EDUMASPUL:
Jurnal Pendidikan
P-ISSN 2548-8201 | E-ISSN 2580-0469

Vol. 10 No. 2 (2026), 789-795
DOI: https://doi.org/10.33487/edumaspul.v10i2.409

Developing an Unplugged Coding-Based Geometry Traffic Board Learning Medium to Foster Logical Thinking in Group B Kindergarten Children

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Received	Revised	Accepted	Published
27/07/2026	06/08/2026	17/08/2026	**25/08/2026**

Abstract: Logical thinking is a foundational competency in early childhood education, yet learning media in many Indonesian kindergartens remain static and rarely challenge children to sequence, classify, or reason about cause and effect. Preliminary observation at TK Muamalah Kepahiang showed that geometry was introduced mainly through visual memorisation of basic shapes, without structured problem-solving scenarios. This study aimed to develop a Geometry Traffic Board learning medium based on unplugged coding that is valid and practical for fostering the logical thinking of Group B children. The research used a research and development design following the ADDIE model, limited to four stages: analyse, design, develop, and evaluate. Participants comprised two content-expert validators, two media-expert validators, kindergarten teachers as practitioner respondents, six children in the limited trial, and eighteen children in the field trial, all at TK Muamalah Kepahiang in the 2025/2026 academic year. Data were collected through expert validation sheets, teacher response questionnaires, and structured observation of four logical thinking indicators, and were analysed as percentages against validity and practicality criteria. Content-expert validation reached 95% and media-expert validation 93%, both highly valid. Teacher responses reached 94% in the limited trial and 95% in the field trial, both highly practical, while children's logical thinking attainment reached 94% and 95% respectively. The medium is therefore declared valid and practical for fostering logical thinking in early childhood.

Keywords: Logical thinking; unplugged coding; geometry traffic board; learning media; early childhood education

Abstrak: Berpikir logis merupakan kompetensi dasar dalam pendidikan anak usia dini, namun media pembelajaran di banyak TK di Indonesia masih statis dan jarang menantang anak untuk mengurutkan, mengklasifikasikan, atau bernalar tentang sebab dan akibat. Observasi awal di TK Muamalah Kepahiang menunjukkan bahwa geometri diperkenalkan terutama melalui hafalan visual bentuk-bentuk dasar, tanpa skenario pemecahan masalah yang terstruktur. Penelitian ini bertujuan untuk mengembangkan media pembelajaran Papan Lalu Lintas Geometri berbasis pengkodean tanpa perangkat elektronik (unplugged coding) yang valid dan praktis untuk menumbuhkan berpikir logis anak-anak Kelompok B. Penelitian ini menggunakan desain penelitian dan pengembangan mengikuti model ADDIE, terbatas pada empat tahap: menganalisis, merancang, mengembangkan, dan mengevaluasi. Partisipan terdiri dari dua validator ahli konten, dua validator ahli media, guru TK sebagai responden praktisi, enam anak dalam uji coba terbatas, dan delapan belas anak dalam uji coba lapangan, semuanya di TK Muamalah Kepahiang pada tahun ajaran 2025/2026. Data dikumpulkan melalui lembar validasi ahli, kuesioner respons guru, dan observasi terstruktur dari empat indikator berpikir logis, dan dianalisis sebagai persentase terhadap kriteria validitas dan kepraktisan. Validasi ahli konten mencapai 95% dan validasi ahli media 93%, keduanya sangat valid. Respons guru mencapai 94% dalam uji coba terbatas dan 95% dalam uji coba lapangan, keduanya sangat praktis, sementara pencapaian berpikir logis anak-anak mencapai 94% dan 95% secara berturut-turut. Oleh karena itu, media tersebut dinyatakan valid dan praktis untuk menumbuhkan berpikir logis pada anak usia dini.

