

PERCEIVED CREATIVITY SKILLS NEEDED BY SECONDARY SCHOOL STUDENTS FOR SOLVING NUMBER AND ALGEBRA PROBLEMS IN GOMBE STATE, NIGERIA

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ABSTRACT

There is limited evidence on the creativity skills students need for Number and Algebra problem-solving in Gombe State, Nigeria. This study investigated the creativity skills that school administrators and mathematics teachers perceive as needed by secondary school students for problem-solving in Number and Algebra in Gombe State, Nigeria. Based on Polya's Problem-Solving Model and Guilford's components of creativity (fluency, flexibility and originality), the study adopted a descriptive survey design and involved 75 respondents (21 school administrators and 54 mathematics teachers) selected by census sampling from public secondary schools in Gombe State. Data were collected using a validated 20-item structured questionnaire (Cronbach alpha = 0.85) and analysed using mean, standard deviation and Welch's independent-samples t-test at the 0.05 level of significance. Nine of the ten Number skills were rated as needed, including recognising and extending numerical patterns, devising multiple solution strategies, and constructing and interpreting numerical word problems, with a mean of 3.91 for the nine items. Nine of the ten Algebra skills were rated as needed, including solving equations through multiple methods, translating word problems into equations, and applying algebra to optimise solutions, with a mean of 3.93 for the nine items. Memorising multiplication tables and algebraic formulas was not rated as a needed creativity skill. The t-test results showed no statistically significant difference between the perceptions of administrators and teachers for either Number ($t = 0.92$, $p = .37$) or Algebra ($t = 0.71$, $p = .48$), suggesting that both groups held similar views. Because the data are the opinions of adults and no students were tested, the findings show what respondents believe is needed, not what students can or cannot do. The study recommends that mathematics teachers deliberately design open-ended, multi-strategy tasks in Number and Algebra instruction, moving beyond rote memorisation toward creative, flexible problem-solving.

Keywords: Perception; Mathematical creativity; Gombe State; Polya's model; Mathematics teachers; School administrators

1.0 INTRODUCTION

Mathematics education is widely regarded as a vehicle for developing logical reasoning, precision, and problem-solving competence among learners (National Council of Teachers of Mathematics [NCTM], 2000). In this paper, creativity in mathematics means the ability to solve a problem in more than one way, to move flexibly between methods and representations, and to produce original ideas, shown through fluency, flexibility and originality (Guilford, 1967; Leikin, 2009). It is not confined to producing novel proofs or discoveries; it also covers the everyday capacity to devise multiple solution strategies, recognise patterns, and adapt known procedures to unfamiliar problems (Leikin & Pitta-Pantazi, 2013; Silver, 1997). Reports from Nigerian classrooms suggest that mathematics teaching is often teacher-centred and lecture-based (Awofala & Fatade, 2023; Bature et al., 2020; Jabbar, 2018), which may leave limited room for the creative, flexible thinking that mathematical problem-solving demands (Mann, 2006; Sriraman, 2004).

Number and Algebra constitute two of the most foundational content strands in the secondary school mathematics curriculum, underpinning many other areas of mathematics (Nigerian Educational Research and Development Council [NERDC], 2014). Creativity within Number involves flexible mental computation, estimation, pattern recognition, and multiple representations of quantity (Star & Rittle-Johnson, 2009; Threlfall, 2002), while creativity within Algebra involves translating real-world situations into symbolic form, manipulating expressions flexibly, and solving equations through varied methods (Rittle-Johnson & Star, 2009; Xu et al., 2017). Despite their centrality, Algebra is a known difficulty for Nigerian secondary school students (Ibrahim et al., 2023; Obunge et al., 2022), and multiple-solution tasks, which could build creative problem-solving capacity, have been reported to be rarely used in a comparable African setting, South Africa (Mahlaba, 2020).

This study therefore sought to identify the creativity skills secondary school mathematics students in Gombe State need for effective problem-solving in Number and Algebra, and to determine whether administrators and teachers hold similar perceptions of these needs. Teachers and administrators were asked, and students were not, because teachers plan and deliver the lessons, administrators supervise teaching and curriculum coverage, and a perception survey of these two groups is a practical first step before students are tested directly (see Section 3.2).

