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Tracing creative thinking patterns in homogeneous primary student groups during collaborative problem posing

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ABSTRACT

Creative thinking is a vital ability that should be nurtured from the primary level, particularly through collaborative learning activities that engage students in mathematical problem posing. This study aims to investigate the patterns of creative thinking exhibited by primary school students working in homogeneous ability groups during collaborative problem-posing tasks. A qualitative descriptive approach was employed, with data collected through classroom observations, field notes, student-generated problem artifacts, and focus group discussions involving six fifth-grade student groups categorized as high-, medium-, and low-ability. The findings reveal distinct creative thinking patterns across ability groups shaped by internal group dynamics. High-ability groups demonstrated strong fluency in generating ideas but showed limited flexibility and novelty due to dominance by one or two members. Medium-ability groups exhibited more balanced participation, resulting in relatively stronger fluency and flexibility, though originality remained moderate. In contrast, low-ability groups displayed minimal indicators of creative thinking, characterized by passive participation and limited engagement. These results highlight a gap between students' cognitive potential and their collaborative creative performance within homogeneous group settings. The study concludes that creative thinking in homogeneous ability groups is influenced not only by cognitive level but also by the quality of interaction and equitable participation, underscoring the crucial role of teacher facilitation in designing instructional supports that foster inclusive dialogue and creative collaboration.

INTRODUCTION

Creative thinking has been widely acknowledged as a core skill for navigating the complexities of the 21st century (Inganah et al., 2023). Global institutions such as UNESCO, OECD, and the Council of Europe emphasize cultivating creative thinking through education, fostering active knowledge construction, problem-solving, and innovation (OECD, 2015; Unesco, 2017). In particular, UNESCO's *Futures of Education* report highlights the importance of nurturing learners' ability to think creatively and collaboratively preparing them to adapt to change and shape it. In mathematics education, creative thinking plays a crucial role in helping students move beyond procedural fluency toward deeper conceptual understanding (Bailin, 1987; Hitchcock, 2017). Research indicates that fostering creative thinking at the primary level strengthens cognitive foundations for future academic success (Beghetto & Kaufman, 2010; Klein & Leikin, 2020). However, in many educational contexts including Indonesia, creative thinking remains underdeveloped. Recent international assessments underscore this concern (i) The 2015 TIMSS ranked Indonesian students 44th out of 49 countries in mathematics. (ii) The 2022 PISA assessment revealed further declines in mathematical literacy. (iii) The 2015 Global Creative thinking Index placed Indonesia 115th out of 139 countries (Florida et al., 2011; Florida & Mellander, 2023). These findings highlight an urgent need for pedagogical strategies that explicitly target creative competencies and equip students with the ability to generate, evaluate, and refine original ideas from an early age (Kozlowski et al., 2019).

One promising instructional approach is problem posing, which involves generating new problems or reformulating existing ones (Cai & Leikin, 2020; Silver, 2013). Unlike problem-solving, problem-posing is inherently open-ended and encourages students to actively construct and reframe mathematical ideas. It not only enhances students' mathematical understanding but also supports the development of creative thinking through the processes of exploration, interpretation, and expression. Furthermore, studies have shown that engaging in problem-posing tasks benefits both students and teachers, enriching learners' creative thinking while also strengthening educators' pedagogical content knowledge (Verschaffel et al., 2020). When implemented in collaborative contexts, problem-posing becomes even more powerful. Collaborative learning environments allow students to exchange diverse perspectives, negotiate meaning, and co-construct understanding. Collaborative problem posing has thus gained increasing attention in mathematics education research for its potential to foster higher-order thinking and creative thinking (Sung et al., 2016, 2019). Several models and technologies have been developed to support this approach, including guided prompts, structured templates, and mobile learning systems. These approaches have demonstrated promising outcomes in promoting student engagement, interaction, and reflective thinking.

When implemented in collaborative contexts, problem-posing becomes even more powerful. Collaborative learning environments allow students to exchange diverse perspectives, negotiate meaning, and co-construct understanding, making collaborative problem posing a promising approach for fostering higher-order and creative thinking (Sung et al., 2016, 2019). However, research in this area has largely been shaped by a preference for heterogeneous group compositions, underpinned by the assumption that cognitive diversity stimulates richer interaction and more creative outcomes (Dillenbourg, 1999; Webb, 2013). In classroom reality, homogeneous ability groups frequently emerge through two pathways: pedagogical design and social self-selection. Teachers often deliberately form homogeneous groups to enable differentiated instruction, reduce cognitive overload among struggling students, and provide targeted support. Simultaneously, students naturally gravitate toward peers with similar ability levels during informal collaborations, reflecting social homophily and shared comfort zones. Whether by design or emergence, homogeneous grouping is a prevalent social-organizational pattern in real classrooms. Yet, this prevalence contrasts sharply with the limited understanding of its impact on creative thinking processe**s.** Thus, while collaborative problem-posing itself is well-studied, how it functions within homogeneous ability settings remains an underexplored yet pedagogically and socially relevant line of inquiry.

Despite the growing body of research on collaborative problem posing in mathematics education, several important gaps remain. First, existing studies have predominantly emphasized learning outcomes or overall creative performance, with limited attention to the *processes* through which creative thinking emerges during collaborative interactions. Second, while collaborative learning is often examined within heterogeneous group settings, far fewer studies have investigated how creative thinking unfolds in *homogeneous ability groups*, despite their widespread use in classroom practice. In particular, little is known about how interaction patterns, participation equity, and dominance dynamics within homogeneous groups shape key dimensions of creative thinking, such as fluency, flexibility, and novelty. As a result, current literature provides limited empirical insight into the social and interactional mechanisms that support or constrain creative thinking in ability-based collaborative problem-posing contexts.

