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Implementation of the Group Investigation Model Assisted by Liveworksheet E-Worksheets to Improve Students' Cognitive Learning Outcomes

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Abstract
Cognitive learning outcomes in the abstract subject of Hydrology remain low due to teacher-centered instructional practices. This study aims to analyze the effect of the Group Investigation (GI) model assisted by Liveworksheet electronic worksheets (e-LKPD) on the cognitive learning outcomes of tenth-grade students at SMA Negeri 1 Singaparna, Tasikmalaya Regency. This quantitative study employed a quasi-experimental method with a nonequivalent control group design. Two classes selected through random drawing, each comprising 44 students, were assigned to the experimental group (GI assisted by Liveworksheet e-worksheets) and the control group (Direct Instruction assisted by PowerPoint) over two instructional sessions taught by the researcher. Data were collected using pretests and posttests consisting of 39 validated and reliable multiple-choice items ($\alpha = 0.925$) and analyzed using the Mann-Whitney U test, due to non-normal data distribution despite homogeneous variances, alongside normalized gain (N-Gain). The mean posttest score of the experimental group (83.68) exceeded that of the control group (64.09), with mean N-Gain scores of 0.65 and 0.34, respectively (both categorized as moderate). Hypothesis testing revealed a statistically significant difference in posttest scores with a large effect size ($U = 170; Z = -6.682; p < 0.001; r = 0.71$), and N-Gain scores also differed significantly ($p < 0.001$). The novelty of this study lies in its quasi-experimental evaluation of integrating GI and Liveworksheet e-worksheets specifically in senior high school Hydrology, which has not been identified in prior literature reviewed by the author.

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Introduction

Education plays a pivotal role in preparing students to develop their cognitive, affective, and psychomotor potentials in a balanced manner. Within the revised Bloom's taxonomy, the cognitive domain spans from remembering to creating, serving as a foundational framework for formulating and assessing learning outcomes (Nafiati, 2021). Cognitive learning outcomes are understood as changes in students' knowledge capacities following their engagement in the instructional process (Djamaluddin & Wardana, 2019). Nevertheless, the cognitive achievement of Indonesian students remains a pressing challenge. In the 2022 PISA assessment, only 18% of Indonesian students achieved minimum proficiency (Level 2) in mathematics, 25% in reading, and 34% in science, trailing substantially behind the OECD averages of 69%, 74%, and 76%, respectively (OECD, 2023). This disparity underscores the urgent need to strengthen conceptual understanding across core disciplines, including Geography. Geography examines natural and social phenomena surrounding learners, with hydrology serving as a primary topic encompassing the water cycle, water resources, and their interconnections with flooding, drought, and water resource management. However, hydrology is inherently abstract, involving processes such as evaporation, condensation, and precipitation that are difficult to grasp when delivered solely through direct instruction (El Ghuraba & Sumarmi, 2025; Gultom, 2025). When instruction relies predominantly on lectures, students tend to memorize terminology without comprehending its relevance to everyday phenomena. Consequently, Geography education requires instructional models and media that actively engage learners.

A similar challenge was observed at SMA Negeri 1 Singaparna, Tasikmalaya Regency. An archival analysis of 2024 daily Geography test scores in Class X.10 ($N = 35$) revealed a mean score of 58.5 on Hydrology, falling substantially below the school's Minimum Mastery Criteria (*Kriteria Ketuntasan Minimal* [KKM]) of 76. The concentration of scores within the 40–75 range indicated that the majority of students failed to achieve mastery. This underperformance was closely linked to predominantly teacher-centered pedagogy and the suboptimal integration of digital technology. One-way instruction affords limited opportunities for students to independently investigate and synthesize concepts. Conversely, a meta-analysis of 225 studies across science, technology, engineering, and mathematics (STEM) education demonstrated that active learning increases student performance by approximately half a standard deviation compared to traditional lecturing (Freeman et al., 2014). Furthermore, digital media have been associated with enhanced student motivation and learning outcomes (Nurhasanah et al., 2025), while student preparation and synchronous participation significantly contribute to improved performance in blended learning environments (Clark & Post, 2021). Innovative instructional media also clarify content presentation and foster learning interest (Suryani et al., 2018). Thus, integrating collaborative learning with digital media offers a relevant pedagogical approach for teaching Hydrology.