Kata kunci: berpikir logis; pengkodean tanpa komputer; papan lalu lintas geometri; media pembelajaran; pendidikan anak usia dini

CITATION:	Hamida, E., Nopriyeni, N., & Ade Cahaya, M. (2026). Developing an Unplugged Coding-Based Geometry Traffic Board Learning Medium to Foster Logical Thinking in Group B Kindergarten Children. *Edumaspul: Jurnal Pendidikan*, *10*(2), 789–795. https://doi.org/10.33487/edumaspul.v10i2.409

Introduction

Logical thinking is among the competencies most needed for participation in contemporary life. Individuals are expected to analyse problems, make reasoned decisions, and evaluate information critically so that they are not easily misled by false claims (Handini & Maf'ulah, 2025). In education, logical thinking equips learners to resolve problems using evidence and sound inference (Ameylia & Kurniasih, 2022). Because it underpins later reasoning, this capacity must be stimulated from the earliest years of schooling rather than deferred to formal instruction in primary school.

Indonesian regulation frames the competency concretely. Ministerial Regulation No. 137 of 2014 on early childhood education standards specifies that logical thinking at this stage includes recognising differences in shape and size, taking initiative in choosing a play theme, planning activities, recognising cause and effect, classifying objects by colour, shape, and size, grouping objects into sets with more than two variations, recognising ABCD–ABCD patterns, and ordering objects by size (Kemendikbud, 2014). Early childhood, commonly described as the golden age spanning birth to six years, is the period in which these abilities develop most rapidly and therefore requires deliberate stimulation (Widari & Sumiati, 2025). Logical thinking also supports children in articulating ideas prompted by objects in their surroundings (Wijayanti & Lestariningrum, 2022).

The choice of learning medium matters greatly at this stage. Interactive media grounded in direct experience suit young children, and play that doubles as a learning medium supports the development of logical thinking (Aulia et al., 2022). Concrete manipulatives are particularly effective: Madang et al. (2022) found that a geometry board stimulated children's knowledge of shape, Takumansang et al. (2025) showed that a three-dimensional G-Box medium improved children's ability to group geometric forms, and Justo et al. (2022) demonstrated the general learning advantage of physical manipulatives. Geometry media are well suited to early childhood because manipulating shape pieces lets children learn about form, size, and pattern while developing fine motor skills and collaborating with peers (Vriegde & Pudyaningtyas, 2025).

Unplugged coding offers a complementary route. It introduces fundamental programming concepts through physical interaction with everyday objects, without any digital device (Mutoharoh et al., 2023), and helps children construct strategies, evaluate solutions, and understand cause-and-effect relationships (Fauziah et al., 2025). Chen et al. (2023) synthesised a substantial body of evidence showing that unplugged activities foster computational thinking, while Busuttil and Formosa (2020) argued for their pedagogical value as a strategy in their own right. Empirical work in Indonesia points the same way: Masfiyah (2025) recorded significant gains in pattern recognition, sequencing, and simple problem solving among four- to five-year-olds; Mutoharoh et al. (2021) documented improvements in problem-solving skills; Oktaviani et al. (2025) found gains in computational and collaborative thinking; and Karimah and Sholeha (2024) reported similar effects for five- to six-year-olds. Dayurni and Rahmadhani (2025) developed an unplugged coding gameboard specifically for this age group.

Despite these parallel lines of evidence, few media combine geometry content with coding logic in a single structured package. Existing products tend either to present geometric shapes for identification or to deliver coding activities detached from curricular content. Interviews with teachers at TK Muamalah Kepahiang confirmed that the school still relied on conventional, one-directional media: available resources were limited to ordinary blocks or shape pieces without structured problem-solving scenarios. Observation showed geometry being introduced through visual memorisation of circles, triangles, and squares, drawing, and simple games, with no integration of computational reasoning.

Baseline observation of Group B children against four logical thinking indicators showed correspondingly modest attainment. On showing initiative, 75% of children were at the emerging level and 25% at the developing-as-expected level; on planning activities, 65% were emerging and 35% developing as expected; on recognising cause and effect, 40% were emerging and 60% developing as expected; and on classifying objects, most children remained at the developing-as-expected level. The pattern is consistent with media that direct attention to identifying shapes rather than to decomposing a task into steps.

This study therefore develops a Geometry Traffic Board medium based on unplugged coding, integrating geometric shape pieces with a route board on which children program a vehicle's journey

using mission cards. The medium is designed to be inexpensive, free of screen exposure, and appropriate to early childhood development. Two questions guide the research: how valid is the developed medium according to content and media experts, and how practical is it according to teacher responses? The study contributes an expert-validated design that links geometry and computational reasoning within one artefact, together with evidence on the logical thinking indicators it most strongly stimulates.