This study investigates creative thinking patterns among primary school students working in homogeneous ability groups during collaborative problem-posing in mathematics. Specifically, it examines (1) how fluency manifests in the number and variety of problems generated by each group, (2) how flexibility is reflected in students' ability to shift between different strategies or contextual adaptations, and (3) how novelty is evidenced through the originality and conceptual variation of the problems posed**.** By analysing group dynamics, interaction behaviours, and the distribution of these creative indicators across high-, medium-, and low-ability groups, the study aims to reveal how creative thinking is facilitated or hindered within different peer group contexts. In doing so, this research offers both theoretical and practical contributions. Theoretically, it frames creative thinking not merely as an individual cognitive trait, but as a socially mediated process shaped by group interaction. Practically, it provides insights for designing inclusive, participatory learning environments that promote creative thinking and equity in primary mathematics education.

METHOD

This study employed a qualitative descriptive approach to investigate primary students' creative thinking patterns during collaborative problem-posing activities within homogeneous ability groups. This methodological choice was guided by three primary objectives: to capture authentic classroom interactions, to examine the social construction of mathematical creative thinking, and to align with sociocultural learning theories. The qualitative descriptive design was particularly well-suited for documenting both cognitive processes and group dynamics as they unfolded naturally in real classroom contexts (Aspers & Corte, 2019; Reeves et al., 2008). This approach facilitated rich, contextualized analyses of how creative thinking emerged through verbal exchanges, problem-posing behaviours, and collaborative negotiations among students of similar ability levels. Following Merriam and Tisdell's framework, the methodology emphasized depth of understanding over generalizability, enabling a nuanced exploration of the social dimensions of creative thinking (Tisdell et al., 2025). The research design was intentionally crafted to address the central research question concerning how homogeneous group composition influences creative processes. By prioritizing naturalistic observation over controlled experimentation, the study was able to explore how the core dimensions of creative thinking fluency, flexibility, and novelty emerged organically through peer interaction. This approach was especially valuable for capturing both verbal and non-verbal aspects of creative collaboration that might be overlooked in more structured research paradigms.

The participants in this study were 30 fifth-grade students, aged 10 to 11 years, enrolled in a public school in East Java, Indonesia. A purposive sampling technique was employed to select students who represented a range of mathematical abilities and demonstrated varied collaborative behaviours. To ensure informed grouping, a Mathematics Proficiency Test *(Tes Kemampuan Matematika, TKM)* was administered prior to the collaborative activities and piloted to examine its validity and reliability. Based on the TKM scores, students were classified into three ability levels: high (81–100), medium (61–80), and low (below 61), following ability classification principles commonly applied in differentiated instruction (Tomlinson, 2014). Following this classification, the students were divided into six homogeneous groups of five, with two groups representing each ability level (high, medium, and low). This homogeneous grouping strategy was intentionally adopted to explore how creative thinking unfolds when students collaborate with peers of comparable ability levels.

The problem-posing tasks were implemented using a Problem-Posing Mathematical Thinking Instrument (TPMP) in the form of student worksheets *(Lembar Kerja Peserta Didik)*. The worksheets contained non-routine open-ended mathematical tasks focused on the topic of fractions, specifically addition and subtraction of fractions, which aligns with the fifth-grade mathematics curriculum. The tasks were designed to move beyond routine procedural practice and encourage students to engage in higher-order thinking and creative mathematical exploration. Each worksheet consisted of two main components. First, students were asked to solve a non-routine problem involving the addition and subtraction of fractions, which served as a contextual and conceptual stimulus. Second, students were instructed to collaboratively pose new mathematical issues related to fraction addition and subtraction based on the given situation or their own modifications of the original problem. An open response space was provided to allow groups to generate, revise, and document multiple problem formulations during discussion.

The problem-posing tasks were intentionally designed as open-ended, allowing for more than one valid problem structure, numerical variation, and solution pathway. Students were encouraged to modify quantities, change problem conditions, or create new contexts while ensuring mathematical solvability. This level of openness enabled the observation of key dimensions of creative thinking fluency (the generation of multiple problems), flexibility (variation in problem structures and representations), and novelty (the originality of issues posed). The collaborative problem-posing activities were conducted during regular mathematics lessons and lasted approximately 45 minutes per session. Students worked in homogeneous ability groups throughout the activity, progressing through three stages: (1) solving the initial non-routine fraction problem, (2) collaboratively generating and discussing multiple problem ideas, and (3) finalizing and recording the posed problems. During the activity, the teacher acted as a facilitator, providing clarification when necessary without directing students' problem-posing decisions.

To ensure analytical transparency, the three core indicators of creative thinking fluency, flexibility, and novelty were operationalized with explicit criteria based on observable student behaviours and problem-posing outcomes (Silver, 1997). Fluency was defined as the ability to generate multiple correct responses or alternative solutions to a given problem and to propose new problems derived from prior tasks. Flexibility referred to the capacity to approach problems from diverse perspectives, producing varied solutions or formulating new problems with structural or contextual differences. Novelty (originality) involved creating solutions or problems that were distinct from textbook examples or prior teacher explanations. Each indicator was further detailed through a rubric specifying performance levels, from high achievement to limited demonstration, which guided systematic coding of discussion transcripts, artefacts, and observational notes (Siswono, 2010). Table 1 summarizes these operational definitions and corresponding scoring criteria used in this study.

Table 1. Operational definitions and rubrics for creative thinking indicator

No.	Factor	Indicator	Rubric
1	Fluency	Proposing new problems or ideas correctly based on previously solved problems	High: Student proposes 2 diverse problems and can solve them correctly. Medium: Student proposes 1 problem and can solve it correctly. Low: Student cannot propose the required number of new problems or solve them correctly.
2	Flexibility	Proposing new problems that vary in structure or perspective	High: Student proposes 2 new problems differing in perspective or structure correctly. Medium: Student proposes 1 new problem differing in perspective or structure correctly. Low: Student cannot propose new problems differing in perspective or structure.
3	Novelty	Creating new problems from previously solved problems	High: Student creates 2 new problems that are unique or different from usual. Medium: Student creates 1 new unique or different problem. Low: Student cannot create any unique or different problems.

