Jurnal Tarbiyah dan Ilmu Keguruan Borneo
Volume 7, Nomor 2, 2026
E-ISSN: 2714-6030, P-ISSN: 2987-7725, Halaman 171-188
https://doi.org/10.21093/jtikborneo.v7i2.13980

The Influence of the Process Oriented Guided Inquiry Learning (POGIL) Model Assisted by Assembler Edu on Students' Science Process Skills

Vivi Oktaviani*, Sri Lestari Handayani
vivioktaviani148@gmail.com
Muhammadiyah University Prof. Dr. Hamka

Article History:
Received: 08 Juli 2026
Accepted: 18 Agustus 2026
Published: 21 September 2026

Kata Kunci:
Assemblr Edu; Keterampilan Proses Sains; Pembelajaran Sains Process Oriented Guided Inquiry Learning (POGIL); Sekolah Dasar

Keywords:
Assemblr Edu; Elementary School; Process Oriented Guided Inquiry Learning (POGIL); Science Learning; Science Process Skills

A B S T R A K

Penguasaan keterampilan proses sains sangat penting dalam pendidikan sains sekolah dasar, namun siswa muda sering kali kesulitan memahami materi vertebrata–invertebrata akibat pembelajaran yang berpusat pada guru dan terbatasnya media interaktif. Penelitian ini mengevaluasi pengaruh integrasi model Process Oriented Guided Inquiry Learning (POGIL) dengan aplikasi Assemblr Edu terhadap keterampilan proses sains siswa Kelas III. Desain kuasi-eksperimen non-equivalent control group diterapkan pada 54 partisipan yang dibagi menjadi kelas eksperimen (n = 27) dan kelas kontrol (n = 27). Data dikumpulkan menggunakan 25 soal pilihan ganda (Cronbach's alpha = 0,93) dan dianalisis menggunakan ANCOVA dengan skor pretes sebagai kovariat. Setelah mengontrol skor awal, kelas eksperimen memperoleh rata-rata postes yang secara signifikan lebih tinggi (88,74) dibandingkan kelas kontrol (58,67), F(1,51) = 50,90, p < 0,001, dengan perbedaan rata-rata terdistribusi sebesar 13,14 poin dan rata-rata N-Gain yang tinggi (0,80). Integrasi POGIL dengan Assemblr Edu terbukti efektif meningkatkan keterampilan proses sains siswa sekolah dasar.

A B S T R A C T

Mastering scientific process skills is essential in primary science education, yet young learners often struggle with vertebrate–invertebrate topics due to teacher-centered instruction and limited interactive media. This study evaluated the effect of integrating Process Oriented Guided Inquiry Learning (POGIL) with the Assemblr Edu application on Grade III students' scientific process skills. A quasi-experimental, non-equivalent control group design was conducted with 54 participants, divided into experimental (n = 27) and control groups (n = 27). Data were collected using 25 multiple-choice questions (Cronbach's alpha = 0.93) and analyzed using ANCOVA with pretest scores as a covariate. Controlling for initial scores, the experimental group achieved a significantly higher posttest mean (88.74) than the control group (58.67), F(1, 51) = 50.90, p < .001, with an adjusted mean difference of 13.14 points and a high average N-Gain (0.80). Integrating POGIL with Assemblr Edu effectively enhances elementary students' scientific process skills.

Citation: Oktaviani, V., & Handayani, S.L (2026). The Influence of the Process Oriented Guided Inquiry Learning (POGIL) Model Assisted by Assembler Edu on Students' Science Process Skills. *Jurnal Tarbiyah dan Ilmu Keguruan Borneo*, *7(2),* 171–188. https://doi.org/10.21093/jtikborneo.v7i2.13980

A. Introduction

Natural Science education at the primary level plays a vital role in helping young learners understand natural phenomena through meaningful scientific inquiry and hands-on learning. Under the Merdeka Curriculum framework, this subject is integrated with Social Studies into IPAS, aiming to help students recognize the connection between the natural and social world while fostering critical thinking, problem-solving, and scientific competence from an early age, in line with efforts to support SDG 4 on quality education (Evitasari et al., 2025 ;

**** Corresponding Author:***
Vivi Oktaviani: vivioktaviani148@gmail.com

Saputra et al., 2026). Science instruction emphasizes not only conceptual mastery but also students' capacity to construct knowledge through scientific inquiry, delivered through interactive learning approaches (Kusuma & Suratno, 2025). Scientific process skills are therefore among the key competencies that must be cultivated in elementary students, as they foster a systematic scientific mindset and support deeper understanding of science concepts (Angelia et al., 2022; Hambali, 2024).

