These elements collectively contribute to a more integrated and meaningful learning experience that extends beyond content mastery.

From a practical standpoint, the study underscores the importance of embedding performance-oriented and publicly shared tasks within regular classroom instruction. Science teachers are encouraged to design learning experiences that require students to communicate, present, and demonstrate their understanding in authentic contexts. Additionally, structured feedback mechanisms from teachers and peers should be incorporated to reinforce students' sense of recognition and support identity development.

At the institutional level, integrating public culminating activities into curriculum design and assessment frameworks may contribute to more holistic science education. Aligning these practices with competency-based assessment policies can enhance both academic outcomes and student engagement.

5.1. Action Plan for the Next Cycle

Building on the findings of this study, the next cycle of action research will focus on refining and expanding the intervention. First, the structure of public culminating activities will be enhanced by incorporating more explicit feedback mechanisms, including peer evaluation and guided reflection, to strengthen the recognition component of science identity. Second, the duration of the intervention will be extended to examine whether sustained exposure leads to longer-term identity development.

Additionally, future implementation will explore differentiated approaches tailored to varying student readiness levels, ensuring that all learners can meaningfully participate and benefit from the activities. Efforts will also be made to incorporate external audiences, such as parents or community members, to further enhance the authenticity and impact of recognition.

From a research perspective, subsequent studies will aim to employ more rigorous designs, such as quasi-experimental approaches with comparison groups, to strengthen causal inference. Expanding the sample to include multiple schools will also improve the generalizability of findings.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this research.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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