The study employed a triangulated approach to capture creative thinking processes during collaborative problem-posing tasks. Primary data came from video-recorded classroom observations of six homogeneous groups, documenting verbal interactions, participation patterns, and non-verbal engagement cues. Immediately following each session, semi-structured focus group discussions (15-20 minutes per group) explored students' reflections on their collaborative processes and creative decision-making. Student-generated problem formulations and revisions were collected as artifacts, providing tangible evidence of creative output. These were supplemented by researcher field notes documenting contextual factors like teacher interventions and group dynamics. Together, these methods provided multiple perspectives on how creative thinking emerged in homogeneous ability groups, while aligning with the study's sociocultural framework.

This study employed an iterative qualitative analysis process based on the framework of Miles et al conducted concurrently with data collection to inform ongoing observations and subsequently applied in a systematic manner (Miles et al., 2018). The analysis focused on three core indicators of creative thinking fluency, flexibility, and novelty through the examination of problem-submission artifacts, discussion transcripts, and observation notes. Thematic coding was used to identify patterns within the collaborative process across three stages: goal-setting, idea generation, and problem formulation. Data were organized into thematic matrices according to ability level (high, medium, low), allowing for comparative analysis of strategy use, participation dynamics, and creative outcomes across groups. To ensure analytical rigor, findings were verified through data triangulation, peer debriefing, and member checking. This approach facilitated the capture of nuanced variations in how creative thinking emerged within different group contexts, strengthening the trustworthiness of the findings.

RESULTS

1. High-Ability Groups

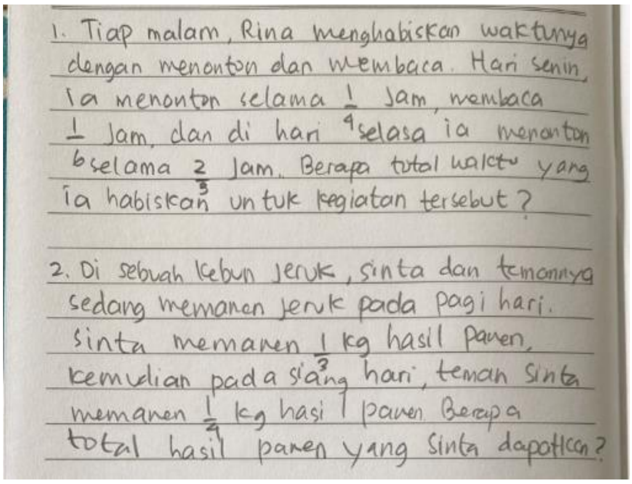
The analysis of high-ability groups revealed a striking paradox: although composed of academically strong students, these groups displayed limited collective creative thinking during collaborative problem-posing tasks. Patterns of creative thinking across fluency, flexibility, and novelty were clearly visible but unevenly distributed. In terms of fluency, high-ability groups generated between 8 and 12 problem formulations per session. However, around 72% of substantive ideas came from only one or two dominant members in each group. This pattern is evident in the following interaction excerpts:

"At first, I immediately shared my idea because it already came to my mind when I saw the example." (Student TT11)*"I also connected my idea with TT11's idea, so we were the ones who started."* (Student TT12)*"I just waited. When they had already started, I became confused about how to join in."* (Student TT13)

When asked about role distribution, one student explained, *"We didn't divide roles. TT11 and I just started working, while the others listened."* (TT11). Another student added, *"I just followed along. The problem had already been decided before I had a chance to give my opinion."* (TT13).

These excerpts illustrate how idea generation, although quantitatively high, was concentrated among a small number of students, thereby limiting broader participation and the collective development of ideas. These students typically initiated ideas and guided the group toward final selections, while less vocal members contributed sporadically and were often overlooked. As a result, the total number of ideas did not fully reflect the group's creative potential, as contributions were concentrated rather than distributed. Flexibility was also limited. Approximately 67% of the problems followed standard textbook structures, with minimal variation in representation or context. Although some students proposed alternative approaches, these suggestions were often set aside, as reflected in students' comments such as, *"Sometimes we didn't get to hear all the ideas before someone had already created the problem"* (TT23) and *"I suggested using a selling context, but it wasn't accepted, so I just followed the group's decision"* (TT21). Another student noted that *"we all talked at the same time, so the decision was made quickly"* (TT22), indicating that rapid consensus-building limited opportunities to explore diverse representations or contextual variations. These interaction patterns constrained the development of cognitive flexibility during collaborative problem posing.

The group tended to prefer familiar, procedural approaches over exploratory or diverse formulations. Novelty appeared to be the least developed dimension, with only 18% of the posed problems classified as novel based on originality of context or deviation from typical classroom formats. Most problems closely mirrored instructional examples, differing only in numerical values. In several instances, students explicitly chose not to pursue unconventional or more challenging ideas, favoring efficient and straightforward formulations instead. This tendency is reflected in students' remarks such as, *"At that time we just wanted to finish quickly, so I started right away"* (TT11) and *"I think it could be made more difficult, like finding the remainder, but we didn't continue it"* (TT23). These creative constraints were closely linked to interaction patterns. Discourse analysis showed that dominant members controlled approximately 83% of meaningful talk time, which further limited opportunities for collective exploration. As one student acknowledged, *"Two of our friends tend to decide quickly, so other ideas are not always heard"* (TT21). Together, these excerpts illustrate how interactional dominance and efficiency-oriented decision-making constrained the emergence of novelty during collaborative problem posing. This tendency toward procedural and familiar problem formulations is further illustrated by the student-generated artifact shown in Figure 1. The problem closely resembles textbook examples on fraction addition, differing primarily in numerical values while maintaining an identical solution structure. Despite being collaboratively produced, the task demonstrates limited contextual originality and offers little opportunity for multiple solution paths, reinforcing the observed constraints in novelty within high-ability homogeneous groups.