Although scientific process skills play an important role in science learning, various studies indicate that these abilities remain low among elementary students. Angelia et al. (2022) documented that students continue to struggle with formulating hypotheses, pinpointing variables, and designing scientific investigation activities. Other research also revealed that students' scientific process skills in identifying scientific questions and using scientific evidence still sit at a low level, accounting for only 43.08% (Dwisetiarezi & Fitria, 2021). In addition, observations conducted by Maisarah (2023) showed that elementary students' scientific process skills are still low because learning has not fully provided opportunities for students to carry out scientific activities actively. A similar condition was found among Grade III students at one public elementary school in East Jakarta, where students still experienced difficulties in observing, classifying, interpreting data, and communicating observation results on the material of vertebrates and invertebrates.

Previous research has established that applying POGIL yields improvements in both science process skills and students' academic performance, largely because it gives students room to construct knowledge via active inquiry activities (Dionisius et al., 2019). Other studies also prove that Assemblr Edu media can increase learning activities, creativity, and elementary school students' learning outcomes (Handayani, 2024; Khaira et al., 2025). However, most of these studies were still conducted separately, meaning they only examined the effectiveness of the POGIL model without the support of augmented reality media or only studied the use of Assemblr Edu without combining it with a certain learning model. Beyond this, studies examining how the combined use of POGIL and Assemblr Edu shapes elementary students' scientific process skills in the context of vertebrates and invertebrates remain scarce and difficult to locate. Therefore, the novelty of this study lies in integrating the POGIL model with Assemblr Edu media to improve third-grade elementary students' science process skills on vertebrates and invertebrates. Drawing on this background, the current research seeks to determine how the Process Oriented Guided Inquiry Learning (POGIL) model, when paired with Assemblr Edu, influences the science process skills demonstrated by third-grade students at SD Negeri Cijantung 01.

B. Literatur Riview

1. Definition Of Science Process Skills

Scientific process skills refer to a cluster of abilities that students draw on to gain knowledge through hands-on scientific engagement, encompassing tasks like observation, classification, measurement, prediction, drawing conclusions, and reporting what has been observed. Cultivating these abilities from the elementary level onward matters because doing so equips students with a scientific, systematic, critical, and logical mindset for making sense of natural phenomena. In addition, scientific process skills also play a role in improving students' conceptual understanding and science learning outcomes. However, various studies indicate that students still experience difficulties in carrying out scientific processes, such as formulating hypotheses, identifying variables, and designing scientific investigations (Angelia, 2022). Consequently, cultivating scientific process skills stands as a key element within elementary science education, enabling students to move beyond mere concept mastery toward independently constructing knowledge through scientific inquiry (Hambali et al., 2024 ; Gowa & Tawil, 2024 ; Mumtaza & Zulfiani, 2023).

2. Theory Of Process Oriented Guided Inquiry Learning

Process Oriented Guided Inquiry Learning (POGIL) is a learning model centered on students, structured around guided inquiry tasks that let learners build concepts on their own. (Moog & Spencer, 2008) describe how POGIL treats students as active participants who explore, form concepts, and apply them, so knowledge emerges from direct experience rather than rote memorization. (Hanson et al., 2010) adds that the model targets both conceptual mastery and process-related competencies thinking, communication, and collaboration cultivated through organized group work, a design that has since been empirically validated in POGIL-based worksheet development research (Hidayah et al., 2023).

POGIL's emphasis on inquiry-driven exploration and independent concept-building gives it real potential to strengthen students' scientific process skills, since each stage pushes learners to observe, sort information, analyze findings, draw conclusions, and share results. A substantial body of research backs this potential: POGIL instruction has been linked to notable gains in process skills and collaborative ability (Sumanti et al., 2023), classification and scientific communication (Fitriah et al., 2025), and elementary science outcomes through heightened classroom engagement (Ayu et al., 2025). Beyond process skills, POGIL also boosts students' critical thinking and academic performance, as shown among elementary students (Yustitia et al., 2023 ; Wijaya & Handayani 2021) and reinforced by global evidence linking POGIL to stronger academic outcomes and science literacy through active, collaborative inquiry (Idul & Caro, 2022). Collectively, this body of research positions POGIL as an effective approach for advancing science process skills, critical thinking, and academic achievement in science education.