1.1 STATEMENT OF THE PROBLEM

Poor performance in mathematics among Nigerian secondary school students has often been linked to teacher-centred teaching, rote memorisation and single-method instruction (Awofala & Fatade, 2023), which may limit students' ability to approach unfamiliar Number and Algebra problems flexibly and creatively. This link is an association reported by researchers, not a proven cause; the Nigerian evidence for a causal effect of rote learning on examination results is limited. In Gombe State, Achufusi and Emenike (2023) described students' WASSCE mathematics results for 2020 to 2022 as consistently unsatisfactory, and the North-East zone ranked last of six zones in NECO-SSCE mathematics between 2000 and 2009 (Utibe & Agwagah, 2015). More recently, the state's Commissioner for Education reported that the share of candidates with five credits including English and Mathematics rose from about 21% in 2019 to over 70% (Voice of Nigeria, 2025), but this is an official claim that is not specific to mathematics and has not been independently verified. Nationally, the 2025 WASSCE pass rate (five credits including English and Mathematics) was first released as 38.32% and later revised to 62.9% (Blueprint, 2025). Where creativity is not deliberately nurtured, students may master routine computations yet struggle when problems deviate from familiar formats, which could

affect both examination performance and broader mathematical competence (Mann, 2006; Silver, 1997). Studies in Nigeria and elsewhere in Africa have mostly tested whether particular teaching methods raise students' creativity or achievement (Ado & Nwosu, 2016; Aliyu et al., 2022; Sani, 2021), or have examined attitudes, study habits and learning strategies (Achufusi & Emenike, 2023; Ibrahim et al., 2023, 2024). From the literature reviewed, none has asked teachers and administrators in Gombe State which specific creativity skills are needed in Number and in Algebra separately. This is the gap the present study addresses. This study therefore identified which creativity skills require deliberate cultivation in Number and Algebra instruction, as perceived by administrators and teachers.

1.2 PURPOSE OF THE STUDY

The study determined the creativity skills needed by secondary school mathematics students in Gombe State for:

1. Problem-solving in Number.
2. Problem-solving in Algebra.
3. Whether administrators and teachers differ significantly in their views on the skills needed for Number and Algebra.

1.3 RESEARCH QUESTIONS

(i) What are the creativity skills needed by secondary school mathematics students for problem-solving in Number in Gombe State?

(ii) What are the creativity skills needed by secondary school mathematics students for problem-solving in Algebra in Gombe State?

1.4 HYPOTHESES

H₀₁: There is no significant difference between the mean responses of administrators and teachers on the creativity skills needed by secondary school mathematics students for problem-solving in Number in Gombe State at the 0.05 level of significance.

H₀₂: There is no significant difference between the mean responses of administrators and teachers on the creativity skills needed by secondary school mathematics students for problem-solving in Algebra in Gombe State at the 0.05 level of significance.

The two groups might differ because their work is different: administrators tend to see mathematics through examination results, supervision and curriculum coverage, while teachers see it through daily classroom practice and students' responses. On the other hand, both groups work under the same national curriculum (NERDC, 2014) and prepare students for the same examinations, so similar views were expected, and the hypotheses are stated in null form to test this.

2.0 LITERATURE REVIEW

2.1 Concept of Creativity in Mathematics

In psychology, creativity is commonly described as the production of ideas that are both new and useful. Guilford (1950, 1967) linked it to divergent thinking and named fluency (how many ideas are produced), flexibility (how varied the ideas or approaches are), originality (how unusual the ideas are) and elaboration (how fully they are developed) as its main components, and Torrance (1974) built these into his widely used tests of creative thinking. In mathematics, Leikin (2009) used fluency, flexibility and novelty to judge how learners respond to multiple-solution tasks, and Leikin and Pitta-Pantazi (2013) reviewed the field, noting that mathematical creativity can be seen both in the work of professional mathematicians and in the everyday work of school learners. Silver (1997) argued that creativity is closely tied to deep, flexible mathematical knowledge and can be developed in all students through problem solving and

problem posing, while Sriraman (2004) and Mann (2006) discuss the place of creativity in school mathematics and the need to nurture it. In this study, creativity skills therefore refer to learners' capacity to generate more than one workable approach to a problem (fluency), to move between methods and representations (flexibility), and to produce or recognise unusual but valid ideas (originality).

2.2 Theoretical Framework

This study was based on Polya's (1945) Problem-Solving Model, which outlines four stages of mathematical problem-solving: understanding the problem, devising a plan, carrying out the plan, and looking back to evaluate the solution. Polya's model describes the steps of problem-solving; it does not itself define creativity. For this reason it is paired here with Guilford's (1967) components of creativity (fluency, flexibility and originality). Creativity can appear at every stage, but in this study it is treated as most visible in the second stage, devising a plan, where problem-solvers must generate, compare, and select among multiple possible strategies rather than mechanically applying a single memorised procedure. This is the authors' reading, informed by Polya's emphasis on heuristics at that stage and by Silver's (1997) link between problem solving and flexible, novel approaches, and it is not a claim made by Polya. Together, the two frameworks offer a way to study creativity in Number and Algebra, both of which require learners to move flexibly between representations and strategies rather than following one fixed algorithm. Table 1 shows how each of the 20 questionnaire items relates to the stages of Polya's model, to Guilford's components, and to supporting literature.

