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Article

Student-Centered Pedagogy in Mathematics Education: Evidence from Dibacong National High School

[1] **Edwin C. Vanzuela**
Northeastern College, Santiago City, Philippines
Eliseo C. Ronquillo Sr. Memorial National High School
Correspondence: reynon.panginen@deped.gov.ph

Abstract

Student-centered pedagogy (SCP) has been widely promoted in mathematics education for strengthening conceptual understanding, problem solving, and learner engagement. Yet, classroom enactment varies across contexts, especially in public secondary schools where diverse proficiency levels, time constraints, and assessment pressures shape instruction. This qualitative case study examined how student-centered pedagogical practices were enacted in mathematics classrooms at Dibacong National High School and how these practices influenced learners' engagement and mathematical thinking. Data were generated through classroom observations, semi-structured interviews with mathematics teachers, and focus group discussions with learners. Reflexive thematic analysis produced four interrelated themes: (1) participation broadened when discussion routines and cooperative structures were intentionally designed; (2) conceptual understanding deepened through multiple representations and explanation-centered talk; (3) formative feedback and scaffolding supported persistence and strategic problem solving; and (4) a supportive classroom climate reduced fear of error and sustained engagement. Findings suggest that improved outcomes emerged not from "activity" alone but from coherent task design, accountable talk, and instructional supports that made participation safer and reasoning more visible. Implications highlight professional development focused on high-leverage student-centered routines, formative assessment, and task design aligned with conceptual goals.

Keywords: *student-centered pedagogy, mathematics education, engagement, formative assessment, cooperative learning, qualitative case study*

1. Introduction

Mathematics learning in secondary education is a key predictor of learners' academic trajectories and opportunities in higher education and employment. Beyond procedural competence, contemporary mathematics education aims to develop conceptual understanding, reasoning, and problem-solving capacity competencies that require learners to actively construct meaning and communicate mathematical ideas. In many public school settings, however, mathematics instruction still leans toward teacher-dominated explanation and repetitive seatwork, which can contribute to superficial learning and disengagement, particularly among learners who need opportunities to verbalize thinking and receive timely support.

Student-centered pedagogy (SCP) offers an alternative approach that positions learners as active participants in making sense of mathematics through discussion, exploration, collaboration, and reflection. SCP is strongly aligned with constructivist and sociocultural perspectives that view learning as a process of meaning-making mediated by tools, representations, and interaction (Cobb, 1994; Sfard, 2008). In mathematics classrooms, student-centered instruction is often operationalized through rich tasks, discourse routines, cooperative learning, and formative assessment practices that surface learners' thinking and support conceptual growth (Hiebert et al., 1997; National Council of Teachers of Mathematics [NCTM], 2014).

Despite strong theoretical and empirical support, implementation of student-centered mathematics teaching remains uneven. Teachers navigate large classes, time constraints, heterogeneous proficiency, and high-stakes expectations, which can limit sustained discourse and exploratory task work. There is therefore a continuing need for school-based evidence documenting how student-centered practices are enacted in everyday instruction and how these practices shape learners' engagement and mathematical thinking.

This study examines student-centered pedagogy in mathematics education at Dibacong National High School. Rather than treating SCP as a general "style," the study focuses on concrete practices participation structures, discourse routines, representation use, scaffolding, and formative feedback and analyzes how these contribute to learners' engagement and understanding.

2. Review of Related Literature

2.1 Student-centered pedagogy in mathematics

Student-centered mathematics pedagogy emphasizes learners' active engagement in reasoning, explaining, representing, and justifying ideas, with teachers facilitating learning through tasks and discourse rather than delivering procedures for imitation. Research argues that understanding develops when learners grapple with meaningful problems and construct relationships among concepts, representations, and procedures (Hiebert et al., 1997). NCTM (2014) identifies teaching practices such as posing purposeful questions, facilitating meaningful discourse, building procedural fluency from conceptual understanding, and using evidence of student thinking to guide instruction as core components of effective mathematics teaching.