3. Assemblr Edu

Advances in educational technology have driven wider adoption of augmented reality (AR)-based learning media, aimed at making lessons feel more interactive, engaging, and immersive. Through AR, virtual objects can be layered onto the real-world environment, giving students a more tangible way to grasp abstract concepts. (Joseph et al., 2024) found that web-based AR delivered through the Assemblr platform boosts students' interest and engagement, since it turns lessons into a more enjoyable, hands-on experience, a benefit consistent with broader findings that AR-based instruction improves learning outcomes across science-related subjects (Safitri et al., 2025). Assemblr Edu itself functions as an AR-based application that lets both teachers and students build, adjust, and present 3D objects without requiring advanced programming knowledge. Given these features, Assemblr Edu stands out as a promising innovation capable of supporting 21st-century instructional demands and the Merdeka Curriculum's emphasis on active, exploratory, student-centered learning.

Evidence from multiple studies converges on the same conclusion: Assemblr Edu benefits both the process and outcomes of elementary learning, with documented improvements in learning outcomes (Handayani & Asih 2024), creative thinking (Khaira & Hermita, 2025), motivation and engagement across subject areas (Aprianti et al., 2025 ; Divanggi et al., 2026), and critical thinking skills with a medium effect size (Handayani & Handayani, 2025). In a related study, combining Problem-Based Learning with Assemblr Edu was also found to enhance elementary students' creativity spanning fluency, flexibility, originality, and elaboration while fostering a more engaging learning environment (Al-Zahra & Handayani 2025). Collectively, these results frame Assemblr Edu as more than a visualization aid; it functions as a catalyst for students' active construction of knowledge.

C. Methods

A quantitative approach guides this study, chosen to examine how the Process Oriented Guided Inquiry Learning (POGIL) model, complemented by Assemblr Edu, shapes elementary school students' progress in building their science process skills, enabling researchers to gather measurable empirical data for objective statistical analysis (Sugiyono, 2023). This research uses a quasi-experiment method, applied because full randomization of subjects was not possible given the schools' pre-formed classes, though it still permits examination of how the treatment influences the dependent variable (Akbar et al., 2022).

1. Research Design

A Nonequivalent Control Group arrangement was applied, pairing one class receiving treatment with another serving as comparison; both sit through pretests and posttests, but only the former undergoes instruction shaped by the POGIL model paired with Assemblr Edu media, whereas the latter follows standard teaching practices. This design sees frequent use in educational studies, as it enables researchers to track shifts in students' learning outcomes and abilities from pre- to post-treatment across two groups (Sugiyono, 2023).

Table 1. Research Design Nonequivalent Control Group Design

Group	Pretest	Treatment	Posttest
Experimental Class	O_1	X	O_2
Control Class	O_3	–	O_4

Note: O_1 and O_2 denote the treatment group's pre- and post-intervention scores, respectively, while O_3 and O_4 denote the same measurements for the group receiving no treatment. X signals that POGIL paired with Assemblr Edu was applied, whereas (–) signals ordinary classroom teaching without this intervention. Source: Adapted from (Sugiyono, 2023) .

2. Participants of the Study

The research population comprised every third-grade student enrolled at SD Negeri Cijantung 01, East Jakarta, during the even semester of the 2025/2026 academic year. This population spanned two classes, III-A and III-B, with 27 students apiece, yielding a combined sample of 54 students.

Sample selection followed the convenience sampling approach, in which pre-existing, intact classes were used as sampling units because random assignment of individual students was not feasible within the school's regular classroom structure (Sugiyono, 2023). To ensure comparability between groups, the researcher assessed the homogeneity of both classes based on the teacher's evaluation, including academic ability, age range, and prior coverage of the learning material (Etikan & Bala, 2017) . Based on this assessment, class III-B was assigned as the experimental class, receiving instruction through the POGIL model paired with Assemblr Edu media, while class III-A served as the comparison group taught through standard classroom instruction. Pretest and posttest measurements using identical instruments were administered to both groups to capture shifts in science process skills once the treatment had been carried out.

3. Instruments

Data collection relied on a multiple-choice test built around four science process skill indicators observing, classifying, interpreting data, and communicating applied to vertebrate and invertebrate content. Students sat this instrument twice, once before and once after the intervention, allowing pretest and posttest scores to capture any shift in their abilities. Items were constructed based on the learning objectives and these four indicators.

