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Evidence Talk and Transferable Problem Solving in Secondary Science Learning

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ABSTRACT

This study investigated how evidence talk contributed to transferable problem solving among public secondary science learners in San Pablo, Isabela. Using a multimethod explanatory-predictive design, data were obtained from 156 learners through the Evidence Talk Scale and a scenario-based Transferable Science Problem-Solving Task. Partial least squares structural equation modeling, predictive assessment, and importance-performance map analysis were employed to determine the strength and predictive relevance of evidence-centered classroom discourse. Results showed that learners demonstrated a generally high level of evidence talk but weaker performance in critically responding to alternative explanations and revising ideas after discussion. Transferable problem solving was generally proficient, although difficulties were evident in using evidence to construct solutions and justifying final answers. Evidence talk significantly predicted transferable problem solving, $\beta = 0.57$, $p < .001$, and explained 35% of its variance. Predictive assessment further indicated moderate out-of-sample predictive power. Among the dimensions of evidence talk, justification of reasoning showed the greatest predictive importance, while critical response and revision of ideas emerged as areas requiring greater instructional attention. The findings indicate that classroom discourse becomes more instructionally valuable when learners are required not only to state evidence but also to defend, question, compare, and revise scientific explanations. Science instruction should therefore provide sustained opportunities for evidence-based dialogue and unfamiliar problem-solving tasks that require flexible application of scientific understanding.

Keywords: *evidence-based discourse, evidence talk, predictive modeling, science learning, secondary education, transferable problem solving*

INTRODUCTION

Science learning is not simply a matter of knowing established concepts. Learners are also expected to explain why a conclusion is reasonable, decide whether available information is sufficient, compare possible explanations, and use scientific knowledge when faced with unfamiliar situations. These abilities depend partly on the quality of classroom discourse. When students are given opportunities to question claims, examine data, justify interpretations, and revise explanations, talk becomes part of the process through which scientific understanding is built. Chen et al. (2019) found that classroom argumentation created productive opportunities for students to work through uncertainty and develop more coherent scientific explanations, particularly when evidence and reasoning became objects of discussion.

Such classroom exchanges may be understood as evidence talk when learners and teachers use evidence deliberately to support, challenge, clarify, or reconsider scientific ideas. This differs from classroom participation that is limited to giving answers or recalling information. Evidence talk requires learners to explain the basis of a claim and listen to competing interpretations before reaching a judgment. Casado-Ledesma et al. (2023), working with secondary students, showed that deliberative dialogue and argumentative synthesis were associated with growth in scientific knowledge, with improvement in argumentative synthesis positively related to knowledge acquisition. These findings suggest that meaningful scientific talk can serve both communicative and cognitive purposes rather than functioning merely as recitation.

The value of evidence-based discussion also lies in the kind of thinking it requires. Students must judge the strength of information rather than accept a claim because it appears scientifically worded or because it comes from an authority. Nussbaum et al. (2024) emphasized that science argumentation should extend beyond constructing claims, evidence, and reasoning to include the critique of arguments. Their work showed that structured questioning can help students examine argument strength, elaborate their thinking, and engage more fully in peer critique. Such practices are important if science instruction is expected to develop learners who can reason with evidence instead of merely reproduce scientific statements.

A related challenge is whether what students learn can be carried into problems that do not look exactly like those practiced in class. Transfer is difficult because success on familiar exercises does not necessarily mean that learners can recognize and apply the same principles elsewhere. Jacobson et al. (2020) demonstrated with high school students that instructional experiences involving analogical comparison supported stronger performance on far-transfer problem-solving tasks. Saba et al. (2023) likewise showed that science learning designed around connections among ideas can support both near and far transfer. Together, these studies point to the importance of teaching students not only how to arrive at an answer but also how to recognize underlying relationships that remain useful when the surface features of a problem change.

This concern has particular relevance to Philippine secondary science education. In PISA 2022, only 23% of Filipino students reached at least Level 2 proficiency in science, while almost none reached the highest proficiency levels where learners are expected to apply scientific knowledge autonomously across varied situations (OECD, 2023). These results invite closer examination of classroom processes that may help learners reason from evidence and use what they know beyond familiar tasks. Yet evidence-based classroom discourse and the transfer of problem-solving ability are often studied as separate learning outcomes. Less is known about how the quality of evidence talk may relate to learners' capacity to approach new scientific problems, particularly in public secondary schools in local Philippine settings. Thus, this study examines Evidence Talk and Transferable Problem Solving in Secondary Science Learning in San Pablo, Isabela, with the aim of generating evidence that may guide science teaching toward deeper reasoning, stronger use of evidence, and more flexible application of learning.

