Influence of a Flipped Classroom Approach on Achievement and Motivation in Grade 9 Chemistry: Evidence from a Resource-Limited Context

Raihana M. Mangilala, Dr. Edna B. Nabua

Mindanao State University-Iligan Institute of Technology, Philippines

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ABSTRACT

This study examined the use of a flipped classroom instructional approach in teaching periodic trends in Grade 9 chemistry, with emphasis on students' academic achievement and learning motivation. A quasi-experimental one-group pretest–posttest design was employed involving learners from a resource-limited secondary school. Data were collected using a researcher-developed achievement test and a validated learning motivation questionnaire administered before and after the instructional intervention. Statistical analyses included descriptive statistics, the Wilcoxon Signed-Rank Test, and Spearman's rank-order correlation.

The results showed statistically significant improvements in students' achievement following the implementation of the flipped classroom approach, as evidenced by higher posttest scores compared to pretest scores. Students' learning motivation also demonstrated a statistically significant increase after the intervention. However, correlational analysis revealed no statistically significant relationship between achievement and motivation in both pre-intervention and post-intervention measures, indicating that changes in these variables were not linearly associated within the duration of the study. These findings suggest that instructional designs emphasizing pre-class engagement with content and structured in-class activities may be associated with improvements in learning outcomes and motivation.

Overall, the results highlight the potential of the flipped classroom approach as a learner-centered instructional option for teaching abstract chemistry concepts in resource-limited contexts, while underscoring the need for cautious interpretation due to the study's design limitations. Future research is recommended to employ longer intervention periods, comparison groups, and additional learner-related variables to further examine the relationships among instructional design, motivation, and academic achievement.

Keywords: Academic Achievement, Chemistry Education, Flipped Classroom, Learning Motivation, Periodic Trends.

INTRODUCTION

Chemistry is consistently identified as one of the most cognitively demanding science subjects at the secondary level due to its abstract concepts, extensive use of symbolic representations, and the necessity for learners to integrate macroscopic observations, submicroscopic explanations, and symbolic notations. These inherent challenges are further intensified among Grade 9 learners in resource-limited school settings, where insufficient laboratory facilities, inadequate instructional materials, and limited access to educational technologies constrain opportunities for meaningful and inquiry-oriented learning. In such contexts, instruction frequently relies on teacher-centered pedagogical approaches, which may restrict students' conceptual understanding and hinder their ability to apply chemical principles effectively (Mojica & Upmacis, 2022).

Beyond cognitive complexity, students' motivation toward learning chemistry has been widely recognized as a critical determinant of academic engagement and performance. Low levels of learning motivation are often associated with passive instructional environments, reduced learner autonomy, minimal peer interaction, and limited opportunities for self-directed learning—conditions that are prevalent in classrooms with constrained resources (Orosz et al., 2023). Addressing both academic achievement and learning motivation is therefore essential, particularly at the junior high school level, where foundational chemistry concepts are introduced, and students' attitudes toward science are shaped.

In response to these challenges, the flipped classroom has emerged as an instructional approach that has gained increasing attention within chemistry education research. The flipped classroom model reallocates direct instruction to the pre-class phase through teacher-curated videos or reading materials, thereby reserving in-class time for active learning, guided practice, collaborative problem-solving, and formative feedback. Empirical evidence suggests that flipped classroom instruction can enhance student engagement, motivation, and academic achievement relative to traditional lecture-based approaches (Bancroft et al., 2021; Shi et al., 2024). In chemistry education, this approach is particularly well suited for teaching periodic trends, as it allows students to independently familiarize themselves with foundational concepts and utilize classroom interactions to refine understanding through structured discussion and application-based tasks. Consequently, the flipped classroom represents a promising pedagogical strategy for improving learning outcomes and motivation in Grade 9 chemistry, especially within resource-constrained educational contexts.

Research Objectives

This study examined the learning outcomes and learning motivation of Grade 9 students before and after the implementation of a flipped classroom approach in selected topics on periodic trends. Specifically, the study sought to:

1. determine the level of students' learning outcomes in selected periodic trends before and after the flipped classroom intervention;

2. determine the level of students' learning motivation toward chemistry before and after the flipped classroom intervention;

3. identify whether a statistically significant difference exists between students' pretest and posttest learning outcomes following the intervention; and

4. examine the relationship between students' learning motivation and learning outcomes before and after the flipped classroom intervention.