Prior to its use in this research, the instrument underwent expert validation (expert judgment) by two lecturers and one elementary school teacher, who evaluated how appropriate the content was, how well-constructed the questions were, and how suitable the language used was. Expert validation confirmed the instrument's feasibility (81.94% for content/indicator suitability, 82.41% for question quality and language) and it was deemed usable after minor revisions. Next, the instrument was tested on 28 students who had studied vertebrate and invertebrate material. The empirical validity test found that 25 of the 30 questions met the validity criteria, and these were then retained as the research instrument.

Instrument reliability was determined by computing the Cronbach's Alpha coefficient, computed with the help of IBM SPSS Statistics, producing a value of 0.93, which falls into the very high reliability category (Sugiyono, 2023). This finding is consistent with (Handayani & Iba, 2020), who emphasized that a science process skills test instrument must demonstrate strong validity and reliability, alongside an appropriate level of difficulty and discrimination, to ensure it accurately measures students' abilities. Such a result points to robust internal consistency within the instrument, affirming its suitability for gathering data in this study.

Table 2. Characteristics of Research Instruments

Aspect	Result
Number of questions developed	30
Number of valid questions	25
Number of questions used	25
Cronbach's Alpha	0.925
Reliability category	Very high

4. Data Analysis Techniques

Data for this research were gathered across three phases: preparation, implementation, and completion. During the preparatory phase, the researcher put together learning tools, Assemblr Edu media, and research instruments, all of which had already passed expert validation and empirical testing prior to being used in the study. The implementation stage started with administering a pretest across both groups to gauge where students stood in terms of science process skills at the outset. The treatment group then proceeded through instruction built around the Process Oriented Guided Inquiry Learning (POGIL) model supported by Assemblr Edu, whereas its counterpart covered the same content via standard teaching methods. Once the learning sessions had concluded, a posttest with the identical instrument was administered to both groups to assess how students' science process skills had changed. Scores from both testing points then went through descriptive and inferential analysis to establish whether the Process Oriented Guided Inquiry Learning (POGIL) model, applied alongside Assemblr Edu, made any difference to elementary students' capacity for scientific process work.

IBM SPSS Statistics served as the platform for both descriptive and inferential analysis of the collected data. On the descriptive side, indicators such as mean, minimum, maximum, and standard deviation characterized the science process skills scores across both classes. Prior to hypothesis testing, the data first underwent prerequisite analysis covering both normality and homogeneity checks. Given that each group's respondent count fell under 50 ($n < 50$), the Shapiro–Wilk Test was chosen to examine normality, with a significance value (Sig.) above 0.05 serving as the benchmark for a normal distribution (Ghasemi & Zahediasl, 2012). Homogeneity was then verified through Levene's Test, where a significance value (Sig.) exceeding 0.05 signaled that the variance was homogeneous.

With prerequisites satisfied, ANCOVA tested the hypothesis at a 5% alpha ($\alpha = 0.05$), using pretest scores as a covariate to control for initial ability differences between groups; a Sig. under 0.05 for the group effect would confirm a genuine gap in science process skills between the two classes after adjustment. Treatment effectiveness was further gauged via N-Gain, interpreted against established classification thresholds high ($g > 0.70$), medium ($0.30 \leq g \leq 0.70$), and low ($g < 0.30$) consistent with their application in prior research assessing science learning outcomes on animal classification topics among elementary students (Suciati et al., 2026).