1. Tiap malam, Rina menghabiskan waktunya dengan menonton dan membaca. Hari senin, ia menonton selama $\frac{1}{4}$ jam, membaca $\frac{1}{6}$ jam, dan di hari selasa ia menonton selama $\frac{2}{3}$ jam. Berapa total waktu yang ia habiskan untuk kegiatan tersebut?

2. Di sebuah kebun jeruk, sinta dan temannya sedang memanen jeruk pada pagi hari. Sinta memanen $\frac{1}{3}$ kg hasil panen, kemudian pada siang hari, teman sinta memanen $\frac{1}{4}$ kg hasil panen Berapa total hasil panen yang Sinta dapatkan?

Figure 1. Example of a Collaborative Problem-Posing Task from a High-Ability Homogeneous Group

Other students mainly participated through short affirmations, contributing little to the collective development of ideas. Non-verbal behaviors, such as limited eye contact and passive posture, suggested that some group members gradually disengaged from the task. Although collaboration was present in structure, the interaction patterns restricted meaningful co-construction of ideas. Overall, these findings indicate that while high-ability groups possessed strong individual capabilities, their creative output as a group was constrained by unequal participation and limited openness to diverse perspectives.

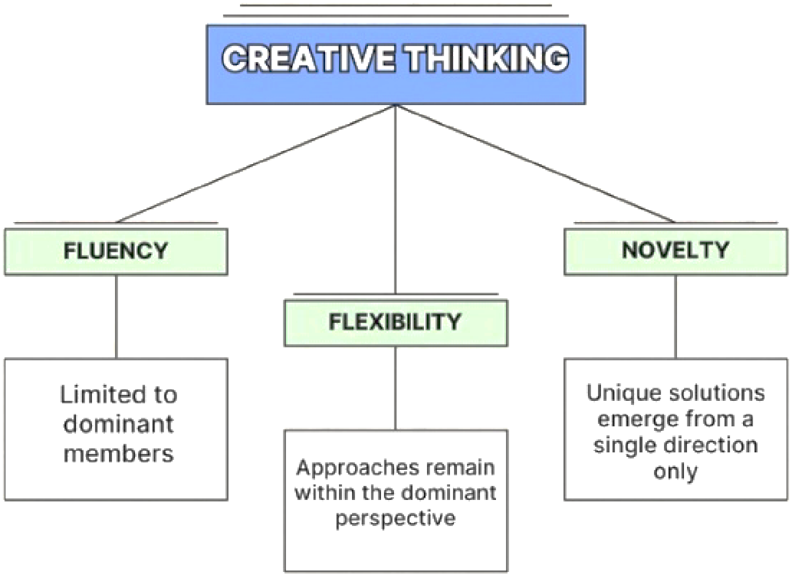


Figure 2. Creative Thinking Pattern in High-Ability Homogeneous Group

2. Medium-Ability Groups

The medium-ability groups demonstrated relatively consistent performance in two dimensions of creative thinking: fluency and flexibility. Across collaborative sessions, each group successfully posed multiple mathematical problems, typically generating between 7 and 10 distinct formulations. Their ideas reflected an emerging ability to shift between procedural approaches and contextual adaptations, indicating developing cognitive flexibility. Students combined algorithmic reasoning with everyday scenarios, such as school-related or local contexts, enabling connections between abstract mathematical concepts and real-life situations. However, the dimension of novelty remained limited. Most problem variations involved superficial modifications, such as changing characters, objects, or settings, while the underlying mathematical structure and level of difficulty remained largely unchanged. This pattern suggests a reliance on familiar formats and a tendency toward idea recycling, in which surface-level alterations create an appearance of creativity without substantially transforming the core mathematical challenge. Only a small proportion of the posed problems deviated meaningfully from established instructional models.

This limited novelty appeared to be closely related to students' comfort zones and their reluctance to take cognitive risks. Several students explicitly expressed a preference for problems that were easy to understand and solve, stating that *"the important thing is that the problem can be solved"* (SS21) and that they had *"not yet thought about creating problems with multiple solutions"* (SS22). Although students showed openness to discussion and collaborative planning, they tended to avoid more complex or unconventional formulations. Interaction patterns within the medium-ability groups were generally balanced and supportive, with most members contributing during discussions. Turn-taking occurred naturally, and students acknowledged one another's ideas, as reflected in statements such as *"sometimes someone talks more and guides the discussion, and we just agree"* (SS21) and *"I usually listen first before giving my opinion"* (SS23). While these interactions fostered a cooperative atmosphere, they often remained at a surface level, with limited elaboration or critical justification. Overall, the medium-ability groups demonstrated a solid foundation for collaborative problem posing, particularly in fluency and flexibility, yet their creative potential remained constrained by reliance on familiar strategies and cautious engagement with novel ideas. This pattern is reflected in the student-generated problems, which demonstrate contextual variation while maintaining conventional mathematical structures.