Group Investigation (GI) is a cooperative learning model in which students select subtopics, plan investigations, gather and analyze information, and present their findings collaboratively (Sharan & Sharan, 1990, 1992). Cooperative learning itself constitutes an instructional method wherein students work in small groups to facilitate mutual learning (Slavin, 2015). Within Geography education, a quasi-experimental study employing a

nonequivalent control group design reported that GI yielded superior learning outcomes compared to conventional discussion on the topic of coastal abrasion (Taher et al., 2019). Corroborating results were reported among eleventh-grade high school students, where the GI group achieved a higher final mean score (81.01) than the expository group (72.39) (Winanti et al., 2018). Across other disciplines, GI has been investigated for enhancing collaboration and academic achievement (Binur & Sahono, 2023), motivation and biology learning outcomes (Kumalasari, 2021), as well as learning outcomes and digital literacy through internet-based GI (Sai, 2017). The impact of GI on critical thinking and social skills in biology instruction has also been documented (Herlina et al., 2019).

On the other hand, Liveworksheet-based electronic student worksheets (e-LKPD) enable students to complete interactive exercises online (Susilawati et al., 2022). Their effectiveness in improving learning outcomes has been empirically tested in senior high school Sociology (Hurrahma & Sylvia, 2022) and tenth-grade Protista concepts (Mispa et al., 2022). In Geography, Liveworksheets-based e-worksheets have been developed for geographic research topics (Ain et al., 2025), whereas GI-based e-worksheets have been designed for junior high school science instruction (Sajidi & Parmin, 2025). Additional e-worksheet developments have been reported in chemistry (Farkhati & Sumarti, 2019), elementary mathematics (Putra et al., 2021), and biology (Zahroh & Yuliani, 2021).

Existing studies on GI in Geography reviewed by the author (Taher et al., 2019; Winanti et al., 2018) did not integrate the model with interactive digital worksheets. Meanwhile, prior research on digital media in high school Geography has primarily focused on developing Liveworksheets-based e-worksheets (Ain et al., 2025), Articulate Storyline media (El Ghuraba & Sumarmi, 2025; Norsidi et al., 2024), augmented reality for the hydrological cycle (Raharja & Suharto, 2024), and evaluating Articulate Storyline combined with guided discovery learning (Rivaldi et al., 2024). However, experimental investigations evaluating the integration of GI and Liveworksheet e-worksheets on cognitive learning outcomes in Hydrology remain absent from the literature reviewed by the author. Pedagogically, GI provides a structured framework for collaborative inquiry, whereas Liveworksheet e-worksheets deliver interactive exercises accessible via mobile devices. Combining both is expected to help students comprehend abstract hydrological cycle processes through collaborative investigation and interactive practice. The novelty of this study lies in conducting a quasi-experimental evaluation of this integrated approach in tenth-grade Hydrology compared against PowerPoint-assisted Direct Instruction. Beyond comparing posttest scores, this study computes normalized gain (N-Gain) (Hake, 1998) to evaluate learning progression despite unequal baseline abilities between groups. This investigation is delimited to cognitive learning outcomes and does not examine motivation, attitudes, or learning activities. Specifically, this study aims to analyze the effect of the GI model assisted by Liveworksheet e-worksheets on the cognitive learning outcomes of tenth-grade students at SMA Negeri 1 Singaparna. It is hypothesized that there is a statistically significant difference in cognitive learning outcomes (posttest scores) between students taught using GI assisted by Liveworksheet e-worksheets and those taught using Direct Instruction assisted by PowerPoint.