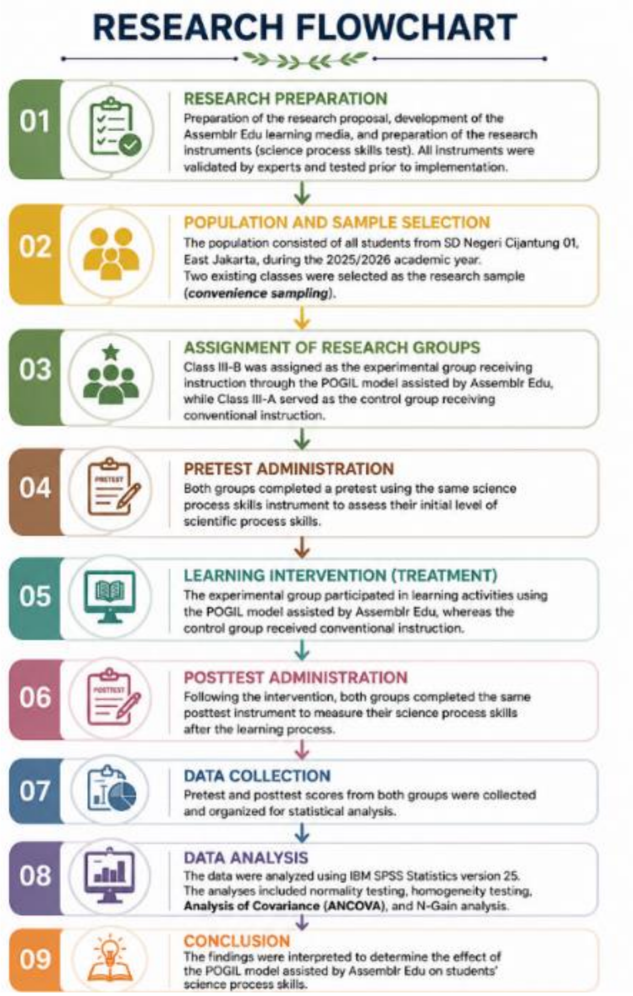

Figure 1. Research Flowchart

D. Results

This study aims to analyze the effect of implementing the Process Oriented Guided Inquiry Learning (POGIL) model assisted by Assemblr Edu media on the science process skills of third-grade students in vertebrate and invertebrate materials. Findings were examined in stages, beginning with descriptive measures and progressing to inferential statistical procedures. Descriptive statistics are used to provide an overview of students' initial and final abilities across the two groups, whereas inferential statistics serve to examine whether the gap in learning outcomes following treatment is statistically meaningful. According to (Subhaktiyasa et al., 2025), laying out descriptive statistics serves as a crucial initial move toward grasping the characteristics of the data prior to conducting further analysis.

Among the key competencies targeted in science instruction is students' capacity for scientific process skills, encompassing their ability to observe, classify, interpret data, and communicate observations in a scientific manner. Therefore, measuring science process skills through pretests and posttests is necessary to see changes in students' abilities after going through the learning process. Using pretests and posttests in experimental research also allows researchers to compare students' initial and final abilities more objectively, particularly when a nonequivalent control group design is employed and initial differences between groups need to be statistically controlled (Susilawati et al., 2026).

In this study, both groups sat a pretest prior to instruction to establish their starting point in science process skills. The treatment group then went through lessons built on the Process Oriented Guided Inquiry Learning (POGIL) model, supported by Assemblr Edu, whereas its counterpart received ordinary classroom teaching. Once every session had wrapped up, a posttest using the identical instrument was given to both, enabling an analysis of how abilities shifted from before to after the intervention. This approach fits the characteristics of quasi-experimental research, which aims to evaluate the effectiveness of a treatment on pre-existing groups (Sugiyono, 2023). Table 3 lays out the statistical profile of pretest and posttest scores across both groups.

Table 3. Descriptive Statistics of Pretest and Posttest Scores

Class	N	Minimum	Maximum	Mean	Std. Deviation
Control Pretest	27	12	40	28.15	8.556
Control Posttest	27	40	76	58.67	10.288
Experimental Pretest	27	28	64	46.37	8.683
Experimental Posttest	27	72	100	88.74	8.003

Based on the descriptive statistics in Table 3, there is a noticeable difference in the average scores (mean) between the control class and the experimental class both before and after the treatment was given. The pretest mean scores indicate that the initial abilities of the two groups were not exactly the same, while the posttest mean scores show an improvement in learning outcomes for both groups, with a greater increase in the experimental class. Additionally, the minimum, maximum, and standard deviation values shed light on how students' science process skills were spread out within each research group.

Although descriptive statistics have provided information about the characteristics of the research data, these results cannot yet serve as grounds for concluding what impact the treatment had. Therefore, inferential statistical analysis is needed to determine whether the differences that occur are statistically significant. Before conducting hypothesis testing using parametric statistics, the research data must meet basic assumptions, namely being normally distributed and having homogeneous variance (Ghasemi & Zahediasl, 2012).

The initial stage of the prerequisite test was carried out through a normality test using the Shapiro–Wilk Test, because the number of samples in each research group was less than 50 respondents (n = 27). Data is considered normally distributed if the significance value (Sig.) is greater than 0.05. Normality test outcomes for the pretest and posttest scores across both groups appear in Table 4.

Table 4. Shapiro–Wilk Normality Test Results

Data	Sig.
Control Pretest	0.111
Control Posttest	0.207
Experimental Pretest	0.490
Experimental Posttest	0.131

Based on the normality test results in Table 4, every pretest and posttest score in both the control and experimental classes registered a significance value exceeding 0.05, indicating that the research data are normally distributed and thus meet one of the basic assumptions for using parametric statistical analysis.