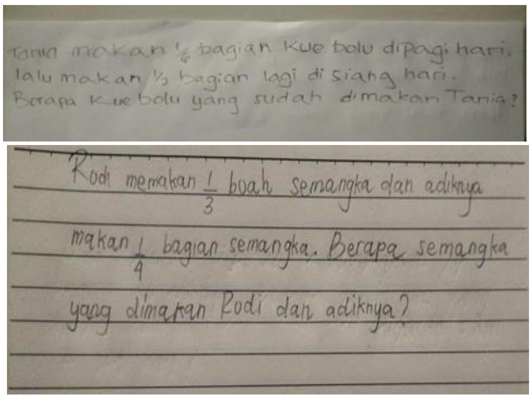


Figure 3. Example of a Collaborative Problem-Posing Task from a Medium-Ability Homogeneous Group

As shown in Figure 3, indicators of fluency and flexibility are evident, as the group generated two distinct problems with different contextual settings, demonstrating variation in problem situations despite similar underlying procedures.

Both groups showed openness to each other's input, allowing for idea co-construction and collective refinement. The environment was conducive to collaboration, with little evidence of conflict or exclusion. However, opportunities for more robust critical dialogue or synthesis of divergent perspectives were often missed, possibly due to students' shared tendency to remain within familiar conceptual frameworks. Overall, the medium-ability groups exhibited encouraging creative thinking skills in terms of idea generation and strategy variation, supported by equitable collaboration. However, novelty remained underdeveloped, suggesting a need for targeted scaffolding to help students move beyond their comfort zones and explore more original, conceptually rich problem ideas. To further illustrate the observed thinking process, Figure 4 presents a visual representation of the creative thinking pattern demonstrated by the medium-ability groups.

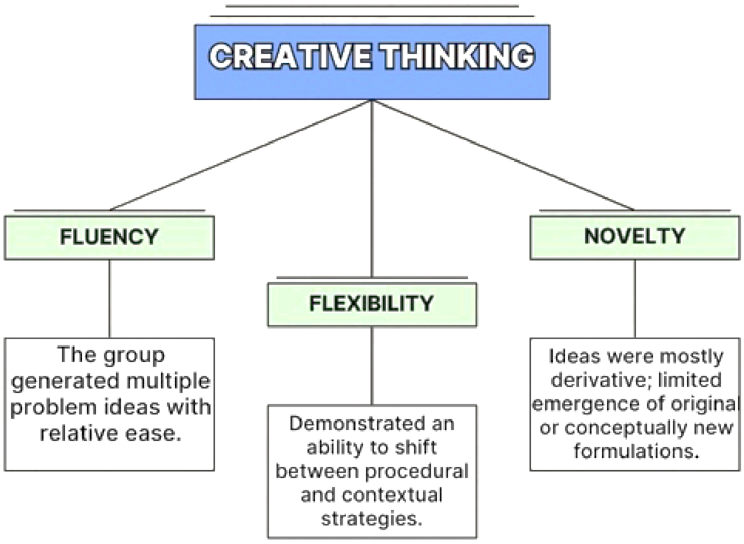


Figure 4. Creative Thinking Pattern in Medium-Ability Homogeneous Group

3. Low Ability Groups

From a creative thinking standpoint, the low-ability groups exhibited rigid and predominantly linear cognitive patterns. Rather than exploring diverse strategies, students relied heavily on a single familiar procedure, typically one that had been explicitly modelled by the teacher. This dependence on procedural recall constrained both the fluency and flexibility dimensions of creative thinking, as students rarely generated multiple ideas or shifted between alternative problem-posing strategies. The dimension of novelty was virtually absent; most problems closely mirrored textbook examples, with little to no contextual adaptation or reinterpretation. These limitations in creative thinking were closely intertwined with the groups' interactional dynamics. Group discussions were minimal and often short-lived, with participation largely passive and few students initiating ideas or critically engaging with peers.

This constrained creative performance was clearly reflected in students' verbal interactions during the focus group discussions. When asked how they developed their problems, students repeatedly relied on existing examples rather than generating new ideas, stating that they "made problems similar to the teacher's questions, only changing the numbers" (RR11) and that they felt "confused because we have never made our own problems before" (RR22). Several students explicitly acknowledged their inability to initiate alternative ideas, admitting that they "did not know where to start" (RR13) and preferred to "wait and look at example problems first" (RR21). As a result, group decision-making consistently gravitated toward the most familiar and cognitively safe options. This passivity was reinforced by interactional patterns in which students positioned themselves as followers rather than active contributors, as reflected in statements such as "*I just listen and follow what others suggest*" (RR13) and "*we usually follow the decision of the person who talks more*" (RR21). These interactional tendencies were directly mirrored in the problems produced by the groups, which largely replicated textbook formats with minimal variation in context, structure, or level of challenge, indicating a strong alignment between passive discourse patterns and limited creative output. This alignment between passive interaction patterns and procedural thinking is evident in the student-generated problems, as illustrated in Figure X, where the posed tasks closely resemble instructional examples with only superficial modifications.

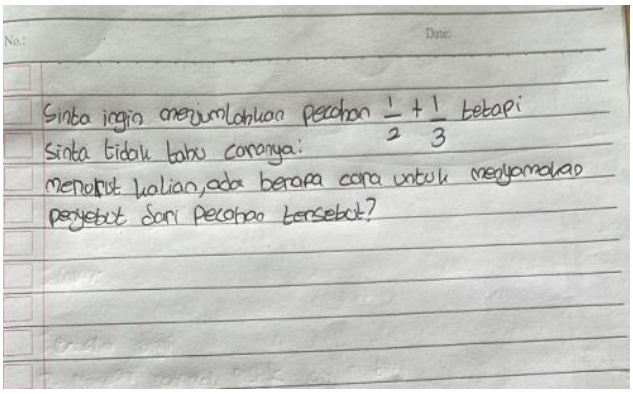


Figure 5. Example of a Collaborative Problem-Posing Task from a low-Ability Homogeneous Group

As illustrated in Figure X, indicators of creative thinking were largely absent in the low-ability group. The group produced only a single problem, which closely replicated the structure and context of the original problem-solving task provided by the teacher. This outcome reflects limited fluency and flexibility, as no alternative ideas or strategies were generated, and novelty was not observed due to the absence of contextual or structural variation.