2.2 Classroom discourse and learning as participation

Mathematics learning is not only cognitive but also social: learners develop mathematical meanings through participation in classroom discourse where ideas are proposed, challenged, and refined (Cobb, 1994). Sfard (2008) conceptualizes learning as becoming able to participate in mathematical

discourse, underscoring the importance of talk moves, explanation norms, and collective reasoning. Productive discourse depends on teachers' capacity to orchestrate discussion, press for reasoning, and ensure equitable participation.

2.3 Engagement and motivation in student-centered classrooms

Engagement is commonly described as behavioral (participation and effort), emotional (interest and belonging), and cognitive (strategic and self-regulated learning) (Fredricks, Blumenfeld, & Paris, 2004). Student-centered approaches can strengthen engagement when learners experience autonomy, competence, and relatedness motivational needs emphasized by self-determination theory (Deci & Ryan, 2000). However, autonomy-supportive environments must be paired with structure clear expectations, scaffolding, and feedback to sustain cognitive effort.

2.4 Formative assessment, feedback, and cooperative learning

Formative assessment practices eliciting evidence of learning and using it to adjust instruction have strong evidence bases for improving achievement (Black & Wiliam, 1998). In mathematics, feedback that focuses on reasoning, misconceptions, and next steps supports persistence and deeper understanding. Cooperative learning is also robustly supported, particularly when designed with positive interdependence and individual accountability rather than unstructured grouping (Johnson & Johnson, 2009). Well-designed collaboration can broaden participation and support peer explanation, which strengthens conceptual learning.

3. Methodology

This study employed a qualitative case study design to examine how student-centered pedagogy was enacted in mathematics classrooms at Dibacong National High School and how these practices influenced learners' engagement and mathematical thinking. A case study approach was appropriate for capturing instructional processes in natural settings and for understanding how teaching practices, classroom interaction, and learner experiences intersect within a specific school context (Yin, 2018). The research site was purposively selected because mathematics teachers had been implementing student-centered strategies such as group problem solving, discussion-based lessons, and performance tasks. Participants included mathematics teachers and learners from selected grade levels. Teachers were selected based on teaching assignment and involvement in student-centered initiatives, while learners were selected to represent varied participation levels to ensure diverse engagement experiences. Data were generated through (a) classroom observations focusing on task design, participation structures, questioning, discourse moves, representation use, and feedback routines; (b) semi-structured interviews with teachers exploring pedagogical intentions, constraints, and perceptions of learner engagement; and (c) focus group discussions with learners to elicit experiences of participation, confidence, collaboration, and understanding. Data were analyzed using reflexive thematic analysis: transcripts and fieldnotes were coded inductively, themes were developed through constant comparison across data sources, and interpretations were refined through triangulation and member checking with selected participants (Braun & Clarke, 2006). Ethical procedures included informed consent, confidentiality, and the use of pseudonyms.

4. Findings and Results

Theme 1: Participation broadened through structured discourse and cooperative routines

Behavioral engagement increased when teachers designed participation intentionally rather than relying on volunteer-only recitation. Lessons that used structured talk routines think-pair-share,

group reporting with rotating spokespersons, and "explain your answer" protocols distributed participation more equitably. Cooperative work was most effective when roles (e.g., solver, checker, explainer, recorder) and accountability mechanisms (e.g., random reporting, individual exit responses) were embedded. These routines reduced dominance by a few confident learners and provided low-risk entry points for hesitant learners to contribute.

Participant **responses**

A teacher explained, "Kapag groupwork lang na walang roles, yung magagaling lang ang gumagawa. Pero kapag may taga-explain at taga-check, napipilitang makisali ang lahat." Learners echoed this, noting that pair discussion helped them participate: "Mas nakakasagot ako kapag napag-usapan muna namin sa katabi ko bago mag-share sa klase." Another learner shared, "Kapag may role ako, alam ko kung ano gagawin ko, kaya hindi ako tahimik lang."