Homogeneity testing checks whether the variance found in both the comparison and treatment groups shows a comparable degree of spread, indicating homogeneity. In this study, the homogeneity test was carried out using Levene's Test on the pretest and posttest data. The data are considered to have homogeneous variance if the significance value (Sig.) is greater than 0.05. The homogeneity test results are shown in Table 5.

Table 5. Levene's Test of Equality of Error Variances

F	df1	df2	Sig.
0.121	1	52	0.730

Based on Table 5, Levene's test yields a significance value of 0.730, which exceeds the 0.05 threshold, indicating that the error variance of the posttest scores is homogeneous across the control and experimental groups, satisfying a key assumption required for ANCOVA.

Because the pretest scores of the two groups were not equivalent (see Table 3), a simple comparison of posttest means using an independent-samples t-test would not adequately isolate the effect of the treatment from pre-existing differences in students' initial ability. Therefore, ANCOVA was employed, using the pretest score as a covariate. Table 6 summarizes the descriptive statistics of posttest scores across both groups.

Table 6. Descriptive Statistics (Post test Science Process Skills)

Class	N	Mean	Std. Deviation
Control	27	58.67	10.288
Experimental	27	88.74	8.003
Total	54	73.70	17.712

Based on Table 6, each research group comprised 27 participants, bringing the overall respondent count for this study to 54. Analysis revealed a mean posttest figure of 88.74 for the treatment group, against just 58.67 for its comparison counterpart. The results of the ANCOVA analysis are shown in Table 7.

Table 7. Tests of Between-Subjects Effects (Dependent Variable: Posttest Science Process Skills)

Source	Type III SS	df	Mean Square	F	Sig.	Partial η^2
Corrected Model	15545.622	2	7772.811	366.494	<.001	.935
Intercept	4043.160	1	4043.160	190.638	<.001	.789
Pretest	3335.548	1	3335.548	157.274	<.001	.755
Group	1079.525	1	1079.525	50.900	<.001	.500
Error	1081.637	51	21.209			
Total	309968.000	54				
Corrected Total	16627.259	53				

Based on Table 7, the pretest covariate significantly predicted posttest scores, $F(1, 51) = 157.27$, $p < .001$, partial $\eta^2 = .755$, confirming that students' initial ability substantially influenced their final performance and justifying its inclusion as a covariate. After adjusting for this covariate, group membership remained a significant predictor of posttest science process skills, $F(1, 51) = 50.90$, $p < .001$, partial $\eta^2 = .500$. The estimated marginal mean for the experimental group was 13.14 points higher than the control group after controlling for pretest scores (95% CI [9.45, 16.84]). This indicates that the group difference in science process skills remained statistically significant after adjustment for pretest scores, suggesting that the higher posttest performance in the experimental class was associated with the implementation of the POGIL model assisted by Assemblr Edu.

These ANCOVA results corroborate the earlier descriptive findings, in which the treatment group recorded a superior average posttest score relative to its comparison counterpart, even after accounting for initial ability differences. To gain a fuller picture of how much students' skills actually improved in absolute terms, the analysis moved beyond ANCOVA and additionally computed the Normalized Gain (N-Gain), presented in Table 8 as supplementary descriptive information.

Table 8. N-Gain Calculation Results

N	Minimum	Maximum	Mean	Category
27	0.56	1.00	0.80	High

Based on Table 8, the results of the Normalized Gain (N-Gain) calculation show that the average N-Gain score of students in the experimental class is 0.8045, with a minimum score of 0.56 and a maximum of 1.00. Referring to the classification criteria applied in prior research (Suciati et al., 2026), this score falls into the high gain category, indicating that most students experienced optimal improvement in their science process skills after learning using the Process Oriented Guided Inquiry Learning (POGIL) model with the help of Assemblr Edu.

Besides showing a high improvement category, the analysis results also revealed that the average percentage increase in students' science process skills reached 80.45%. A high N-Gain value suggests that the learning process not only produced statistically significant differences in posttest scores but also led to a substantial improvement in learning abilities.

Taken as a whole, the full set of statistical procedures descriptive statistics, normality checks, homogeneity checks, ANCOVA, and N-Gain analysis pointed in the same direction. Every prerequisite for parametric analysis was satisfied, a meaningful gap emerged between the two classes ($p < 0.05$), and gains in science process skills within the treatment group fell into the high category. Collectively, these findings offer empirical support for the Process Oriented Guided Inquiry Learning (POGIL) model, paired with Assemblr Edu, as an effective means of boosting scientific process abilities among third-graders studying vertebrate and invertebrate content.