Members in the low-ability groups tended to wait for direction or approval rather than initiating ideas independently, resulting in limited co-construction and minimal mutual scaffolding. When prompted to generate problems, students frequently hesitated, abandoned incomplete ideas, or reproduced the structure of problems previously encountered in class, as reflected in the single problem they ultimately produced. These interactional patterns suggest the presence of cognitive hesitation and low psychological safety, constraining students' willingness to take intellectual risks. Although the intention to collaborate was evident, the actual problem-posing process remained fragmented and largely individualistic. The overall pattern of creative thinking and interaction dynamics in this group, highlighting the absence of fluency, flexibility, and novelty, is summarized in the following diagram.

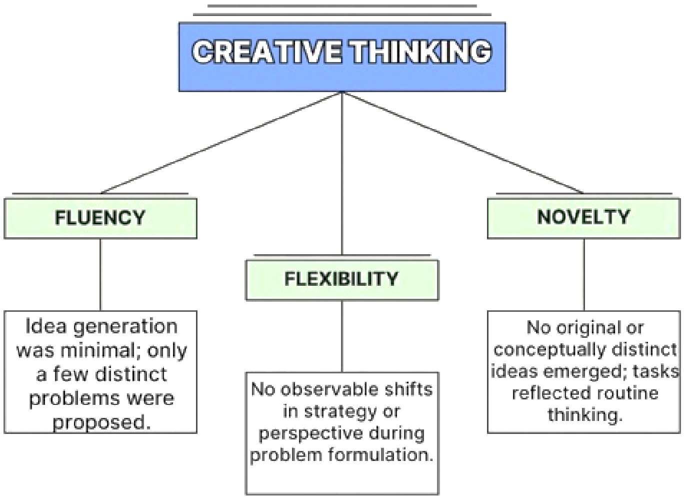


Figure 6. Creative Thinking Pattern in low-Ability Homogeneous Groups

Although the findings for each ability group have been presented in detail in the preceding sections, a cross-group comparison is necessary to more clearly capture shared patterns and critical contrasts in creative thinking and collaborative processes. Therefore, Table X provides a comparative synthesis that highlights key similarities and differences across high-, medium-, and low-ability groups with respect to fluency, flexibility, novelty, and interaction dynamics.

Table 2. Comparative Summary of Creative Thinking Indicators and Interaction Patterns Across Homogeneous Ability Groups

Aspect	High-Ability Groups	Medium-Ability Groups	Low-Ability Groups
Fluency	High, but dominated by few members	Moderate and distributed	Low, limited ideas
Flexibility	Limited, textbook-oriented	Moderate, some variation	Very limited
Novelty	Low, risk-averse	Emerging but constrained	Absent
Interaction pattern	Dominance, pseudo-collaboration	Balanced, exploratory	Passive, dependent
Creative risk-taking	Low	Moderate	Very low

DISCUSSION

This study set out to explore how primary students’ creative thinking unfolds within homogeneous ability groups during collaborative problem-posing tasks. Drawing on Torrance’s framework (fluency, flexibility, novelty), the findings revealed distinct patterns across high-, medium-, and low-ability groups, shaped not only by cognitive readiness but also by the nuances of peer interaction, group structure, and sociocultural factors. This section discusses these patterns in light of existing research and considers implications for theory and pedagogy.

1. The Creative Paradox in High-Ability Groups

Despite their strong cognitive foundations, high-ability groups exhibited a surprising constraint in collective creative thinking. While fluency was relatively high, it was primarily driven by one or two dominant individuals, resulting in participation asymmetry and suppressing the diverse potential of other group members. This pattern emerged because dominant members tended to initiate ideas and verbalize solutions immediately, leaving little cognitive space for peers to contribute, reflect, or challenge suggestions. As a result, group members often adopted a wait-and-see approach, leading to a concentration of ideation in the hands of few participants.

A deeper theoretical examination reveals that this dominance is not merely a behavioral tendency but is rooted in social and motivational structures. First, from the perspective of Status Characteristics Theory (Berger & Gundy, 2015), high academic achievement operates as a diffuse status characteristic within the group. Peers implicitly attribute higher competence and legitimacy to these 'high-status' members, which leads to unequal participation patterns where their ideas are prioritized and others' contributions are undervalued or withheld. Second, drawing on Goal Orientation Theory (Dweck & Leggett, 1988; Luszczynska & Schwarzer, 2015), high-ability students in such visible group settings often adopt performance-approach goals striving to demonstrate their competence and maintain their 'smart' reputation. This makes them risk-averse, favoring familiar, textbook-perfect problem formats over exploratory, unconventional approaches that could entail errors and threaten their status. Thus, the group's creativity is constrained not by a lack of cognitive resources, but by social dynamics that centralize authority and prioritize safety over innovation.

This aligns with Barron's concept of pseudo-collaboration, where group work appears cooperative on the surface but lacks true joint construction of knowledge (Barron, 2003; Bates & Gupta, 2017; Woolley et al., 2015a). The group's limited flexibility and novelty manifested in a reliance on textbook-based problem formats. Such reliance can be explained by cognitive fixation and a risk-averse orientation: students prioritize correctness and efficiency over exploration, which constrains their willingness to experiment with unconventional problem formulations (An & Zhang, 2024; Chiu & Lehmann-Willenbrock, 2016; Woolley et al., 2015b).