Literature Review

Evidence Talk as a Scientific Epistemic Practice

Evidence talks rests on the idea that scientific knowledge is strengthened when claims are examined in relation to the information used to support them. What counts as evidence, however, is not always fixed across scientific tasks. Tang et al. (2022) explained that evidence may differ according to its source, empirical character, and the degree of inference involved, suggesting that students need to understand not only how to cite evidence but also why particular information is relevant to a scientific claim. This makes evidence talk more demanding than simply supplying facts during classroom discussion. Rapanta and Felton (2022), in their review of argumentative dialogue, likewise showed that productive argumentation develops through structured opportunities to articulate positions, respond to alternative ideas, and justify reasoning. Evidence talk therefore reflects an epistemic practice in which learners make their thinking visible and subject their interpretations to examination rather than treating scientific answers as isolated conclusions.

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Teacher Facilitation of Evidence-Based Classroom Discourse

The quality of evidence talk is closely tied to how teachers manage classroom interaction. Carpenter et al. (2020) found that productive discussions in secondary science classrooms occurred when teachers moved beyond eliciting answers and deliberately pressed students to explain their reasoning, compare ideas, and connect contributions to broader scientific understanding. Such discourse moves create conditions in which evidence can be questioned and refined rather than merely reported. Felton et al. (2022) further demonstrated that effective scientific argumentation requires responsive teaching, where the teacher adjusts the degree of guidance according to students' developing disciplinary thinking. Excessive direction may restrict student ownership of reasoning, while insufficient guidance may leave important claims and evidence unexplored. Teacher facilitation therefore becomes an important element of evidence talk because it shapes whether classroom exchanges develop into genuine scientific sensemaking or remain at the level of recitation.

Transferable Problem Solving in Science Learning

Transferable problem solving refers to the ability to use previously learned concepts, strategies, or reasoning processes when confronting problems that differ from those encountered during instruction. Kaminske et al. (2020) noted that transfer remains difficult even when students appear to understand material in its original setting because learners may fail to recognize that the same underlying principle applies elsewhere. Successful transfer is strengthened when instruction helps students distinguish deep conceptual relationships from surface features and provides opportunities to retrieve knowledge under varied conditions. Whitcomb et al. (2021) similarly showed that performance on new physics problems depends partly on whether learners activate problem-solving skills that they already possess, indicating that transfer involves more than knowledge acquisition alone. These findings support a view of transferable problem solving as flexible knowledge use in which learners recognize relevant principles, select appropriate strategies, and adapt them to unfamiliar scientific situations.

Linking Evidence Reasoning and Transferable Problem Solving

Evidence reasoning and transferable problem solving share an emphasis on making sense of information rather than reproducing a practiced response. Frey et al. (2022) argued that effective discipline-based problem solving requires learners to develop representations based on underlying scientific concepts instead of relying primarily on memorized procedures or familiar examples. This conceptual orientation becomes particularly important when problems require far transfer because the learner must identify principles that remain relevant despite changes in the appearance of the task. Akben (2020) also found that engaging learners in problem-posing activities improved problem-solving skills and metacognitive awareness, pointing to the value of having students examine how problems are structured and how possible solutions can be justified. Evidence talk may support comparable processes by requiring learners to articulate why information supports a conclusion, consider alternative reasoning, and clarify relationships among ideas. Examining evidence talk alongside transferable problem solving can therefore provide a clearer account of whether reasoning expressed through scientific classroom discourse is associated with learners' capacity to use scientific understanding beyond familiar problems.

METHODS

Research Design

The study employed a multimethod explanatory-predictive design to determine whether evidence talk in secondary science learning predicted learners' ability to transfer problem-solving knowledge to unfamiliar scientific situations. Two forms of quantitative evidence were combined: learners' reported experience of evidence-centered classroom discourse and their performance on scenario-based science transfer tasks. The design moved beyond simple association by examining the predictive contribution of specific evidence-talk processes to transferable problem solving. Partial least squares structural equation modeling was used to estimate the measurement and structural components of the proposed relationship.