It should be noted, however, that unlike the ANCOVA results above, the N-Gain score does not statistically control for initial ability differences between groups; it is therefore reported here as supplementary descriptive evidence of improvement rather than as primary confirmatory evidence of the treatment's effect.

E. Discussion

This research demonstrates that applying the Process Oriented Guided Inquiry Learning (POGIL) model in combination with Assemblr Edu has a significant impact on the science process skills of Grade III students learning about vertebrates and invertebrates at SD Negeri Cijantung 01. This conclusion is supported by the ANCOVA results, which showed a significant effect of group membership on posttest science process skills after controlling for pretest scores, $F(1, 51) = 50.90$, $p < .001$, leading to the acceptance of the alternative hypothesis (H_a). Additionally, the experimental class achieved a higher mean posttest score (88.74) compared to the control class (58.67), indicating that the POGIL model assisted by Assemblr Edu is more effective than the instruction provided in the control class. Such results suggest that combining an inquiry-driven instructional model together with AR-based media produces a richer learning experience, ultimately strengthening students' science process skills.

Learning effectiveness is also evident from the N-Gain calculation, which yielded a mean value of 0.8045, categorized as high and equivalent to an 80.45% improvement. This value indicates that most students saw a rise in their abilities after taking part in learning using the POGIL model assisted by Assemblr Edu. According to Dionisius et al. (2019), the POGIL model can enhance scientific thinking abilities and science process skills through structured inquiry activities, thereby enabling students to become more active in constructing their own knowledge.

The Process Oriented Guided Inquiry Learning (POGIL) model positions learners as the center of instruction through systematic inquiry activities identifying problems, exploring information, constructing concepts, applying them to new situations, and reflecting making it highly relevant for developing science process skills (Walker & Warfa, 2017).

From a theoretical perspective, each POGIL syntactic stage is closely related to the science process skills indicators measured in this study. The orientation and exploration stages provide opportunities for students to observe objects or phenomena, thereby developing their observation skills through investigative activities. Subsequently, in the concept formation stage, students organize the information they obtain, compare object characteristics, and classify them based on similarities and differences, which supports the abilities to classify and interpret data. In the application stage, students apply the concepts they have acquired to new situations, while in the closure or reflection stage, students present discussion results, provide scientific reasoning, and draw conclusions, thereby optimizing the development of communication skills. Thus, all stages of POGIL directly facilitate the development of the science process skills indicators that constitute the focus of this study (Moog & Spencer, 2008; Walker & Warfa, 2017).

These findings match a wider body of research positioning POGIL as a strong contributor to science process skills and scientific thinking, including gains relative to conventional teaching (Dionisius et al., 2019; Geçgil & Investigating, 2024), improved scientific literacy (Husna et al., 2022), heightened engagement and critical thinking (Sukaisih et al., 2026; Muangbangyung et al., 2026), and worksheet-supported inquiry shaping observation, analysis, and communication skills (Wazni & Fatmawati, 2022). Given how well these findings line up, the present results gain further backing, positioning POGIL as a well-suited instructional strategy for nurturing science process skills among young learners.

The gains in science process skills seen in the experimental class stemmed not solely from applying the Process Oriented Guided Inquiry Learning (POGIL) model, but were also bolstered by Assemblr Edu media, which draws on

Augmented Reality (AR) technology. In elementary science learning, particularly on the topics of vertebrates and invertebrates, many concepts are abstract and thus difficult for students to observe directly. AR technology can transform abstract objects into three-dimensional visual representations that can be observed concretely through digital devices. This condition echoes what (Fonseca et al., 2025) reported, namely that AR strengthens conceptual understanding, engagement, and outcomes by offering a learning experience that is more concrete and interactive than conventional media allows.

In this study, Assemblr Edu let students observe three-dimensional models of vertebrate and invertebrate animals directly through digital devices, helping them identify morphological characteristics, compare attributes, classify objects, and communicate observation results directly reinforcing all four science process skill indicators tracked in this study. This corresponds with (Joseph et al., 2024), who found web-based AR delivered via Assemblr fosters more interactive learning and eases students' grasp of science concepts.

Such results echo earlier work affirming Assemblr Edu's effectiveness in elementary science instruction, documenting gains in learning outcomes, creative thinking, motivation, and conceptual grasp through 3D visualization (Handayani et al., 2024 ; Khaira & Hermita, 2025 ; Aprianti et al., 2025 ; Divanggi et al., 2026), reinforcing Assemblr Edu's role as a key factor in improving students' science process skills.