The 20 questionnaire items were mapped to Polya's four stages and Guilford's three components of creativity, and each was tied to a supporting source. Ten items covered Number skills and ten covered Algebra skills.

For Number, skills linked to devising a plan included using multiple strategies for arithmetic problems (fluency and flexibility; Star & Rittle-Johnson, 2009; Threlfall, 2002), estimating and approximating (flexibility; Star & Rittle-Johnson, 2009), and applying elementary number theory to real-life problems (originality; NERDC, 2014). Recognising and extending numerical patterns (fluency; Samson, 2012) spanned understanding the problem and devising a plan. Skills tied to understanding the problem included representing numbers in multiple forms (flexibility; Deliyianni et al., 2016) and constructing and interpreting word problems (originality and fluency; Arabacı & Baki, 2023). Skills tied to carrying out the plan included mental computation using flexible strategies (flexibility; Threlfall, 2002) and simplifying complex numerical expressions (flexibility; Gray & Tall, 1994), while estimation to check reasonableness belonged to looking back (flexibility; Star & Rittle-Johnson, 2009). Memorising multiplication tables was included as a negative item under carrying out the plan, since it reflects routine recall rather than any creativity component (Gray & Tall, 1994; National Research Council, 2001).

For Algebra, translating word problems into equations was linked to understanding the problem (flexibility; Ogbu, 2025), and patterns in algebraic sequences spanned understanding the problem and devising a plan (fluency; Radford, 2008). Modelling real-world situations algebraically also spanned these two stages (originality; Mwambazi et al., 2024). Skills tied to devising a plan included solving equation by multiple methods (fluency and flexibility; Rittle-Johnson & Star, 2009), solving simultaneous equations (flexibility; Ogbu, 2025), and applying algebra to optimise solutions (originality; Mwambazi et al., 2024). Skills tied to carrying out the plan included manipulating expressions flexibly (flexibility; Xu et al., 2017) and factorising by varied approaches (flexibility; Vilakazi, 2021), while graphing and interpreting functions spanned carrying out the plan and looking back (flexibility; Ogbonnaya & Mushipe, 2020).

Memorising formulas without variation was the second negative item, placed under carrying out the plan and associated with no creativity component (Vilakazi, 2021).

2.3 Creativity in Number Problem-Solving

Number sense and mathematical creativity overlap but are not the same thing. Number sense concerns a flexible, intuitive feel for numbers and operations, whereas creativity, as defined above, concerns generating, comparing and choosing between ways of dealing with a problem. The two meet in flexible mental calculation. Threlfall (2002) argued that flexible mental calculation means choosing a method that suits the particular numbers in a problem, and that teaching methods as fixed wholes does not build this flexibility. Gray and Tall (1994) reported that stronger mathematical thinkers handle arithmetic symbols flexibly, as both process and concept, while less able learners meet a harder, procedure-bound form of mathematics that widens the gap in performance. The National Research Council (2001) likewise separates procedural fluency, the skill of carrying out procedures flexibly, accurately and efficiently, from a productive disposition, so the recall of facts such as multiplication tables (item 7) is useful but is not by itself the flexibility described in the creativity literature.

Studies of learners give some evidence about what strong learners can do. Kattou et al. (2013), working with 359 elementary students, found that creativity and mathematical ability were positively correlated and that creativity behaved as a component of ability. Leikin and Lev (2013) found that differences between mathematically excelling adolescents and others depended on the task and on the level of insight it required, and Arabacı and Baki (2023), in an interview study of 12 secondary students, found that gifted students posed more creative and flexible problems than non-gifted students although they showed no clear advantage in fluency. On specific Number skills, Star and Rittle-Johnson (2009) found that Grade 5 and 6 students ($N = 157$) who compared alternative strategies became more flexible estimators than those who studied strategies one at a time. Deliyianni et al. (2016), with 1,701 primary and secondary students, showed that representational flexibility is a major component of problem-solving ability with fractions and decimals. In South Africa, Samson (2012) found that Grade 9 learners had difficulty expressing the general term of a pattern when their local and global views of it conflicted. These studies come from different countries and age groups and most do not separate Number from Algebra, which is why the present study asks about the two strands separately.

2.4 Creativity in Algebra Problem-Solving

Evidence at the secondary level suggests that flexibility is central to learning Algebra. Rittle-Johnson and Star (2009), working with 162 students in Grades 7 and 8, found that comparing different solution methods best supported conceptual knowledge and procedural flexibility in equation solving. Xu et al. (2017), with 158 Grade 7 students in China, found that knowing several strategies and actually using them are distinct but related kinds of flexibility. Radford (2008) described how Grade 7 learners generalise patterns algebraically through different forms of expression.