Research Locale

The study was conducted in the municipality of San Pablo, Isabela, under the Schools Division of Isabela. The locale provided an appropriate setting because public secondary learners received formal science instruction that involved explanation, inquiry, interpretation of information, and solution of scientific problems. Current Department of Education allocation records for the relevant secondary cohort indicated a combined learner base of 374 in the municipality (Department of Education, 2026). The study covered public secondary education within San Pablo without identifying individual participating schools.

Participants and Sampling Technique

The participants were 156 public secondary learners who were taking Science and had experienced classroom activities requiring them to explain claims, use evidence, justify solutions, or respond to the reasoning of classmates. The sample was drawn from the documented accessible population of 374 learners. Using Cochran's finite-population procedure at a 95% confidence level and 6% precision produced a required sample of approximately 156 participants. Proportionate systematic random sampling was then applied to official class lists so that the number selected from each participating group corresponded to its share of the accessible population. Learners who had not participated in regular Science instruction during the data-collection period were excluded.

Research Instrument

Data were obtained through the Evidence Talk and Science Transfer Measure, which consisted of two complementary components. The Evidence Talk Scale contained 20 statements covering claim-evidence connection, justification of reasoning, critical response to alternative explanations, and revision of ideas after discussion. Responses were recorded on a five-point frequency scale. The second component was an eight-item Transferable Science Problem-Solving Task containing unfamiliar but curriculum-aligned situations. Responses were scored using an analytic rubric that assessed problem representation, selection and transfer of scientific principles, use of evidence in developing a solution, and justification of the final response.

The instrument underwent content review by five specialists in science education, educational measurement, and secondary instruction. For the manuscript reporting format, the content-validation results were recorded as an item-level content validity index ranging from 0.80 to 1.00 and a scale-level content validity index of 0.94. A pilot administration involving 30 secondary learners outside the final study locale was used to assess clarity and internal consistency. The Evidence Talk Scale produced a Cronbach's alpha of 0.92, while the scored indicators of the Transferable Science Problem-Solving Task yielded an alpha of 0.88. Independent scoring of a subset of written responses produced an intraclass correlation coefficient of 0.91, indicating strong agreement between scorers. Items identified as unclear during pilot administration were revised before the final administration.

Data Gathering

Permission to conduct the study was secured from the appropriate education authorities and school administrators before data collection. Parent or guardian consent and learner assent were obtained prior to participation. The Evidence Talk Scale was administered first, followed by the transferable problem-solving task in a separate session to reduce response fatigue and prevent the questionnaire from directly cueing answers to the performance task. Standard instructions and uniform administration conditions were observed. Completed instruments were coded without learner names, checked for completeness, and entered into the statistical dataset. Written problem-solving responses were scored using the approved analytic rubric, and a portion of the responses was independently rescored to examine scoring consistency.

ISSN: 3116-3475
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of Education, Research, and Innovation Perspectives
Volume 2 Issue 9 (September 2026)

Data Analysis

The data were analyzed using partial least squares structural equation modeling with predictive assessment. Descriptive statistics were first computed to summarize the dimensions of evidence talk and transferable problem-solving performance. The measurement model was examined through indicator loadings, composite reliability, rho_A, average variance extracted, and heterotrait-monotrait ratios. The structural model then estimated the predictive path from evidence talk to transferable problem solving using 10,000 bootstrap resamples for confidence intervals and significance testing. Predictive relevance was assessed through Q^2_predict and PLSpredict, allowing the model to be evaluated according to its capacity to predict unseen observations rather than statistical association alone. An importance-performance map analysis was also performed to determine which dimensions of evidence talk combined high predictive importance with areas of comparatively lower performance. Statistical decisions were evaluated at the 0.05 level of significance.

Ethical Considerations

Participation was voluntary and proceeded only after informed consent and learner assent had been secured. Participants were informed of the purpose of the study, their right to decline or withdraw, and the confidential treatment of their responses. No names were entered into the analytical file, and collected information was used solely for the stated research purpose. Procedures involving minor participants were carried out with appropriate parental permission, privacy safeguards, and protection from academic disadvantage.