These accounts indicate that student-centered participation depends on instructional design rather than learner confidence alone. Consistent with research on cooperative learning, structured interdependence and individual accountability made participation more inclusive and sustained (Johnson & Johnson, 2009). The findings also align with discourse-oriented views of learning as participation in mathematical talk: when classroom norms required explanation and justification, more learners entered mathematical discourse (Sfard, 2008).

Theme 2: Conceptual understanding deepened through multiple representations and explanation-centered talk

Student-centered lessons strengthened conceptual understanding when teachers required learners to represent ideas in multiple ways (tables, diagrams, number lines, graphs, symbolic expressions) and to explain connections among representations. Rather than immediately correcting answers, teachers frequently asked learners to show reasoning and compare strategies. This practice shifted lessons from answer-getting to sense-making, especially in topics where learners typically rely on memorized steps.

Participant **responses**

One teacher stated, "Hindi sapat na tama ang sagot gusto kong makita paano nila nakuha. Kapag naipaliwanag nila, doon ko nakikitang naiintindihan." Learners described that drawing or using representations helped them think: "Kapag nagdi-diagram kami, mas malinaw kung ano yung hinahanap." Another learner noted, "Mas natututo ako kapag may iba't ibang paraan na pinapakita, tapos pinag-uusapan kung alin ang mas mabilis o mas malinaw."

The findings suggest that explanation-centered talk and representational work supported conceptual development by making relationships visible and debatable. This aligns with mathematics education research emphasizing that understanding is strengthened when learners connect procedures to meanings and representations (Hiebert et al., 1997; NCTM, 2014). It also supports sociocultural accounts that classroom discourse can function as a mechanism for conceptual change through negotiation of meanings (Cobb, 1994).

Theme 3: Formative feedback and scaffolding supported persistence and strategic problem solving

Cognitive engagement was strongest when teachers paired learner autonomy with instructional structure. Teachers used guiding questions ("Ano ang given? Ano ang hinahanap? Anong strategy ang

babagay?"), provided sentence starters for explanations, and broke complex problems into steps without removing the reasoning demand. Feedback was often delivered during work time through circulating, probing, and giving hints rather than after final answers. This reduced unproductive struggle and helped learners persist, revise strategies, and justify solutions.

Participant **responses**

A teacher explained, "Kapag nakita kong stuck sila, hindi ko agad sinasagot. Tatanungin ko muna: 'Bakit iyan ang ginawa mo? Ano pa ang pwedeng paraan?'" Learners emphasized the value of timely feedback: "Kapag chine-check agad ng teacher habang ginagawa namin, mas natutuloy ko yung solution." Another shared, "Hindi ako agad sumusuko kasi tinatanong kami ng teacher kung anong susunod na step."

These findings reinforce the role of formative assessment and feedback as central mechanisms in student-centered instruction. By using evidence of learner thinking to adjust prompts and supports, teachers enabled deeper reasoning and persistence, consistent with the foundational evidence base on formative assessment (Black & Wiliam, 1998). The scaffolding patterns also reflect sociocultural principles of guided participation and gradual release of responsibility, where assistance supports learners toward more independent strategic problem solving (Cobb, 1994; Vygotsky, 1978).

Theme 4: A supportive classroom climate reduced fear of error and sustained engagement

Across classrooms, teachers' relational practices shaped whether learners took risks to speak, explain, and attempt challenging tasks. Student-centered work required learners to expose thinking publicly, which can increase anxiety. Teachers who normalized mistakes ("Okay lang magkamali dito tayo natututo"), praised effort and strategy use, and used respectful correction cultivated psychological safety. This climate increased willingness to participate, particularly among learners who previously avoided mathematics talk.