Several African studies bear on the specific Algebra items. Ogbu (2025) surveyed 140 secondary students in Nsukka, Nigeria, and found that they could use letters for unknowns but struggled to equate expressions and to build two distinct simultaneous equations from a word problem. Ogbonnaya and Mushipe (2020) found that GeoGebra-assisted teaching improved Grade 9 students' ($N = 94$) drawing and interpretation of linear functions. Vilakazi's (2021) doctoral study of Grade 10 factorisation in South Africa reported heavy reliance on memorised rules by teachers and learners and recommended teaching several factorising methods. Mwambazi et al. (2024), in a small qualitative study in Zambia (15 participants), reported that

contextual teaching improved understanding of linear programming, a topic that involves optimising. Students who can approach a single problem from more than one angle, for instance solving simultaneous equations by substitution, elimination or graphs, show a depth of understanding that rote procedural mastery alone does not guarantee (Rittle-Johnson & Star, 2009).

2.5 Empirical Studies

We compare recent studies from Nigeria and other African countries that are closest to the present one. They differ widely in sample size (from 10 participants to 1,330 students), in method (experiments, correlational and cross-sectional surveys, interviews, and a literature synthesis), and in what they measured.

Ado and Nwosu (2016) found that the laboratory method significantly improved the mathematical creativity of 122 junior secondary students in Bayelsa State, Nigeria. Aliyu et al. (2022) reported higher creativity scores for SS3 students in Sokoto State taught with a Van Hiele-based approach. Sani (2021) found that Kaduna State senior secondary students taught through analytic and creative problem-solving outperformed those taught by lecture. In Kenya, Chesimet et al. (2016) showed that experiential learning significantly raised the mathematical creativity of Form Two students in Kericho East.

Ovat et al. (2024) found that self-efficacy, attitude and motivation together explained variance in fluency, flexibility and originality among 654 Nigerian mathematics students. Bature et al. (2020) reported that engagement strategies helped problem-solving in two Nigerian schools, although teaching remained largely teacher-centred. Consistent with this, Jabbar (2018) found that lecture was the most commonly used method among secondary school teachers in Kano.

Ibrahim et al. (2024) found that students, teachers and school heads in Adamawa State saw negative attitudes and the secondary curriculum as contributors to poor performance. Ibrahim et al. (2023) showed that learning strategy had a significant effect on algebra achievement among Adamawa State senior secondary students. In Gombe State, Achufusi and Emenike (2023) found that study habits were positively related to the mathematics achievement of SS2 students.

In South Africa, Ubah and Ogbonnaya (2021) found that about half of the pre-service primary teachers studied could not produce varied solutions to pattern tasks. Mahlaba (2020) concluded from a literature synthesis that multiple-solution tasks are rarely used but could build creativity.

Read critically, this body of work has four limits for the present purpose. First, most studies that measured creativity directly tested a teaching method on students (Ado & Nwosu, 2016; Aliyu et al., 2022; Chesimet et al., 2016; Sani, 2021), and several relied on intact or non-randomised classes, which limits causal claims. Second, these studies usually targeted one topic, such as geometry, and did not separate Number from Algebra, so they cannot say which creativity skills matter in each strand. Third, the survey and correlational studies measured attitudes, study habits or learning strategies and not creativity skills (Achufusi & Emenike, 2023; Ibrahim et al., 2023; Ovat et al., 2024), and a cross-sectional design cannot show cause. Fourth, the samples range from very small qualitative groups to large student samples, and the studies that included teachers or school heads as respondents (Bature et al., 2020; Ibrahim et al., 2024; Jabbar, 2018) did not ask them which creativity skills are needed in Number and Algebra; none of the studies found was set in Gombe State on mathematical creativity. The experimental

studies nevertheless point in one direction, that creativity-oriented methods are associated with better creativity or performance than lecturing, which is the premise of the present study.

2.6 Summary and Research Gap

In summary, the literature defines mathematical creativity through fluency, flexibility and originality, links flexible mental calculation, strategy comparison, pattern generalisation and multiple-method equation solving to better learning, and suggests that Nigerian classrooms lean toward teacher-centred teaching. What is missing is evidence from Gombe State on which specific creativity skills teachers and administrators consider necessary in Number and in Algebra separately. The present study addresses this gap.

3.0 METHODOLOGY

3.1 Research Design

The study adopted a descriptive survey research design, which suits a study that gathers and compares the opinions of defined groups of respondents.

3.2 Population, Sampling and Procedure

The population consisted of 75 respondents from public secondary schools in Gombe State: 21 school administrators (principals and vice-principals) and 54 mathematics teachers. All 75 respondents were used (census sampling) because the population was small. The respondents were drawn from seven (7) public secondary schools in five (5) of the 11 local government areas of Gombe State. The questionnaire was administered by hand delivery in schools with the help of research assistants in the month of July, 2026 and all the copies distributed were returned and usable. Teachers and school administrators, rather than students, were asked because they are the people who plan, deliver and supervise mathematics lessons and who interpret the national curriculum, so they are well placed to say which skills students need. A perception survey of this kind is also a practical first step: it can identify the skills worth testing before a creativity test is built and given to students. The cost of this choice is that the findings describe what adults believe is needed and not what students can do, a limitation discussed in Section 5.1.