This challenges assumptions in prior research that associates high academic ability with elevated creative performance (Leikin, 2009; Leikin & Sriraman, 2022). The why and how are therefore intertwined: the high cognitive ability of individuals does not automatically translate into group-level creativity when social dynamics inhibit equitable participation, and dominant behaviors channel the group's ideational energy toward familiar, safe problem formats. This reinforces Vygotsky's argument that creative thinking is not solely internal but emerges from socially mediated interaction (L. Vygotsky & Cole, 2018). The theoretical insights from status characteristics and goal orientation theories lead to specific pedagogical imperatives. To counteract status-based dominance, teachers can implement structured role assignments (e.g., facilitator, idea recorder, challenger) that deliberately rotate and legitimize diverse contributions, thereby disrupting automatic deference to high-achievers. Furthermore, to shift the group's goal orientation from performance to learning, tasks can be framed with explicit evaluation criteria that reward risk-taking, originality, and multiple solution paths not just correctness. Thus, scaffolds for high-ability groups should target both the social structure of interaction and the motivational climate to transform their cognitive potential into collective creative output.

2. Productive Potential in Medium-Ability Groups

Medium-ability groups demonstrated more balanced interaction and consistent fluency and flexibility. Their ability to shift between algorithmic and contextual strategies reflects a moderate level of cognitive flexibility, and an openness to co-constructing problems collaboratively. While novelty remained limited likely due to a tendency toward safe, familiar templates these groups showed promising signs of creative growth, especially when supported by open dialogue and mutual affirmation. Theoretically, this productive balance can be understood through the lens of the collective Zone of Proximal Development (ZPD) and Optimal Challenge Theory. As Vygotsky's ZPD is applied at the group level, medium-ability students operated within a collaborative ZPD (Goos, 2004; Makar, 2024), their collective ability was sufficient to handle the task with moderate challenge, but not so high as to trigger the performance anxiety seen in high-ability groups or the cognitive overload seen in low-ability groups. This created an optimal tension between familiarity and exploration, enabling them to experiment without being paralyzed by complexity. Furthermore, their reliance on "safe" templates aligns with Moderate Discrepancy Hypothesis (McCall & McGhee, 1977) which suggests that learners are most engaged and willing to explore when tasks are moderately novel neither too familiar nor too alien. Their incremental adaptations represent a scaffolded pathway to novelty, where creativity builds gradually from security.

The observed patterns may be explained by why students remained within familiar problem structures: a combination of developing cognitive skills and a perceived need for success in a peer group context likely motivated them to choose "safe" strategies. Medium-ability students may lack full confidence in generating entirely novel problems, and thus rely on incremental adaptations of familiar examples. How their creative thinking emerged, however, was facilitated by exploratory talk and mutual scaffolding: turn-taking, peer affirmation, and collaborative negotiation of problem solutions encouraged shifts between algorithmic reasoning and contextual adaptation, laying the groundwork for flexibility (Bloom & Keil, 2001; Mercer, 2002; Soames, 2015).This dynamic is reinforced by Social Interdependence Theory (Johnson & Johnson, 2009). The positive goal interdependence within these groups fostered promotive interaction members supported each other's contributions because collective success was perceived as intertwined with individual success. This created a socially safe space where "thinking aloud" and tentative ideas could be shared without fear of judgment, facilitating the co-construction of understanding that is central to creative collaboration.

Though medium-ability students may lack advanced procedural fluency, their willingness to experiment and respond to peer input created fertile ground for idea generation. Nevertheless, adherence to comfort zones and occasional self-doubt indicates that targeted teacher interventions are necessary to promote conceptual risk-taking without undermining group cohesion (Clifford, 1991; Raue et al., 2018). Pedagogically, these theoretical insights suggest that medium-ability groups benefit most from graduated scaffolding initially providing familiar templates to build confidence, then systematically introducing "what-if" perturbations and open-ended constraints that gently push the boundaries of their templates. Teachers can also explicitly teach and model exploratory talk moves (e.g., "What if we changed this number?" "Could we turn this into a story problem?") to formalize the productive interaction patterns these groups naturally begin to exhibit. This approach respects their need for security while strategically stretching their creative capacity.

By providing guided opportunities for creative divergence, educators can help these students expand both the novelty and depth of their problem-posing capabilities.

3. Creative Struggles in Low-Ability Groups

Low-ability groups exhibited the most limited creative thinking across all three dimensions. Their ideation was sparse and rigid, often replicating taught procedures without modification. This pattern can be explained by cognitive load theory (Phan et al., 2017; Sweller, 1988) students' working memory resources were heavily taxed by even basic problem-posing demands, leaving little capacity for flexible or novel thinking. Discussions were minimal, with few attempts to reframe or elaborate on peer ideas, reflecting both social and cognitive hesitancy.

To fully explain the depth of this struggle, we must integrate cognitive, affective, and social perspectives. The cognitive load experienced is not merely computational; it is compounded by what might be termed a creative double-bind: the task demands both procedural recall and generative thinking, creating a paralyzing cognitive conflict. Affectively, this aligns with theories of learned helplessness (Seligman & Hager, 1972) and mathematics anxiety (Adams & Hitch, 2022; Ashcraft & Fierman, 1982). Repeated prior struggles in mathematics condition students to expect failure, leading to motivational withdrawal and avoidance of any task perceived as challenging. Socially, status attenuation occurs within the homogeneous low-ability group, no member possesses high academic status to legitimize and model risk-taking (Cohen & Lotan, 2014). This creates a collective inertia where silence and replication become the default, safest strategies. Thus, the creative block is a systemic outcome of overloaded cognition, diminished affect, and a social context devoid of modeling or safety. Fear of failure and low self-confidence further inhibited risk-taking, suggesting that psychological safety is a key mediator of creative engagement. These findings echo research by Webb, highlighting that low-performing students often withdraw in collaborative settings without sufficient support (Hmelo-Silver & Chinn, 2015; Webb, 2013). How these patterns emerged appears linked to a combination of high task difficulty relative to students' readiness, unclear scaffolding, and limited prior experience with autonomous problem creation.