Method

This study adopted a quantitative approach utilizing a quasi-experimental method with a nonequivalent control group pretest–posttest design, as individual random assignment is impractical in intact school classrooms (Taher et al., 2019). The study population comprised 551 tenth-grade students at SMA Negeri 1 Singaparna during the 2025/2026 academic year, distributed across 12 classes. Two intact classes were selected via simple random drawing: Class X-4 was assigned as the experimental group and Class X-6 as the control group, with each class consisting of 44 students. The experimental group was taught using the GI model assisted by Liveworksheet e-worksheets across six instructional stages (grouping, planning, investigation, organizing, presenting, and evaluating) within six heterogeneous groups, each investigating a distinct hydrological subtopic. Conversely, the control group received Direct Instruction assisted by PowerPoint presentations. The intervention spanned two instructional sessions for each group and was delivered directly by the researcher. Cognitive learning outcome data were collected via pretests and posttests comprising 39 multiple-choice items aligned with cognitive domain indicators of the revised Bloom's taxonomy (C1–C4). From an initial pool of 50 items, empirical tryout validation retained 39 valid items (Pearson product-moment correlation, $r_{\text{table}} = 0.329$) exhibiting high internal consistency (Cronbach's $\alpha = 0.925$). Data were analyzed using SPSS version 26. Because Shapiro-Wilk tests indicated non-normal distributions for several datasets while Levene's test confirmed homogeneity of variance, differences in posttest and N-Gain scores between groups were evaluated using the non-parametric Mann-Whitney U test at a 0.05 significance level (Nachar, 2008). Individual learning gains were calculated using normalized gain, $g = (S_{\text{post}} - S_{\text{pre}})/(100 - S_{\text{pre}})$, categorized as high ($g \geq 0.70$), moderate ($0.30 \leq g < 0.70$), and low ($g < 0.30$) (Hake, 1998). Learning mastery was benchmarked against the institutional Minimum Mastery Criteria (KKM) of 76.

Results and Discussion

Results

Table 1 presents the descriptive statistics for cognitive learning outcomes in the experimental and control groups, each comprising 44 students.

Table 1. Descriptive Statistics of Cognitive Learning Outcomes in the Experimental and Control Groups

Group	N	Pretest M (SD)	Posttest M (SD)	Mean Increase	N-Gain M (Category)
Experimental (X-4)	44	51.07 (8.84)	83.68 (9.25)	63.85%	0.65 (Moderate)
Control (X-6)	44	45.55 (5.62)	64.09 (10.47)	40.70%	0.34 (Moderate)

Note. M = mean; SD = standard deviation. N-Gain represents the mean of individual student N-Gain scores (Hake, 1998). Mean increase = (posttest − pretest)/pretest.

The baseline mean pretest score of the experimental group (51.07) was higher than that of the control group (45.55), indicating unequal initial abilities, with both groups scoring well below the KKM threshold of 76. Following the intervention, the experimental group achieved a mean posttest score of 83.68 (a 63.85% increase), whereas the control group attained a mean of

64.09 (a 40.70% increase) (Figure 1). The mean N-Gain scores were 0.65 for the experimental group and 0.34 for the control group; while both fell within the moderate category according to Hake's (1998) criteria, the experimental group's score approached the upper bound of the moderate range. Moreover, the experimental group's mean posttest score surpassed the KKM, whereas the control group's mean remained below the mastery threshold.

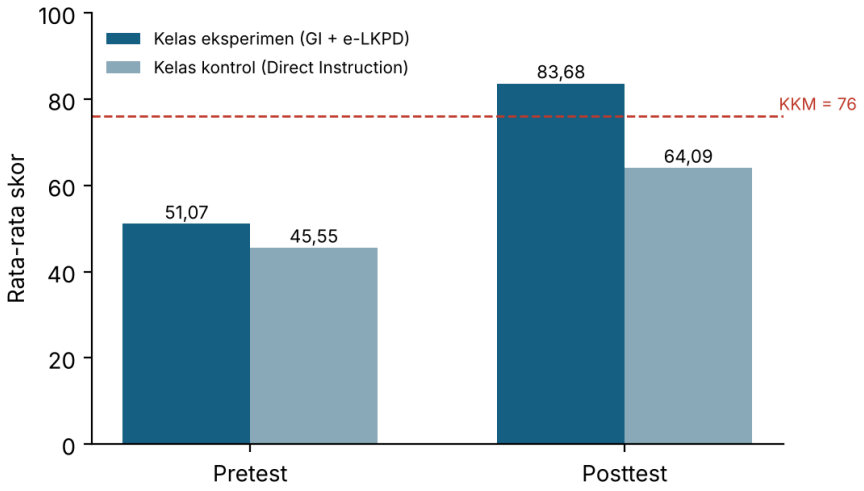


Figure 1. Mean Pretest and Posttest Scores of the Experimental and Control Groups