3.3 Instrument

Data were collected using a researcher-developed 20-item questionnaire, the "Mathematics Creativity Skills Needs Questionnaire" (MCSNQ), covering two thematic parts: Number (items 1 to 10) and Algebra (items 11 to 20). Table 1 shows how each item relates to Polya's stages, Guilford's components and the literature. Responses were rated on a five-point scale: Very Highly Needed (5), Highly Needed (4), Moderately Needed (3), Slightly Needed (2), and Not Needed (1). Items 7 (memorising multiplication tables) and 19 (memorising algebraic formulas without variation) are deliberate negative items: they describe rote recall, not a creativity skill, and were included to check whether respondents could tell the two apart. They were not reverse-scored when means were reported, so a low mean on these items means respondents did not rate rote recall as a needed creativity skill.

3.4 Validity and Reliability

The instrument was validated by three experts in Mathematics Education, Federal College of Education (Technical), Gombe, and pilot-tested on eight respondents outside the main sample, yielding a Cronbach alpha reliability coefficient of 0.85 for the whole instrument (Number part: α ; Algebra part: α). Only eight respondents were used in the pilot because the main study was a census of a small population, so every eligible person who joined the pilot was removed from the pool available for the main study. An alpha based on eight respondents is imprecise, and the coefficients should be recomputed on the full sample of 75 where the raw data allow (Tavakol & Dennick, 2011).

3.5 Method of Data Analysis

Data were analysed with the help of SPSS version 31. Research questions were answered using mean and standard deviation, with a cut-off mean of 3.50: items scoring 3.50 and above were regarded as "Needed". This cut-off is the lower real limit of the "Highly Needed" category, because a mean of 3.50 rounds to 4 on the five-point scale. Because the other items clustered above this value, the tables also rank the items so that readers can see relative importance and not only the pass or fail decision. The standard deviation (SD) in Tables 3 and 4 is the standard deviation of all 75 respondents' ratings of that item; a larger SD means that respondents disagreed more about the item. For the hypotheses, each respondent's mean rating across the ten items of a part (Number or Algebra) was computed, and the mean scores of administrators and teachers were compared using the independent-samples t-test (Welch version, because the group sizes are unequal; Delacre et al., 2017) at the 0.05 level of significance. Effect size was reported as Cohen's d (Lakens, 2013) and equality of variances was examined with Levene's test.

4.0 RESULTS

4.1 Research Question 1: Creativity Skills Needed for Number

Table 3

Mean and Standard Deviation of Respondents on Creativity Skills Needed for Number, Ranked by Grand Mean

Rank	Item	Skill	<i>M</i> Admin	<i>M</i> Teach.	<i>M</i> Grand	<i>SD</i>	Remark
1	3	Ability to recognise and extend numerical patterns	4.45	4.20	4.27	0.90	Needed
2	1	Ability to devise multiple strategies for solving arithmetic problems	4.30	4.10	4.16	0.85	Needed
3	8	Ability to construct and interpret word problems involving numbers	4.20	4.05	4.09	0.83	Needed
4	5	Skill in mental computation using flexible strategies	4.10	3.95	3.99	0.78	Needed
5	10	Skill in using estimation to check reasonableness of solutions	3.95	3.80	3.84	0.76	Needed
6	2	Skill in estimating and approximating solutions creatively	3.90	3.70	3.76	0.72	Needed
7	9	Creativity in simplifying complex numerical expressions	3.85	3.70	3.74	0.71	Needed
8	4	Creativity in applying number theory to real-life problems	3.80	3.65	3.69	0.80	Needed
9	6	Ability to represent numbers in multiple forms (fractions, decimals, ratios)	3.75	3.60	3.64	0.68	Needed
10	7	Skill in memorising multiplication tables for quick recall	2.90	2.55	2.65	0.60	Not needed
Mean of all 10 items			3.92	3.73	3.78	0.76	
Mean of the nine items rated Needed			4.03	3.86	3.91		

Note. Administrators $n = 21$, teachers $n = 54$, $N = 75$. Grand mean is the mean of all 75 respondents. *SD* is the standard deviation of all 75 respondents' ratings of the item. Items with a

grand mean of 3.50 or above were rated Needed. The *SD* in the "Mean of all 10 items" row is the average of the ten item *SD*s. Item 7 is a deliberate negative item.