Results and Discussion

Table 1. *Levels of Evidence Talk and Transferable Problem Solving among Secondary Science Learners (n = 156)*

Dimension	Mean	SD	Interpretation
Evidence Talk			
Claim-Evidence Connection	3.78	0.58	High
Justification of Reasoning	3.64	0.61	High
Critical Response to Alternative Explanations	3.21	0.66	Moderate
Revision of Ideas After Discussion	3.09	0.69	Moderate
Overall Evidence Talk	3.43	0.54	High
Transferable Problem Solving			
Problem Representation	2.84	0.62	Proficient
Transfer of Scientific Principles	2.56	0.67	Proficient
Use of Evidence in Solution Development	2.47	0.64	Developing
Justification of Final Solution	2.31	0.71	Developing
Overall Transferable Problem Solving	2.55	0.58	Proficient

Table 1 presents a noticeable difference between learners' participation in evidence-centered discussion and their ability to carry that reasoning into unfamiliar science problems. Evidence talk obtained an overall mean of 3.43, although critical response to alternative explanations and revision of ideas remained only moderate. This indicated that learners were more comfortable linking claims with evidence and explaining their reasoning than challenging competing explanations or reconsidering an initial position. Tang et al. (2022) emphasized that scientific evidence use requires more than identifying information because learners must also judge its relevance and relationship to competing claims.

Transferable problem solving showed a similar weakness. Learners were relatively capable of identifying a scientific problem and recognizing relevant principles, but their performance declined when they had to use

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evidence in developing a solution and defend the final answer. The lowest result occurred in solution justification, with a mean of 2.31. The pattern suggested that knowledge was available to many learners but was not always applied with sufficient explanatory depth when the task differed from familiar classroom exercises. This supported the observation of Kaminske et al. (2020) that transfer becomes difficult when learners recognize information in its original learning situation but fail to activate or adapt it under changed conditions.

Table 2. *Reliability and Convergent Validity of the Measurement Model*

Construct	Indicator Loading Range	Cronbach's Alpha	rho_A	Composite Reliability	AVE
Claim-Evidence Connection	0.72–0.85	0.84	0.85	0.89	0.62
Justification of Reasoning	0.74–0.87	0.86	0.87	0.90	0.64
Critical Response	0.70–0.83	0.81	0.82	0.87	0.58
Revision of Ideas	0.71–0.84	0.83	0.84	0.88	0.60
Transferable Problem Solving	0.73–0.88	0.88	0.89	0.91	0.66

Table 2 shows that the measurement model demonstrated satisfactory internal consistency and convergent validity. Cronbach's alpha values ranged from 0.81 to 0.88, while composite reliability coefficients ranged from 0.87 to 0.91. The average variance extracted values were between 0.58 and 0.66, indicating that each construct accounted for a substantial proportion of variance in its indicators. The loading pattern also showed that the observed indicators represented their intended latent constructs adequately. These results supported the retention of all constructs for structural model testing.

Table 3. *Heterotrait-Monotrait Ratio of Correlations*

Construct	CEC	JR	CR	RI	TPS
Claim-Evidence Connection (CEC)	1.00				
Justification of Reasoning (JR)	0.72	1.00			
Critical Response (CR)	0.63	0.69	1.00		
Revision of Ideas (RI)	0.58	0.65	0.74	1.00	
Transferable Problem Solving (TPS)	0.61	0.76	0.68	0.59	1.00

Table 3 presents HTMT coefficients ranging from 0.58 to 0.76. The values indicated that the constructs were related but remained empirically distinguishable. Of particular interest was the relatively stronger association between justification of reasoning and transferable problem solving, which yielded an HTMT coefficient of 0.76. This pattern was consistent with the proposition that learners who habitually explained why evidence supported a scientific conclusion were better positioned to construct reasoned solutions when confronted with unfamiliar problems.

Table 4. *Structural Model Results for Evidence Talk and Transferable Problem Solving*

Structural Path	β	SE	t	p	95% CI	f^2
Evidence Talk → Transferable Problem Solving	0.57	0.069	8.26	< .001	[0.43, 0.69]	0.48

Model Indicator	Value
R^2	0.35
Adjusted R^2	0.34
Q^2	0.23
Inner VIF	1.00

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Table 4 shows that evidence talk exerted a positive and statistically significant predictive effect on transferable problem solving, $\beta = 0.57$, $t = 8.26$, $p < .001$. The confidence interval did not include zero, providing further support for the stability of the relationship. Evidence talk accounted for 35% of the variance in transferable problem-solving performance. The effect size of 0.48 indicated a substantial contribution of evidence-centered discourse to differences in learners' transfer performance.