METHODOLOGY

Research Design

This study employed a quasi-experimental one-group pretest–posttest design with a correlational component. A single intact group of Grade 9 students was assessed on learning outcomes and learning motivation prior to the implementation of the flipped classroom approach and reassessed following the instructional intervention. This design allowed for the examination of within-group changes in students' academic performance and motivational levels over time, as well as the analysis of the associations between learning outcomes and learning motivation at both pre-intervention and post-intervention stages.

The absence of a control or comparison group classified the study as quasi-experimental and limited causal inference. Accordingly, the correlational component was included to determine the degree of relationship between variables, without implying causal relationships.

Participants

The participants consisted of 35 Grade 9 students enrolled at Mindanao State University–University Training Center (MSU–UTC) in Marawi City, Lanao del Sur. Participants were selected through convenience sampling, as the class was readily accessible to the researcher, and approval was granted by school authorities. All participants belonged to one intact class and were exposed to the flipped classroom instructional approach focusing on selected periodic trends in the periodic table.

Research Instruments

Two research instruments were utilized to collect data on students' learning outcomes and learning motivation in selected periodic trends.

Teacher-Prepared Learning Activity

A teacher-prepared learning activity was developed and implemented as the core in-class component of the flipped classroom intervention. The activity comprised a set of structured guide questions aligned with the assigned pre-class reading materials and instructional videos covering selected periodic trends, namely atomic radius, ionization energy, and electronegativity. The guide questions were designed to promote comprehension, analytical reasoning, and conceptual understanding by prompting students to reflect on the content encountered prior to class. The questions were sequenced to progressively scaffold students' understanding of periodic trends, enabling concept construction through a step-by-step process. During in-class sessions, students responded to each question and engaged in guided discussions facilitated by the teacher. Formative feedback, clarification of misconceptions, and supplementary explanations were provided as needed to deepen conceptual understanding. This learning activity ensured consistency in instructional delivery and served as the primary mechanism for active learning within the flipped classroom framework.

Achievement Test on Periodic Trends

A 15-item teacher-developed achievement test was constructed to measure students' learning outcomes in selected periodic trends, specifically atomic radius, ionization energy, and electronegativity. The test consisted of objective multiple-choice items aligned with the Grade 9 chemistry curriculum and the targeted learning competencies. Each correct response was awarded one (1) point, while incorrect responses received zero (0) points, yielding a total possible score ranging from 0 to 15. The same instrument was administered as both a pretest and a posttest to determine changes in students' learning outcomes following the flipped classroom intervention.

Table 1. Interpretation of Students' Performance

Score Range	Interpretation
11-15	High
6-10	Moderate
0-5	Low

Learning Motivation Questionnaire

A 15-item learning motivation questionnaire was administered to measure students' motivation toward learning chemistry. The instrument comprised dichotomous (Yes/No) statements designed to capture key motivational dimensions, including students' interest, engagement, and willingness to participate in chemistry lessons on periodic trends. Each affirmative ("Yes") response was assigned a score of one (1), whereas each negative ("No") response was assigned a score of zero (0), yielding a possible total score ranging from 0 to 15. The questionnaire was administered as both a pre-intervention and post-intervention measure to determine changes in students' learning motivation following the implementation of the flipped classroom approach.

Table 2. Interpretation of Students' Learning Motivation

Score Range	Interpretation
11-15	High Motivation

6-10	Moderate Motivation
0-5	Low Motivation

The achievement test was designed to measure students' cognitive learning outcomes in selected periodic trends, whereas the learning motivation questionnaire assessed students' affective responses toward learning chemistry. Total scores obtained from both instruments served as the basis for descriptive analysis, pretest–posttest comparisons, and correlational analysis.

Data Gathering Procedure

Prior to the conduct of the study, formal permission was obtained from the school principal and the teacher concerned at Mindanao State University–University Training Center (MSU–UTC). Upon approval, the researcher oriented the participating students regarding the purpose of the study, the research procedures, and their role as participants.

Before the implementation of the flipped classroom intervention, participants were administered the achievement pretest on selected periodic trends and the pre-intervention learning motivation questionnaire to establish baseline measures of learning outcomes and motivation. Following the pretesting phase, the flipped classroom intervention was implemented. Students were instructed to read the assigned learning materials and view teacher-curated instructional videos on periodic trends outside regular class hours.