METHOD

Research design

This study used a research and development design intended to produce a specific product and examine its quality (Sugiyono, 2022) — in this case a Geometry Traffic Board learning medium based on unplugged coding that is valid and practical. Development followed the ADDIE model, which is systematic, readily understood, and permits repeated revision and evaluation within each stage (Figure 1). Because the medium was trialled rather than deployed across a full instructional programme, implementation in the full sense was not undertaken, and the procedure was limited to four stages: analyse, design, develop, and evaluate.

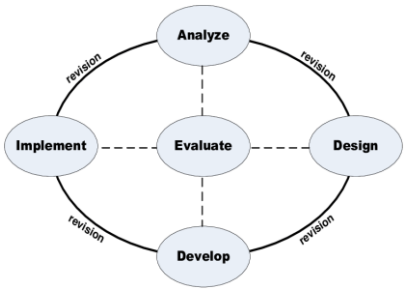

Figure 1. Stages of the ADDIE development model

Setting and participants

The research was carried out at TK Muamalah Kepahiang, Bengkulu Province, between 26 May and 11 June 2026. Participants comprised two content-expert validators and two media-expert validators, kindergarten teachers acting as practitioner respondents, six Group B children in the limited trial, and eighteen Group B children in the field trial, all in the 2025/2026 academic year. Children were selected to represent the full range of attainment on the logical thinking indicators, from emerging through developing as expected to well developed, so that the trials would surface difficulties across ability levels rather than only among the most capable.

Instruments

Three instruments were used. Expert validation sheets for content assessed material, language, and presentation; those for media assessed appearance, fit to the logical thinking indicators, fit to the unplugged coding concept and completeness of components, and usability of the guidebook. Teacher response questionnaires measured practicality across content, language, and presentation. Structured observation sheets recorded children's attainment on the four logical thinking indicators drawn from Ministerial Regulation No. 137 of 2014: showing initiative in choosing a theme, planning the sequence of activities, recognising cause and effect, and classifying objects. All instruments used a five-point Likert scale, and interviews and documentation supplied supporting qualitative evidence.

Development procedure

At the *analyse* stage, children's needs were established through observation of logical thinking attainment, teachers' needs through interview, and curricular fit through analysis of the foundation-phase learning outcomes for Literacy and STEM under the 2025 curriculum decree (Kemendikdasmen, 2025), together with the Pancasila learner profile dimensions of collaboration, independence, critical reasoning, and creativity. At the *design* stage, a storyboard and prototype were prepared and an initial draft assembled around a game-based learning sequence incorporating unplugged coding. At the *develop* stage, Draft I was produced and submitted for expert validation, revised into Draft II, trialled with six children, revised again, and then trialled with eighteen children. *Evaluation* was conducted at the close of each preceding stage and fed forward into the next.

Data analysis

Qualitative data from interviews and documentation were analysed descriptively through data reduction, display, and conclusion drawing. Quantitative data from the validation sheets and questionnaires were converted into percentages by dividing the obtained score by the maximum possible score and multiplying by 100. Validity percentages were interpreted following Sa'adah and Suryanti (2024) as 80–100% (highly valid), 60–79.9% (valid), 40–59.9% (moderately valid), 20–39.9% (less valid), and 0–19.9% (very poorly valid); practicality percentages used the equivalent bands from highly practical to very poorly practical. The medium was

deemed successful when it reached at least the valid and practical categories on both criteria.

RESULTS AND DISCUSSION

The developed medium

The final product is a set of wooden play equipment comprising seven components. A rectangular wooden container measuring approximately 40 × 30 × 10 cm, fitted with internal dividers and finished in wood paint, stores every component and keeps the set intact between uses (Kustiawan, 2016). The *traffic board* itself, a 40 × 30 cm thin wooden panel 2 mm thick, serves both as the container lid and as the arena on which the vehicle travels according to the algorithm the child constructs. Address pieces measuring 8 × 4 cm mark the goal state that must be reached through a sequence of instructions, giving children a concrete referent for the idea that every step should serve a systematic purpose (Chen et al., 2023).