Table 3 shows that nine of the ten Number items were rated as needed creativity skills, with grand means ranging from 3.64 to 4.27. Only item 7 ("skill in memorising multiplication tables for quick recall") fell below the 3.50 cut-off (mean = 2.65), suggesting respondents did not consider rote recall a creativity skill. The three highest-rated skills were recognising and extending numerical patterns (4.27), devising multiple strategies (4.16) and constructing word problems (4.09). The overall mean of 3.78 for all ten items (3.91 for the nine items rated Needed) shows that these skills are needed for Number problem-solving. The *SD*s range from 0.60 to 0.90, so respondents were most divided on pattern recognition (*SD* = 0.90) and most agreed on item 7 (*SD* = 0.60).

Three points need care. First, item 4 ("creativity in applying number theory to real-life problems") ranked eighth of ten (mean = 3.69). Formal number theory is not a secondary school topic, but elementary ideas that belong to it, such as factors, multiples, primes, highest common factor and lowest common multiple, and modular arithmetic, appear in the Number and Numeration work of the senior secondary curriculum; the item is read in that sense, and the wording "number theory" should be changed to "number properties" in future versions of the instrument. Second, item 7 was included on purpose as a negative item, to test whether respondents separated rote recall from creative skill; its low mean, together with the low mean of item 19, suggests that respondents did make this distinction. Third, nearly all items scored above 3.50, so some agreement bias (a tendency to rate every item favourably) is possible (Podsakoff et al., 2003). The two negative items scoring low is some evidence against strong agreement bias, but it cannot rule it out, and the ranking of items is more informative than the pass or fail decision.

4.2 Research Question 2: Creativity Skills Needed for Algebra

Table 4

Mean and Standard Deviation of Respondents on Creativity Skills Needed for Algebra, Ranked by Grand Mean

Rank	Item	Skill	<i>M</i> Admin	<i>M</i> Teach.	<i>M</i> Grand	<i>SD</i>	Remark
1	13	Creativity in solving equations using multiple methods	4.25	4.30	4.29	0.82	Needed
2	11	Ability to translate word problems into algebraic equations	4.35	4.15	4.21	0.88	Needed
3	20	Ability to apply algebraic techniques to optimise solutions	4.15	4.00	4.04	0.80	Needed
4	17	Ability to model real-world situations with algebraic expressions	4.05	3.90	3.94	0.77	Needed
5	12	Skill in manipulating algebraic expressions flexibly	4.00	3.85	3.89	0.75	Needed
6	16	Skill in factorising expressions using varied approaches	3.95	3.80	3.84	0.73	Needed
7	14	Ability to identify patterns in algebraic sequences	3.90	3.75	3.79	0.70	Needed
8	18	Creativity in solving simultaneous equations	3.85	3.70	3.74	0.69	Needed
9	15	Creativity in graphing and interpreting functions	3.70	3.55	3.59	0.66	Needed
10	19	Skill in memorising algebraic formulas without variation	2.80	2.50	2.58	0.58	Not needed
Mean of all 10 items			3.90	3.75	3.79	0.74	
Mean of the nine items rated Needed			4.02	3.89	3.93		

Note. Administrators $n = 21$, teachers $n = 54$, $N = 75$. Grand mean is the mean of all 75 respondents. *SD* is the standard deviation of all 75 respondents' ratings of the item. Items with a grand mean of 3.50 or above were rated Needed. The *SD* in the "Mean of all 10 items" row is the average of the ten item *SD*s. Item 19 is a deliberate negative item.

Table 4 shows that nine of the ten Algebra items were rated as needed, with grand means ranging from 3.59 to 4.29. Only item 19 ("skill in memorising algebraic formulas without variation") fell below the cut-off (mean = 2.58; the weighted mean of 2.80 for administrators and

2.50 for teachers is 2.584, which was previously reported as 2.59). The three highest-rated skills were solving equations by multiple methods (4.29), translating word problems into equations (4.21) and applying algebra to optimise solutions (4.04). The overall mean of 3.79 for all ten items (3.93 for the nine items rated Needed) shows that these skills are needed for Algebra problem-solving. The SDs range from 0.58 to 0.88, with the widest disagreement on translating word problems into equations ($SD = 0.88$).

Two Algebra items need justification. Item 14 ("identify patterns in algebraic sequences") resembles Number item 3 ("recognise and extend numerical patterns"). The items are kept because they ask about different things: item 3 is about extending a pattern of numbers, while item 14 is about expressing the structure of a sequence in algebraic form, such as writing its general term, which the literature treats as a separate algebraic skill (Radford, 2008). The overlap is acknowledged, and the two items ranked differently (first of nine Number items and seventh of nine Algebra items rated Needed), so they were not simply duplicates in the respondents' view. Item 20 ("apply algebraic techniques to optimise solutions") may seem advanced, but optimisation of the kind met in linear programming and in the greatest or least value of a quadratic expression is part of the senior secondary Algebra work, and respondents ranked it third. It is acknowledged as the most demanding Algebra item.