During in-class sessions, structured learning activities consisting of sequenced guide questions were facilitated by the researcher. These questions were designed to scaffold students' understanding and progressively "unlock" core concepts related to atomic radius, ionization energy, and electronegativity. Students responded to the guide questions individually and participated in teacher-guided discussions. When students' responses reflected partial understanding or misconceptions, the teacher provided supplementary explanations and clarifications to reinforce conceptual understanding. Upon completion of all learning activities, the achievement posttest and the post-intervention learning motivation questionnaire were administered to the same group of participants. All collected data were subsequently organized and prepared for statistical analysis.

Limitations of the Study

Several limitations of this study should be acknowledged in interpreting the findings. First, the study employed a quasi-experimental one-group pretest–posttest design, which limits the ability to establish causal relationships between the flipped classroom approach and students' learning outcomes and motivation. While significant improvements were observed after the intervention, the findings demonstrate associations rather than definitive causal effects, as no comparison group receiving traditional instruction was included.

Second, the absence of a control group introduces potential threats to internal validity, including maturation, testing effects, and history effects. Improvements in students' achievement and motivation may have been influenced by increased familiarity with the test instruments, natural academic development over time, or external learning experiences beyond the flipped classroom intervention.

Third, learning motivation was measured using a self-report questionnaire with dichotomous (Yes/No) response options. Although this format facilitated ease of administration and clear interpretation, it may have limited the sensitivity of the instrument in capturing nuanced changes in the intensity or variability of students' motivation. Students' responses reflected their personal perceptions at the time of data collection and may not fully represent longer-term or situational fluctuations in motivation.

Fourth, the study involved a single group of Grade 9 students from one school, which may limit the generalizability of the findings to other educational contexts, grade levels, or subject areas. Differences in student characteristics, instructional practices, and resource availability may influence the effectiveness of the flipped classroom approach.

Finally, the intervention focused on a specific chemistry topic (periodic trends) and was implemented over a relatively short duration. As a result, the findings may not reflect the long-term effects of the flipped classroom approach or its applicability to other chemistry topics that require different instructional strategies.

Data Analysis

Data obtained from the achievement test and learning motivation questionnaire were systematically organized, coded, and analyzed using appropriate descriptive and inferential statistical techniques. Descriptive statistics were employed to summarize students' learning outcomes and motivation levels before and after the flipped classroom intervention.

To determine whether there was a statistically significant difference between students' pretest and posttest achievement scores, the Wilcoxon Signed-Rank Test was applied, given the nonparametric nature of the data. To examine the relationship between students' learning outcomes and learning motivation at both pre-intervention and post-intervention stages, Spearman's rank-order correlation coefficient (ρ) was utilized. All inferential analyses were conducted at a 0.05 level of statistical significance.

Ethical Considerations

Ethical standards were strictly adhered to throughout the study's conduct. Permission to conduct the research was formally secured from the school principal and the teacher concerned at MSU–UTC. Prior to data collection, the purpose and procedures of the study were clearly explained to all participants. Students were informed that participation was voluntary and that their decision to participate or withdraw would not affect their academic grades or standing. Confidentiality and anonymity were ensured by coding participants' responses, and all data collected were used solely for research purposes.

RESULTS AND DISCUSSIONS

This section presents and interprets the study's findings on the implementation of the flipped classroom approach in teaching periodic trends in Grade 9 chemistry. Specifically, it examines changes in students' learning outcomes and learning motivation following the instructional intervention. Quantitative results are analyzed and discussed in relation to observed patterns and statistical differences, with interpretations anchored in existing literature and the context of resource-limited learning environments.

The achievement test measured students' cognitive learning outcomes, while the motivation questionnaire assessed students' affective responses toward learning chemistry. The total scores obtained from both instruments were used for descriptive analysis, pretest–posttest comparison, and correlational analysis in the study.

Table 3. Descriptive Analysis of the Pretest-Posttest

Test	Mean	Standard Deviation	Qualitative Interpretation
Pre	9.057	1.781	Moderate
Post	13.400	1.881	High

Table 3 presents the descriptive statistics of students' achievement scores on the 15-item multiple-choice test administered before and after the instructional intervention. The pretest mean score of 9.06 (SD = 1.781), interpreted as a moderate level of achievement, indicates that students initially demonstrated partial understanding of the targeted chemistry concepts, with relatively uniform performance across the cohort.