Participant **responses**

Learners frequently linked confidence to teacher support: "Mas nagsasabi ako ng sagot kapag hindi pinapahiya pag mali." Another learner shared, "Kapag sinasabi ng teacher na try lang, hindi nakakatakot." Teachers echoed this: "Kapag safe ang classroom, mas lumalabas ang boses nila nagkakaroon ng tiyaga kahit mahirap."

These findings indicate that student-centered pedagogy is sustained through affective and relational conditions, not just tasks and routines. This aligns with engagement research emphasizing emotional engagement and belonging as drivers of persistence (Fredricks et al., 2004) and with motivational theory suggesting that supportive environments that meet learners' needs for competence and relatedness strengthen engagement (Deci & Ryan, 2000). In mathematics contexts where fear of failure is common, psychological safety becomes a key enabling condition for discourse and problem solving.

5. Discussion

The study provides evidence that student-centered pedagogy at Dibacong National High School strengthened engagement and mathematical thinking when enacted through coherent participation structures, representational reasoning, formative feedback, and supportive relationships. Consistent with multidimensional engagement frameworks, behavioral engagement increased when participation routines distributed talk and accountability; emotional engagement improved when learners felt safe to make errors; and cognitive engagement deepened when scaffolding and feedback supported strategic reasoning (Fredricks et al., 2004). These outcomes reflect core recommendations

in mathematics education: effective teaching is not defined by minimizing teacher talk, but by using instruction to elicit student thinking, build conceptual understanding, and facilitate meaningful discourse (NCTM, 2014).

The findings also clarify that student-centered pedagogy is not synonymous with "group work" or "activity-based" teaching. Participation broadened only when collaboration was structured with roles and accountability, consistent with cooperative learning research (Johnson & Johnson, 2009). Similarly, conceptual learning improved when teachers pressed for explanation and multiple representations, echoing long-standing claims that understanding grows from connecting representations and justifying reasoning rather than memorizing procedures (Hiebert et al., 1997). Finally, the prominence of feedback and relational safety suggests that student-centered mathematics teaching depends on a balance between autonomy and structure: learners are invited to think and choose strategies, but teachers actively support competence through scaffolding and formative assessment (Black & Wiliam, 1998; Deci & Ryan, 2000).

6. Implications

For classroom practice. Mathematics teachers should design participation intentionally using structured talk routines and cooperative learning with clear roles and individual accountability. Lessons should prioritize explanation and representation, asking learners to justify strategies and connect diagrams, tables, and symbols. Teachers should use formative feedback during task work to support persistence and strategic thinking rather than limiting feedback to final answers.

For instructional leadership. School leaders should support professional development focused on high-leverage student-centered practices: task design for reasoning, discourse facilitation and questioning, formative assessment routines, and cooperative learning design. Coaching and learning walks can use simple engagement indicators (distribution of participation, quality of explanations, evidence of representation use, feedback routines) to guide reflective improvement cycles.

For curriculum and assessment. Curriculum planning should include rich tasks that invite multiple solution pathways and representations, alongside assessment tools that value reasoning and explanation. Aligning classroom assessment with conceptual goals can reduce pressure for purely procedural coverage and better support student-centered learning.

7. Limitations and Future Research

As a qualitative case study, findings are context-specific and not intended for statistical generalization. Future studies may employ mixed-methods designs linking observation-based measures of student-centered practice with achievement and engagement outcomes. Multi-site studies across rural and urban public schools could examine how resources, class size, and leadership support moderate SCP implementation. Longitudinal work may also explore whether sustained student-centered mathematics instruction improves learners' confidence and long-term mathematics participation.

8. Conclusion

This study provides evidence that student-centered pedagogy in mathematics education can strengthen learners' engagement and mathematical thinking in a public secondary school context when enacted through structured participation routines, explanation-centered discourse, formative scaffolding, and supportive classroom relationships. Engagement improved not simply because learners were more active, but because instruction made reasoning visible, participation safer, and

success more attainable. Sustaining student-centered mathematics teaching requires targeted professional development, instructional leadership support, and assessment practices aligned with conceptual understanding and problem solving.

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