4.3 Hypotheses Testing

Table 5

Welch t-test of the Difference between Administrators and Teachers on Number

Group	<i>n</i>	<i>M</i>	<i>SD</i>	<i>T</i>	<i>df</i>	<i>p</i>	<i>d</i>	Decision
Administrators	21	3.92	0.85	0.92	30.48	.37	0.26	Fail to reject H_0
Teachers	54	3.73	0.68					

Note. *M* and *SD* are the mean and standard deviation of respondents' mean ratings across the ten Number items. Welch's *t*-test for unequal variances; *d* = Cohen's *d* using the pooled SD. Mean difference = 0.19, 95% CI [-0.23, 0.61]. The pooled-variance test gives $t(73) = 1.01$, $p = .32$.

Variance-ratio test from the summary statistics: $F(20, 53) = 1.56$, $p = .20$.

With $t(30.48) = 0.92$ and $p = .37$ ($p > .05$), the null hypothesis (H_{01}) was not rejected: there was no statistically significant difference between administrators ($M = 3.92$) and teachers ($M = 3.73$) regarding the creativity skills needed for Number problem-solving. The effect was small ($d = 0.26$). The 95% confidence interval for the mean difference, [-0.23, 0.61], includes zero but is wide.

Table 6

Welch t-test of the Difference between Administrators and Teachers on Algebra

Group	<i>n</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>df</i>	<i>p</i>	<i>d</i>	Decision
Administrators	21	3.90	0.88	0.71	28.90	.48	0.21	Fail to reject H_0
Teachers	54	3.75	0.65					

Note. *M* and *SD* are the mean and standard deviation of respondents' mean ratings across the ten Algebra items. Welch's *t*-test for unequal variances; *d* = Cohen's *d* using the pooled SD. Mean difference = 0.15, 95% CI [-0.28, 0.58]. The pooled-variance test gives $t(73) = 0.81$, $p = .42$.

Variance-ratio test from the summary statistics: $F(20, 53) = 1.83$, $p = .08$.

With $t(28.90) = 0.71$ and $p = .48$ ($p > .05$), the null hypothesis (H_{02}) was not rejected: there was no statistically significant difference between administrators ($M = 3.90$) and teachers ($M = 3.75$) regarding the creativity skills needed for Algebra problem-solving. The effect was small ($d = 0.21$). The two groups' variances differed more for Algebra than for Number (the

variance ratio was 1.83), which is why the Welch test, which does not assume equal variances, was used.

These results replace the earlier values ($t = 0.94$ and 0.87), which did not match the means and standard deviations in the tables. Using the same summary statistics, the pooled-variance test gives $t(73) = 1.01$ for Number and 0.81 for Algebra, and the Welch test gives 0.92 and 0.71 ; the conclusion does not change. The test has low power: with 21 administrators and 54 teachers, the chance of detecting a medium difference ($d = 0.5$) at the 0.05 level is about 48%, and a difference of about $d = 0.73$ would be needed for 80% power. A non-significant result therefore does not show that the two groups hold the same views; it shows that this study found no evidence of a difference.

5.0 DISCUSSION OF FINDINGS

The findings on Number identified nine creativity skills, with recognising and extending numerical patterns, devising multiple strategies for arithmetic problems and constructing word problems ranked highest, and applying number theory and representing numbers in multiple forms ranked lowest among those rated as needed. A possible reason for the high ranking of patterns, multiple strategies and word problems is that these are the skills most closely tied to non-routine questions, where a single memorised procedure fails; this is an interpretation, since the study did not test it. The lower ranking of number theory and multiple representations may reflect that respondents see them as content knowledge to be taught, not as creative skills, and that number theory receives little attention at secondary level. These findings are consistent with Threlfall (2002), who argued that flexible mental calculation depends on choosing a method to suit the problem, and with Star and Rittle-Johnson (2009), who found that comparing strategies improved estimation flexibility, although those studies tested students and this one asked adults.

For Algebra, nine creativity skills were identified, with solving equations through multiple methods, translating word problems into equations and optimising solutions ranked highest. Graphing and interpreting functions was the lowest of the nine (3.59). A possible explanation is that graphing in many schools is taught as plotting by procedure, with little technology, whereas Ogbonnaya and Mushipe (2020) found that GeoGebra-assisted teaching improved learners' interpretation of linear functions; again, this is an interpretation and was not tested here. The high ranking of multiple-method equation solving agrees with Rittle-Johnson and Star (2009) and Xu et al. (2017), and the high ranking of word-problem translation matches the difficulty that Ogbu (2025) found among secondary students in Nsukka.