Following the instructional intervention, students' achievement increased, as reflected in a higher posttest mean score of 13.40 (SD = 1.881), corresponding to a high level of achievement. The increase in mean score suggests an improvement in students' conceptual understanding of the assessed topics within the observed group. The similarity in standard deviation values between the pretest and posttest further indicates that the observed gains were distributed across most students rather than concentrated among a limited number of high performers. While these results reflect a substantial change in achievement, they should be interpreted as associative outcomes rather than direct causal effects, given the absence of a comparison group.

The observed pattern of achievement gains aligns with prior research indicating that instructional approaches emphasizing active engagement, pre-class preparation, and structured in-class participation are associated with improved academic performance in chemistry. Lo and Hew (2017) noted that flipped classroom implementations can support learning when students meaningfully engage with content prior to class and apply concepts through guided discussion and problem-solving activities. However, they also emphasized that learning gains are contingent upon instructional design quality and student accountability, suggesting that improvements may not occur uniformly across contexts. Similarly, Zainuddin and Halili (2016) reported that while pre-class content exposure and collaborative in-class learning are linked to deeper conceptual understanding, the magnitude of learning gains can vary depending on learner characteristics, assessment alignment, and duration of implementation.

Taken together, these findings suggest that the improvement in students' achievement observed in this study may reflect the alignment between the instructional structure and opportunities for active engagement rather than the flipped classroom approach alone. This interpretation underscores the importance of examining not only whether achievement gains occur, but also the contextual and methodological conditions under which student-centered instructional strategies are associated with improved learning outcomes in abstract chemistry topics.

Table 4. Descriptive Analysis of Motivation for Flipped Classroom

Intervention	Mean	Standard Deviation	Qualitative Interpretation
Pre	11.314	2.026	High
Post	12.886	2.220	High

Table 4 presents the descriptive statistics of students' learning motivation before and after the implementation of the flipped classroom approach. Before the intervention, students obtained a mean motivation score of 11.31 (SD = 2.03), which was qualitatively interpreted as a high level of motivation. This finding suggests that students entered the study with a generally favorable motivational disposition toward learning chemistry, with relatively consistent motivation levels across participants.

Following the instructional intervention, the post-intervention mean motivation score increased to 12.89 (SD = 2.22), which likewise corresponded to a high level of learning motivation. The increase in mean score indicates a positive shift in students' self-reported motivation after the intervention. The similarity in standard deviation values across the two measurement points further suggests that changes in motivation were not limited to a small subgroup of students but were observed across the cohort. However, because motivation levels were already high prior to the intervention, the magnitude of observable change may have been constrained by a ceiling effect, limiting the extent to which further increases could be detected.

The interpretation of these findings should also consider measurement-related factors. Learning motivation in this study was assessed using a dichotomous (Yes/No) response format, which, while practical for classroom-based research, may have limited sensitivity to subtle variations in motivational intensity. As such, the observed increase in mean motivation score should be interpreted cautiously and viewed as an indication of general enhancement rather than a precise measure of motivational growth.

The pattern of results aligns with existing literature suggesting that instructional environments supporting learner autonomy, active participation, and meaningful interaction are associated with higher levels of student motivation. Jeno et al. (2019) and Sailer et al. (2021) reported that learning designs grounded in opportunities for autonomy and collaboration can foster motivational engagement, particularly in cognitively demanding science contexts. However, these studies also emphasize that motivational outcomes are shaped by multiple factors, including measurement approaches, instructional duration, and baseline learner characteristics.

Similarly, Han and Røkenes (2020) noted that while flipped and student-centered approaches are often associated with positive motivational outcomes, the strength and detectability of these effects may vary depending on contextual and methodological conditions.

Taken together, the findings suggest that the flipped classroom approach in this study was associated with modest motivational gains within an already highly motivated group. This underscores the importance of interpreting motivational outcomes in relation to baseline levels, measurement sensitivity, and intervention duration, rather than viewing changes as uniform or solely attributable to the instructional approach.