Consequently, pedagogical responses must be multifaceted and sequential, directly addressing the cognitive-affective-social triad. *First*, to reduce cognitive load, tasks must be fractionated and anchored. This involves breaking down problem-posing into sub-steps (e.g., "first, change only the numbers in this example") and using highly familiar, concrete contexts. *Second*, to build affective safety, the evaluation criteria must be explicitly shifted from correctness to effort and participation, and teachers must actively model and reward "smart guesses" and partial ideas. *Third*, to rebuild social efficacy, interaction scripts with prescribed turn-taking and sentence starters (e.g., "One idea I have is…", "What if we combine your idea and my idea?") are crucial. These scripts provide the missing social architecture that guides productive exchange without relying on student-initiated social skills, which may be underdeveloped. This structured approach aims not just to support a task, but to disrupt the cycle of helplessness and rebuild a foundational belief in their own capacity to think creatively. Rather than dismissing their potential, these groups should be seen as needing structured, emotionally safe scaffolding. By reducing cognitive demand, explicitly modeling open-ended questioning, and providing guided peer interaction, teachers can help build both competence and confidence, enabling gradual engagement in creative problem posing.

4. Rethinking Homogeneous Grouping for Creative thinking

Across all groups, the findings underscore that ability grouping alone does not guarantee optimal creative engagement. While homogeneity can simplify instructional targeting, it may inadvertently reinforce pre-existing hierarchies and inhibit cross-pollination of ideas (Lou et al., 1996; Matthews et al., 2013). Why this occurs appears linked to social dynamics: in high-ability groups, dominant individuals monopolize discussion, limiting the breadth of collective ideation, whereas in low-ability groups, uncertainty and low self-efficacy foster passivity and minimal contribution.

These divergent yet equally constraining patterns point to a fundamental theoretical insight: homogeneous ability grouping, by itself, lacks inherent social-cognitive drivers for creative synergy. Drawing on *Social Interdependence Theory* (Johnson & Johnson, 2009) merely sharing a similar ability level does not create positive goal interdependence the psychological engine of collaboration. Without designed interdependence, groups default to *status-based* (in high groups) or *anxiety-based* (in low groups) interaction patterns, neither of which foster the risk-taking and idea exchange necessary for creativity. Furthermore, from a *Sociocultural* perspective (Vygotsky & Cole, 1978), homogeneous grouping limits the cognitive diversity that often sparks "collaborative ZPDs," where differing ideas create productive friction. In its absence, the group's collective thinking may stagnate within a shared comfort zone or anxiety zone.How these patterns emerged suggests that cognitive similarity without intentional structuring does not naturally lead to productive interaction; instead, collaboration must be scaffolded through clear role distribution, turn-taking norms, and meta-cognitive reflection to encourage equitable participation and mutual support**.**

Therefore, the primary implication is a paradigm shift: from viewing grouping as a *static, compositional* decision (homogeneous vs. heterogeneous) to understanding it as a *dynamic,* interactional design problem. The critical variable is not ability composition per se, but the quality of mediated interaction (Mercer & Littleton, 2007). This aligns with the concept of structuration (Cohen, 1994), the need to actively structure group work to disrupt default social scripts. Teacher-facilitated collaborative scripts (Dillenbourg, 1999; Hmelo-Silver & Chinn, 2015) and role assignments serve as interactional scaffolds that perform this structuration, artificially inducing the positive interdependence and equitable participation that homogeneous groups lack organically.

These findings illustrate that creative thinking is a socially distributed phenomenon: its emergence depends not solely on individual knowledge, but on the quality and structure of interactions. Drawing from the cross-group analysis, a recurring pattern links the degree of collaborative engagement directly to the presence or suppression of creative thinking indicators, as conceptualized in the figure below.In practical terms, this means professional development should move beyond the debate of "which grouping is best" and focus instead on equipping teachers with a toolkit of interactional scaffolds (e.g., talk protocols, role cards, process reflections) that can be deployed within *any* group composition to engineer the conditions for creative thinking. The study ultimately argues that in the context of creativity, group work must be taught, not just assigned.

In practical terms, this means professional development should move beyond the debate of "which grouping is best" and focus instead on equipping teachers with a toolkit of interactional scaffolds that can be deployed within any group composition. For example, teachers may assign rotating roles (e.g., problem generator, checker, explainer) to prevent dominance in high-ability groups, use sentence starters and worked-example fading to support low-ability groups, or introduce reflective prompts such as *"What makes this problem different?"* to encourage risk-taking in medium-ability groups. The study ultimately argues that in the context of creativity, group work must be taught, not just assigned.

CONCLUSION

This study explored creative thinking patterns among primary students working in homogeneous ability groups during collaborative problem posing in mathematics. The analysis revealed that students' creative thinking particularly in terms of fluency, flexibility, and novelty was deeply influenced not only by cognitive ability but also by the dynamics of group interaction. High-ability groups, despite their strong academic profiles, showed limited creative thinking due to dominant participation by one or two members, resulting in constrained fluency and minimal novelty. Medium-ability groups demonstrated more balanced interactions and higher flexibility, yet still relied heavily on familiar formats, leading to limited originality. Low-ability groups struggled with idea generation altogether, displaying rigid thinking, low confidence, and minimal collaborative engagement. These findings indicate that creative thinking is a socially mediated process rather than an individual trait. Group composition and interaction patterns significantly shaped students' creative outcomes, suggesting that homogeneous grouping while helpful for instructional alignment may inadvertently suppress the emergence of diverse and original ideas when not paired with deliberate facilitation strategies. To foster meaningful creative thinking in mathematics classrooms, educators should design collaborative tasks that not only challenge students cognitively but also ensure equitable participation, support risk-taking, and scaffold creative exploration. Future research could further investigate intervention models that balance ability-based grouping with creative thinking-enhancing pedagogies.

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