Notably, respondents did not rate rote memorisation of multiplication tables or algebraic formulas as creativity skills, a finding consistent with earlier work distinguishing procedural recall from flexible problem-solving (Gray & Tall, 1994; Silver, 1997; Vilakazi, 2021). Mental computation was rated needed (item 5, mean = 3.99) while memorising tables was not (item 7, mean = 2.65), because mental computation, as Threlfall (2002) describes it, involves choosing and adapting a method to the numbers in front of the learner, whereas recalling a table involves no such choice. This does not mean that respondents thought recall useless: both negative items fell in the "Moderately Needed" band of the scale, so respondents rated recall as less needed as a creativity skill, not as worthless. This distinction carries clear instructional implications: creativity-focused interventions in Number and Algebra should prioritise strategy generation, pattern extension, and multiple-method solving rather than memorisation drills.

The result agrees in direction with Nigerian studies that tested creativity-oriented teaching. Ado and Nwosu (2016) in Bayelsa State, Aliyu et al. (2022) in Sokoto State and Sani (2021) in Kaduna State each found that students taught with laboratory, Van Hiele-based or

creative problem-solving methods scored higher than comparison groups. Respondents in Gombe State, who rated multiple strategies and open problem solving as the skills most needed, hold views that fit these results. The comparison is limited because those studies measured students' creativity or achievement after teaching, while the present study measured opinions.

The non-significant t-test results for both Number ($p = .37$) and Algebra ($p = .48$) suggest that administrators and teachers share a broadly consistent understanding of the creativity skills mathematics students need. Teachers rated almost every item slightly lower than administrators did (Tables 3 and 4), a pattern that may reflect closer contact with classroom constraints, but the differences were small and not statistically significant.

5.1 Limitations of the Study

The findings must be read with six limits in mind. First, the data are the opinions of adults, and no students were tested, so the results show what respondents believe is needed and not what students can or cannot do. Second, the sample was small (75 respondents, with unequal groups of 21 and 54), which gave the hypothesis tests low power. Third, the study covered one state, so the results cannot be generalised to other states. Fourth, self-reported ratings are open to agreement bias, and the 3.50 cut-off was passed by 18 of the 20 items. Fifth, the instrument was piloted on only eight respondents, and some items (items 4, 14 and 20) are open to the wording and overlap concerns discussed in Section 4. Sixth, the study did not include interviews or observations that could explain why respondents rated the skills as they did.

6.0 CONCLUSION

For Number (research question 1), respondents rated nine of the ten skills as needed, with grand means from 3.64 to 4.27. Recognising and extending numerical patterns (4.27), devising multiple strategies (4.16) and constructing and interpreting word problems (4.09) ranked highest. Only memorising multiplication tables (2.65) fell below the 3.50 cut-off.

For Algebra (research question 2), respondents rated nine of the ten skills as needed, with grand means from 3.59 to 4.29. Solving equations by multiple methods (4.29), translating word problems into equations (4.21) and applying algebra to optimise solutions (4.04) ranked highest. Only memorising algebraic formulas without variation (2.58) fell below the cut-off.

Administrators and teachers did not differ significantly on either strand, so both null hypotheses were not rejected. The study could not show whether students actually have or lack these skills, whether developing them improves students' results, or whether the views held in Gombe State apply to other states.

7.0 RECOMMENDATIONS

Based on the findings, the following recommendations are made:

1. Mathematics teachers should design open-ended Number tasks that require students to generate and compare multiple solution strategies rather than apply a single memorised procedure, because recognising and extending numerical patterns ($M = 4.27$) and devising multiple strategies ($M = 4.16$) were the two highest-rated Number skills. Teachers could set at least one such task each week.

2. Algebra teachers should use multiple-method equation-solving (substitution, elimination, graphical) so that students experience and compare varied approaches to the same problem, because solving equations through multiple methods was the highest-rated Algebra skill ($M = 4.29$).

3. Curriculum planners (the NERDC and the curriculum unit of the Gombe State Ministry of Education) should write clear creativity-based learning outcomes for Number and Algebra, such as constructing and translating word problems ($M = 4.09$ and 4.21), and give them enough

teaching time. We suggest at least one such outcome for each topic, reviewed at every curriculum revision, with a double period set aside each fortnight for open-ended tasks.

4. The Gombe State Ministry of Education should organise regular in-service training for all secondary school mathematics teachers on creativity-focused pedagogical strategies such as open-ended questioning and multiple-strategy instruction, because these skills were rated as needed in both strands (nine of ten items in each). We suggest at least one workshop of two to three days each term, led by mathematics educators from tertiary institutions in the state.

5. Continuous assessment in mathematics should include tasks that reward varied, creative solution approaches rather than a single expected method, and tasks that ask students to check answers by estimation ($M = 3.84$), at least once each term.

6. Further studies should test students directly using creativity tasks scored for fluency, flexibility and originality, use larger samples, add interviews or observations to explain the ratings, and cover other topics, such as Geometry and Statistics, and other states.

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