Note for figure labels: Kelas eksperimen (GI + e-LKPD) = Experimental group (GI + e-Worksheet); Kelas kontrol (Direct Instruction) = Control group (Direct Instruction); Rata-rata skor = Mean score; KKM = 76

At the individual level (Table 2), 18 students in the experimental group (40.91%) achieved high N-Gain, 24 (54.55%) achieved moderate N-Gain, and 2 (4.55%) recorded low N-Gain. In contrast, only 1 student in the control group (2.27%) attained high N-Gain, 21 (47.73%) attained moderate N-Gain, and 22 (50.00%) fell into the low category. Posttest learning mastery reached 88.64% (39 students) in the experimental group compared to 20.45% (9 students) in the control group.

Table 2. Distribution of Individual N-Gain Categories and Posttest Learning Mastery (KKM = 76)

Group	High N-Gain	Moderate N-Gain	Low N-Gain	Mastery (≥76)	Non-Mastery (<76)
Experimental (X-4)	18 (40.91%)	24 (54.55%)	2 (4.55%)	39 (88.64%)	5 (11.36%)
Control (X-6)	1 (2.27%)	21 (47.73%)	22 (50.00%)	9 (20.45%)	35 (79.55%)

Note. N-Gain categories: high ($g \geq 0.70$), moderate ($0.30 \leq g < 0.70$), low ($g < 0.30$).

Prior to hypothesis testing, parametric assumptions were evaluated (Table 3). The Shapiro-Wilk test indicated that the control pretest, control posttest, and experimental pretest scores deviated significantly from normality ($p < 0.05$), whereas the experimental posttest

scores were normally distributed ($p = 0.068$). Because normality assumptions were violated across multiple subsets, non-parametric statistical tests were employed. Levene's test on posttest scores confirmed that error variances were homogeneous across both groups ($p = 0.234 > 0.05$).

Table 3. Results of Assumption Tests (Normality and Homogeneity of Variance)

Test	Dataset	Statistic	df	Sig. (p)	Interpretation
Shapiro-Wilk	Experimental Pretest	0.936	44	0.017	Non-normal
Shapiro-Wilk	Experimental Posttest	0.952	44	0.068	Normal
Shapiro-Wilk	Control Pretest	0.928	44	0.009	Non-normal
Shapiro-Wilk	Control Posttest	0.935	44	0.015	Non-normal
Levene (Based on Mean)	Posttest (Both Groups)	1.439	1, 86	0.234	Homogeneous

The Mann-Whitney U test was conducted on both posttest and N-Gain scores (Table 4). For posttest scores, the experimental group yielded a substantially higher mean rank (62.64) than the control group (26.36), with $U = 170$, $Z = -6.682$, and Asymp. Sig. (2-tailed) = 0.000 ($p < 0.001$), representing a large effect size ($r = |Z|/\sqrt{N} = 0.71$). To account for baseline differences between groups, N-Gain scores were also analyzed, yielding consistent results: the experimental group attained a mean rank of 60.55 versus 28.45 for the control group, with $U = 262$, $Z = -5.893$, $p < 0.001$, and $r = 0.63$. Accordingly, the null hypothesis (H_0) was rejected and the alternative hypothesis (H_a) was accepted, confirming a statistically significant difference in cognitive learning outcomes favoring the GI model assisted by Liveworksheet e-worksheets over PowerPoint-assisted Direct Instruction.

Table 4. Mann-Whitney U Test Results for Posttest and N-Gain Scores

Variable	Group	N	Mean Rank	Sum of Ranks	U	Z	Asymp. Sig. (2-tailed)
Posttest	Experimental	44	62.64	2,756.00	170.000	-6.682	0.000
	Control	44	26.36	1,160.00			
N-Gain	Experimental	44	60.55	2,664.00	262.000	-5.893	0.000
	Control	44	28.45	1,252.00			

Note. Asymp. Sig. = 0.000 denotes $p < 0.001$.