The finding suggested that learners who more consistently connected claims with evidence, justified their reasoning, considered alternative explanations, and revised ideas tended to perform better when scientific knowledge had to be applied to a new problem. This relationship was meaningful because the descriptive findings had already shown that learners experienced difficulty precisely in the more demanding forms of reasoning, particularly critique, revision, evidence use, and final justification. Frey et al. (2022) argued that successful disciplinary problem solving depends on recognizing underlying concepts rather than relying on memorized procedures. The present result extended this idea by indicating that classroom practices requiring learners to verbalize and defend scientific reasoning may contribute to the development of such flexible knowledge use.

Table 5. *PLSpredict Results for Transferable Problem-Solving Indicators*

Target Indicator	Q^2_predict	PLS-SEM RMSE	Linear Model RMSE	Predictive Result
Problem Representation	0.21	0.566	0.591	PLS-SEM lower
Transfer of Scientific Principles	0.18	0.604	0.628	PLS-SEM lower
Evidence Use in Solution Development	0.14	0.621	0.638	PLS-SEM lower
Justification of Final Solution	0.09	0.687	0.681	Linear model slightly lower

Table 5 presents positive Q^2_predict values for all four indicators, showing that the model possessed out-of-sample predictive relevance. The PLS-SEM model produced lower prediction errors than the linear benchmark for three of the four indicators. Its weakest prediction occurred for justification of the final solution, where the linear model recorded a slightly lower RMSE. The overall pattern therefore indicated moderate predictive power rather than uniformly strong prediction.

This result was important because it showed that evidence talk was useful for predicting performance beyond the observations used to estimate the model, yet it did not fully explain learners' ability to justify solutions. Other factors, such as conceptual knowledge, metacognitive regulation, prior achievement, or familiarity with complex problem structures, may also influence this aspect of transfer. Akben (2020) similarly demonstrated that problem-solving development was connected with metacognitive awareness, suggesting that evidence talk may represent an important but not exclusive source of transferable performance.

Table 6. *Importance and Performance of Evidence-Talk Dimensions in Predicting Transferable Problem Solving*

Evidence-Talk Dimension	Total Effect or Importance	Performance Index
Claim-Evidence Connection	0.274	74.8
Justification of Reasoning	0.332	69.4
Critical Response to Alternative Explanations	0.241	61.7
Revision of Ideas After Discussion	0.187	59.9

Table 6 reveals that justification of reasoning carried the greatest predictive importance for transferable problem solving, with an importance value of 0.332. Claim-evidence connection followed at 0.274. Although critical response had slightly lower importance at 0.241, its performance index was only 61.7, identifying it as a particularly important area for instructional improvement. Revision of ideas produced the lowest performance index of 59.9 but contributed less strongly to prediction than justification and critical response.

The importance-performance pattern clarified the central problem revealed by the study. Learners were generally able to state evidence and explain an initial answer, yet the classroom processes requiring them to interrogate another explanation and change a position when stronger evidence emerged were less developed. These same forms of reasoning became important when learners encountered science problems that could not be solved through direct recall. The findings therefore suggested that strengthening evidence talk should not concentrate solely on asking students to provide evidence. Greater instructional attention should be given to comparing competing explanations, questioning the adequacy of evidence, defending alternative solutions, and revising conclusions after discussion. Such practices may provide learners with stronger opportunities to develop the flexible reasoning required for transfer.

CONCLUSION

Evidence talk contributed meaningfully to transferable problem solving in secondary science learning, as learners who more consistently connected claims with evidence, justified their reasoning, examined alternative explanations, and revised ideas demonstrated stronger capacity to apply scientific knowledge to unfamiliar problems. However, weaknesses in critical response, revision of ideas, evidence use in solution development, and justification of final answers indicated that classroom discourse had not yet fully developed the deeper reasoning needed for transfer. It is therefore recommended that Science teachers provide more structured opportunities for learners to defend explanations, challenge competing claims, evaluate the adequacy of evidence, revise conclusions after discussion, and solve unfamiliar science problems that require application rather than recall. Science departments may also incorporate evidence-centered discussion routines, peer critique, and transfer-oriented tasks into classroom assessment and instructional planning, while future studies may examine additional factors such as metacognitive regulation, prior achievement, and conceptual understanding to explain further variations in transferable problem-solving performance.

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