Table 5. Wilcoxon Signed-Rank Test of Students' Achievement

Ranks	N	*Z*	*p*	*r*	Qualitative Interpretation
Negative	1	-4.992	0.000	0.87	Significant
Positive	32				
Ties	2				

Table 5 presents the results of the Wilcoxon Signed-Rank Test comparing students' achievement scores before and after the instructional intervention. The distribution of ranks shows that most students (N = 32) obtained higher posttest scores than pretest scores, while only one student demonstrated a decrease in performance and two students showed no change. This pattern indicates a consistent upward shift in achievement scores within the group across the two measurement points.

Inferential analysis yielded a Z value of −4.99 with an associated p-value of 0.00, indicating a statistically significant difference between pretest and posttest achievement scores. This result suggests that the observed change in achievement is unlikely to be due to random variation. However, given the quasi-experimental one-group design, the findings should be interpreted as evidence of a strong association between the instructional intervention and achievement gains, rather than as definitive proof of causal impact.

The computed effect size (r = .87) indicates a very large magnitude of change, reflecting a substantial difference between pretest and posttest performance. While large effect sizes are often interpreted as indicators of practical significance, prior research cautions that in one-group pretest–posttest designs, effect sizes may also be influenced by factors such as testing effects, short-term instructional focus, and alignment between instructional activities and assessment content (Lo & Hew, 2017; Zainuddin & Halili, 2016). Studies on active and flipped learning environments likewise suggest that achievement gains are often contingent on instructional structure and assessment alignment rather than instructional format alone (Freeman et al., 2014; Theobald et al., 2020).

Taken together, these findings indicate that students' achievement improved significantly following the instructional intervention, with a large magnitude of change observed across the cohort. At the same time, the results underscore the importance of cautious interpretation and support calls in the literature for future studies employing comparison groups and extended implementation periods to better isolate instructional effects (Cheng et al., 2019; Shi et al., 2024).

Table 6. Wilcoxon Signed-Rank Test for Motivation

Ranks	N	*Z*	*p*	*r*	Qualitative Interpretation
Negative	6	-3.136	0.002	0.55	Significant
Positive	27				
Ties	2				

Table 6 presents the results of the Wilcoxon Signed-Rank Test comparing students' learning motivation scores before and after the instructional intervention. The distribution of ranks shows that a majority of students (N = 27) obtained higher post-intervention motivation scores than pre-intervention scores, while six students demonstrated a decrease and two students showed no change. This pattern indicates an overall upward shift in motivation scores within the group across the two measurement points.

Inferential analysis yielded a Z value of −3.14 with an associated p-value of .002, indicating a statistically significant difference between pretest and posttest motivation scores. This result suggests that the observed change in learning motivation is unlikely to be attributable to random variation. However, given the quasi-experimental one-group design, the findings should be interpreted as reflecting a significant association between the instructional intervention and changes in motivation, rather than a definitive causal effect.

The computed effect size (r = .55) represents a moderate magnitude of change, indicating a practically meaningful shift in students' motivation toward learning chemistry. While this effect is smaller than that observed for achievement outcomes, it suggests that motivational responses may be more variable and influenced by multiple factors beyond instructional structure alone. Additionally, the use of a dichotomous (Yes/No) motivation measure and the relatively short duration of the intervention may have constrained the sensitivity of the instrument in capturing more nuanced or sustained motivational changes.

The observed pattern of motivational gains is consistent with prior research indicating that instructional environments supporting active participation, learner autonomy, and meaningful classroom interaction are associated with higher levels of student motivation. Ryan and Deci (2020) emphasized that learning contexts satisfying students' needs for autonomy and competence are conducive to enhanced motivation and engagement. Similarly, Howard et al. (2021) reported that instructional strategies encouraging active involvement and shared responsibility for learning are positively associated with motivational outcomes in science education. At the same time, these studies highlight that motivational gains are shaped by contextual, instructional, and measurement-related factors, reinforcing the need for cautious interpretation of short-term changes. In light of these findings, the flipped classroom approach was associated with moderate improvements in learning motivation, with interpretation shaped by methodological and contextual considerations.