Discussion

The findings directly address the research objective: students instructed via the GI model assisted by Liveworksheet e-worksheets achieved significantly higher cognitive learning outcomes than those receiving PowerPoint-assisted Direct Instruction across posttest scores, N-Gain, and mastery rates. The procedural stages of GI align well with the nature of Hydrology, as students collaboratively formulate work plans, investigate assigned subtopics, synthesize findings, and present their conclusions (Sharan & Sharan, 1990). Furthermore, interactive tasks

embedded within the Liveworksheet e-worksheets, such as completing investigation planning matrices, sequencing hydrological cycle stages via drag-and-drop features, matching conceptual explanations, and analyzing anthropogenic impacts, provided structured, interactive practice for abstract processes. Within a cooperative learning framework, peer scaffolding and shared group accountability likely reinforced conceptual comprehension (Slavin, 2015). Although the researcher informally observed active group discussions and presentations during implementation, these observations were not captured using structured instruments and therefore are not presented as primary empirical evidence.

The direction of these findings aligns with prior studies investigating GI in Geography. Taher et al. (2019) reported superior Geography learning outcomes in GI classes compared to conventional discussions, while Winanti et al. (2018) observed a posttest mean of 81.01 in the GI group versus 72.39 in the expository group, representing an 8.62-point difference. Although the mean posttest difference in the present study was larger (19.59 points), direct comparisons warrant caution due to variations in subject topics, grade levels, measurement instruments, and intervention durations, as well as the inability of the present design to isolate the independent effect of GI from that of the e-worksheets. Regarding instructional media, the experimental group's mean increase from 51.07 to 83.68 parallels the improvement from 52 to 86 reported by Hurrahma and Sylvia (2022) using Liveworksheet-based e-worksheets in Sociology; however, whereas their study utilized a single-group design without a comparator, the present study incorporated a control group to benchmark relative gains. Within the N-Gain framework, Hake (1998) documented average gains of approximately 0.23 for traditional courses and 0.48 for interactive-engagement courses. Both the control (0.34) and experimental (0.65) groups in this study exceeded those benchmarks, although Hake's dataset originated from introductory physics courses, rendering this comparison purely indicative. Broadly, the superior performance observed under active, technology-enhanced instruction corroborates Freeman et al.'s (2014) meta-analytic synthesis.

Several methodological limitations should be acknowledged. First, the experimental group exhibited a higher baseline pretest mean (51.07) than the control group (45.55), and baseline equivalence was not formally tested prior to intervention; while N-Gain was utilized to mitigate initial disparities, potential selection bias cannot be entirely ruled out. Second, the intervention spanned only two class sessions and was taught by the researcher, meaning potential instructor effects and novelty enthusiasm cannot be disentangled from the pedagogical effect of the model. Third, the study was conducted within a single school using an instrument restricted to cognitive levels C1–C4 that lacked high-difficulty items during tryout validation, thereby limiting the measurement of higher-order thinking skills. Fourth, intermittent internet connectivity on students' mobile devices posed technical constraints during Liveworksheet activities.

For Geography educators, these results suggest that integrating GI with Liveworksheet e-worksheets is a viable pedagogical strategy for process-oriented topics, provided that digital devices and stable internet access are ensured and group investigations are closely facilitated. Future research is recommended to employ a four-group or factorial experimental design to disentangle the main and interaction effects of GI and Liveworksheet e-worksheets, establish

baseline equivalence or apply analysis of covariance (ANCOVA) with pretest scores as a covariate, expand sampling across multiple schools, and assess higher-order thinking skills alongside affective outcomes. Collectively, these findings partially substantiate the efficacy of combining cooperative learning models with interactive digital media in Geography, while leaving the underlying cognitive mechanisms open for further inquiry.

Conclusion

The implementation of the Group Investigation model assisted by Liveworksheet e-worksheets exerted a statistically significant effect on tenth-grade students' cognitive learning outcomes in Hydrology compared to PowerPoint-assisted Direct Instruction, demonstrating a large effect size and substantially greater learning gains in the experimental group, thereby confirming the research hypothesis. Theoretically, these findings contribute empirical evidence that inquiry-based cooperative learning can be effectively reinforced by interactive digital worksheets when teaching abstract geographic processes, offering the GI–Liveworksheet integration as a replicable instructional framework. Practically, Geography teachers can adopt this combined approach for process-heavy topics by ensuring adequate device readiness, stable internet infrastructure, and structured facilitation of group work. Because the distinct contributions of GI and Liveworksheet e-worksheets could not be isolated in this design, future studies should employ factorial designs, incorporate multi-school samples, and evaluate higher-order thinking skills and affective domains.

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Authors' Note

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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