Vehicle pieces measuring 4 × 2.5 cm carry stickers of buses, trucks, fire engines, ambulances, and taxis, and execute the instructions the child has arranged. When a vehicle fails to reach its destination, the child must locate the error, correct the sequence, and try again — a cycle that exercises ordering, causal reasoning, decision making, and evaluation of a chosen solution, consistent with constructivist accounts of learning through direct interaction with the environment (Gilano et al., 2024). The *codification board* holds geometric pieces in three basic shapes (circle, triangle, square) and three colours (yellow, red, blue), 4 cm in diameter and 1 cm thick, supporting classification, matching, grouping, and pattern recognition (Resnick et al., 2016). Mission cards measuring 8.5 × 6 cm carry pictures, symbols, and instruction text and act as scaffolding for identifying a goal, composing a simple algorithm, predicting the consequence of each step, and debugging when the vehicle goes astray (Oktaviani et al., 2025). A guidebook completes the set, providing teachers with objectives, rules, procedures, worked examples of algorithm construction, and the developmental indicators targeted.

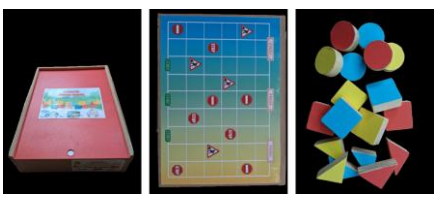

Figure 2. The Geometry Traffic Board: storage container, route board, and geometric pieces

Validity

Content-expert validation is presented in Table 1 and media-expert validation in Table 2.

Table 1. Content-expert validation results

Assessed aspect	Val. 1	Val. 2	Mean
Content	82%	100%	91%
Language	85%	100%	93%
Presentation	100%	100%	100%
Mean	**89%**	**100%**	**95%**
Category		**Highly valid**	

Table 2. Media-expert validation results

Assessed aspect	Val. 1	Val. 2	Mean
Appearance	86%	97%	91%
Fit to indicators	92%	100%	96%
Fit to illustration	80%	100%	90%
Usability	93%	100%	97%
Mean	**88%**	**99%**	**93%**
Category		**Highly valid**	

Content validation reached a mean of 95%, within the highly valid band. Presentation scored highest at 100%, followed by language at 93% and content at 91%. The content aspect, covering suitability, breadth, depth, and accuracy of material, attracted the most reserved judgement from the first validator at 82%, reflecting the difficulty of calibrating breadth for five- to six-year-olds: material must be rich enough to sustain curiosity without overloading cognitive capacity. The material was ultimately built around four basic shapes represented through real parts of land vehicles — circular wheels, rectangular bodies, square windows, triangular roofs — so that geometric concepts remained anchored in objects familiar from daily life.

Media validation reached a mean of 93%, also highly valid. Usability scored highest at 97%, confirming that the guidebook and instructions were clear enough for teachers and children to proceed without repeated explanation, followed by fit to the logical thinking indicators at 96%, appearance at 91%, and fit to the illustration and completeness of components at 90%. The last of these drew the lowest single rating, 80% from the first validator, which is consistent with the developers' own assessment that abstraction and more complex algorithm design were not yet developed in depth. The gap between the two validators on both instruments — 89% against 100% for content, 88%

against 99% for media — indicates that the first validator applied a stricter standard across the board rather than objecting to any particular component.

Practicality and children's logical thinking

Teacher responses and children's attainment across the two trials are presented in Tables 3 and 4.

Table 3. Teacher responses to the practicality of the medium

Practicality aspect	Limited trial	Field trial
Content	93%	92%
Language	93%	93%
Presentation	96%	100%
Mean	**94%**	**95%**
Category	**Highly practical**	**Highly practical**

Table 4. Children's logical thinking attainment

Logical thinking indicator	Limited trial	Field trial
Showing initiative in choosing a theme	93%	96%
Planning the sequence of activities	94%	93%
Recognising cause and effect	94%	98%
Classifying objects	96%	94%
Mean	**94%**	**95%**
Category	**Very good**	**Very good**

Teachers rated the medium highly practical in both trials, at 94% and 95%. The improvement was concentrated in presentation, which rose from 96% to 100%, indicating that revisions made after the limited trial addressed the presentational issues teachers had identified. Teachers reported that the medium was easy to use, that the instructions were clear, and that activities fitted the available lesson time; they also judged the appearance attractive and appropriate to the children's characteristics. That the guidebook removed the need for repeated explanation is itself a practicality finding, since the demands a medium places on teacher time largely determine whether it survives beyond a trial.