Table 7. Correlation Between Achievement and Motivation

Test	Spearman's rho (ρ) value	p-value at 0.05 level of significance	Qualitative Interpretation
Pretest	0.033	0.851	Not Significant
Posttest	0.044	0.802	Not Significant

Table 7 presents the results of the Spearman's rank-order correlation analysis examining the relationship between students' achievement scores and learning motivation before and after the flipped classroom intervention. The pretest correlation coefficient (ρ = 0.033) indicates a very weak positive relationship between students' initial achievement and motivation, with a corresponding p-value of 0.851, which exceeds the 0.05 level of significance. Similarly, the posttest results reveal a very weak positive correlation (ρ = 0.044) with a p-value of 0.802, indicating that the relationship between achievement and motivation remained statistically non-significant following the intervention.

Rather than indicating that achievement and motivation function independently, these findings suggest that the relationship between the two variables may be more complex and context-dependent. The absence of a statistically significant correlation may be partly explained by methodological and contextual factors, including the relatively short duration of the intervention, the limited sample size, and the use of a dichotomous (Yes/No) measure of motivation, which may have constrained variability and reduced sensitivity to subtle motivational differences. Additionally, the high posttest achievement scores observed in the study may have introduced a ceiling effect, further limiting the detectability of meaningful associations between the variables.

This pattern is consistent with prior research emphasizing that motivation does not always exhibit a direct or linear relationship with academic achievement. Scherrer and Preckel (2019) noted that motivational constructs and achievement trajectories may develop asynchronously over time, particularly in short-term educational interventions. Similarly, Talsma et al. (2018) reported that instructional structure and scaffolding can support academic performance even when individual differences in motivational beliefs are weakly related to achievement outcomes.

In light of these considerations, the non-significant correlations observed in this study suggest that improvements in achievement and motivation may reflect parallel but not necessarily synchronized processes, influenced by instructional design, measurement characteristics, and contextual conditions. These findings underscore the importance of cautious interpretation and highlight the need for future research employing more sensitive motivational measures, longer intervention periods, and larger samples to more fully examine the dynamic relationship between motivation and achievement in chemistry learning.

CONCLUSION

The findings of this study indicate that Grade 9 students demonstrated statistically significant improvements in achievement and learning motivation following the implementation of the flipped classroom approach. While these results reflect meaningful changes in students' learning experiences, they should be interpreted as associations rather than causal effects, given the quasi-experimental one-group design. The observed improvements suggest that instructional designs emphasizing active engagement, guided practice, and structured in-class learning activities may support students' understanding of abstract chemistry concepts, such as periodic trends, even in resource-limited educational settings. These results are consistent with prior research highlighting the potential of learner-centered and technology-supported instructional approaches to enhance student participation and academic performance through increased opportunities for application, discussion, and collaboration (Cheng et al., 2019; Bond, 2020).

Notably, the absence of a statistically significant relationship between achievement and learning motivation underscores the complex and multifactorial nature of learning. Gains in academic performance may occur independently of changes in motivational disposition, particularly within short-term instructional interventions. This finding aligns with previous research indicating that achievement and motivation do not always exhibit a direct linear relationship and are shaped by multiple contextual and instructional factors (Mega et al., 2014). Overall, the results suggest that the flipped classroom approach represents a promising instructional option for teaching challenging chemistry topics at the junior high school level, while highlighting the need for further research employing more rigorous designs to clarify causal mechanisms.

RECOMMENDATIONS

The flipped classroom approach may be considered as an instructional strategy for teaching abstract chemistry topics, such as periodic trends, particularly in contexts where active learning opportunities are limited. Structuring instruction to include pre-class engagement with core concepts and in-class guided problem-solving and collaborative activities may support improvements in students' learning outcomes and motivation.

In resource-constrained settings, the use of low-cost and low-bandwidth instructional materials (e.g., short videos, printed guides, and offline digital resources) is recommended to promote equitable access and participation. Effective implementation of flipped instruction requires institutional support; thus, professional development focused on instructional design, facilitation of active learning, and alignment of assessment with learning objectives may enhance teachers' capacity to implement the approach effectively.

Assessment practices should emphasize application, reasoning, and conceptual understanding to reinforce higher-order learning and provide meaningful feedback on student engagement and achievement. Future research should employ longer intervention periods, larger and more diverse samples, and include additional learning-related variables such as self-regulated learning, conceptual retention, and metacognitive skills. The use of comparison groups and mixed-methods designs is recommended to strengthen causal interpretation and deepen understanding of students' learning experiences, consistent with prior research on instructional structure and sustained implementation (Bond, 2020; Strelan et al., 2020).

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