Children's logical thinking attainment reached 94% in the limited trial and 95% in the field trial, both categorised as very good. The pattern across indicators is more informative than the mean. Recognising cause and effect rose from 94% to 98% and was the strongest indicator in the field trial, which is what the design would predict: the immediate feedback of watching a vehicle succeed or fail against a programmed route makes causal relations directly observable rather than merely described. Showing initiative rose from 93% to 96%, reflecting the open structure in which children choose their own mission card, vehicle, shape, and route. Classifying objects fell slightly from 96% to 94%, and planning the sequence of activities was the weakest indicator in the field trial at 93%. Planning requires children to think ahead and commit to a decision before acting, which is developmentally the most demanding of the four and the one most in need of continued teacher guidance.

Discussion

The results support the proposition that geometry and unplugged coding are complementary rather than merely compatible. Identifying shapes, grouping objects, recognising patterns, determining position, and composing a route are all forms of reasoning that involve analysis, classification, prediction, and decision making. When children arrange a sequence of instructions to reach a goal, they are not only meeting basic programming concepts but also building systematic thinking through the causal relation between each action and its result. This aligns with Chen et al. (2023) on the contribution of unplugged activities to computational thinking and with Oktaviani et al. (2025) on gains in sequencing, pattern recognition, decomposition, and algorithmic thinking among young children.

Three features appear to account for the ratings obtained. First, the medium is concrete and manipulable, which matches the concrete operational character of thinking at this age; children hold, move, and match components directly rather than receiving verbal explanation alone, and Nurannisa et al. (2024) found that concrete media help children classify objects and grasp relations between forms more effectively than verbal instruction. Second, the traffic theme provides a familiar context, so that geometric shapes are encountered as parts of vehicles children already know rather than as abstract figures; consistency of colour coding across every component reinforces the association between shape and identity. Third, the guidebook functions as instructional scaffolding, giving teachers a systematic sequence of stimulation and thereby securing consistent implementation — a factor Oktaviani et al. (2025) identified as decisive in unplugged coding, alongside attractive media and the teacher's role as facilitator.

Group work during the field trial, in which eighteen children worked in three groups, also drew on cooperative learning, which raises learning

outcomes while developing communication, collaboration, and social skills through play (Nopriyeni & Nurdiana, 2022). Children were observed to be enthusiastic and engaged, moving components actively rather than waiting for instruction, which is consistent with the motivational effect concrete media have been found to exert (Gilano et al., 2024).

Several limitations qualify these findings. The medium is built around the land-vehicle theme and basic shape recognition, so it does not cover the full range of early childhood learning outcomes; other themes would require modified components. It emphasises sequencing, pattern recognition, and simple problem solving, while abstraction and more complex algorithm design remain undeveloped. Children cannot yet use the medium wholly independently, so the teacher's role in giving instructions, facilitating discussion, and assisting with route construction remains essential. Most importantly, the study establishes validity and practicality but not effectiveness: no control group or pre-test–post-test comparison was used, so the extent to which the medium causes measurable gains in logical thinking remains open.

CONCLUSION

The Geometry Traffic Board learning medium based on unplugged coding meets both criteria set for this research. It is highly valid, with content-expert validation at 95% and media-expert validation at 93%. It is highly practical, with teacher responses at 94% in the limited trial and 95% in the field trial, while children's logical thinking attainment reached 94% and 95% respectively, both categorised as very good. The medium is therefore appropriate for use in early childhood settings to foster logical thinking. Its principal contribution is to integrate geometric content with computational reasoning in a single low-cost, screen-free artefact, with evidence that the design most strongly stimulates recognition of cause and effect while planning ahead remains the indicator most in need of teacher guidance. Future research should test effectiveness experimentally, extend the design to other curricular themes, and develop the abstraction and algorithm-design dimensions that this version leaves underexplored.

Acknowledgment

The authors thank the principal, teachers, and Group B children of TK Muamalah Kepahiang for their participation, and the expert validators for their careful review of the developed medium.

Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Elis Hamida: conceptualization, methodology, investigation, data curation, writing—original draft. Nopriyeni: supervision, validation, writing—review and editing. Mariana Ade Cahaya: supervision, methodology, writing—review and editing.

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