As these results suggest, the gains observed stem not merely from the standalone use of POGIL or Assemblr Edu, but from the combined effect of using both together, creating an active, contextual, and meaningful learning experience. This is consistent with Sumanti et al. (2023), whose work showed POGIL-based learning enhances science process skills through structured inquiry, and with (Hesvina & Andaryani, 2026), who found Assemblr Edu-based AR increases student engagement through interactive, realistic visual representations.

This synergy also finds explanation in constructivist theory, wherein knowledge takes shape actively through the interplay between learning experiences and students' existing cognitive structures. In this study, students actively constructed concepts through group discussions, observation of virtual objects, analysis of animal characteristics, and conclusion formulation (Walker & Warfa, 2017), building conceptual understanding while developing science process skills through authentic learning experiences, confirming this combination as a relevant strategy for 21st-century student-centered learning.

This research carries both theoretical and practical weight for elementary science education. On the theoretical side, the results back up the notion that pairing inquiry-based learning with augmented reality technology supports the growth of scientific process skills more effectively than instruction centered purely on delivering concepts. Such results correspond with a Systematic Literature Review showing that Assemblr Edu, when paired with fitting instructional strategies, can sharpen conceptual understanding, deepen engagement, and elevate learning quality (Purwanti & Dewi, 2025).

Practically, this research offers elementary school teachers an alternative approach for crafting more innovative science lessons, particularly for abstract topics such as vertebrates and invertebrates. This combination creates student-centered learning that facilitates the development of scientific process skills, an important outcome in 21st-century science education, and can serve as a reference for teachers, schools, and researchers developing relevant digital technology-based science learning innovations (Sumanti et al., 2023).

F. Conclusion

This study found that, after controlling for pretest scores, third-grade students who participated in Process Oriented Guided Inquiry Learning (POGIL) assisted by Assemblr Edu achieved significantly higher posttest scores in science process skills than students who received conventional instruction, $F(1, 51) = 50.90$, $p < .001$, partial $\eta^2 = .500$. The adjusted mean difference between the two groups was 13.14 points (95% CI [9.45, 16.84]). These findings suggest that integrating guided inquiry with augmented reality-based media can support students' abilities to observe, classify, interpret data, and communicate scientific findings when learning vertebrate and invertebrate topics.

However, the findings should be interpreted within the limitations of the study. The research employed a quasi-experimental, non-equivalent control group design involving intact classes, convenience sampling, a relatively small sample, and participants from a single elementary school. Moreover, the substantial difference in pretest scores between the groups indicates that the participants were not fully equivalent before the intervention. Although ANCOVA was used to statistically control for initial differences, the results should not be generalized as evidence of the universal effectiveness of POGIL assisted by Assemblr Edu for all elementary school students.

Future research should examine this approach using larger and more diverse samples, multiple schools, and stronger experimental designs, such as randomized assignment at the class level. Further studies should also assess intervention fidelity, use performance-based measures of science process skills, examine the retention of learning outcomes, and investigate its effects on other twenty-first-century competencies, including critical thinking, scientific literacy, and problem-solving skills.

Referensi

Akbar, S., Imamuddin, M., & Rahmi, F. (2022). *The Effectiveness of Innovative Learning on Mathematical Problem- Solving Ability : Quasi-Experimental*. *4*(2), 111–118. https://doi.org/10.26418/ijli.v4i2.59784

Angelia, Y. (2022). *Keterampilan Proses Sains Siswa Sekolah Dasar dalam Pembelajaran IPA Menggunakan Model Pembelajaran Inkuiri*. *6*(5), 8296–8303. https://doi.org/https://doi.org/10.31004/basicedu.v6i5.3692

Annisa Ulfa Khaira, Neni Hermita, J. A. A. (2025). *Efektivitas Media Pembelajaran Augmented Reality Assemblr Edu Pada Pembelajaran IPAS Untuk Meningkatkan Keterampilan Berpikir Kreatif Siswa SD Kelas V*. *5*(01), 144–155. https://doi.org/10.57008/jjp.v5i01.1241

Aprianti, D., Andriana, E., & Syachruroji, A. (2025). *Pengembangan Media Pembelajaran Aplikasi Assemblr pada Materi Struktur Bumi Berbasis Teknologi*

3 Dimensi pada Mata Pelajaran IPAS di Kelas V. *9*(2), 339–347. https://doi.org/http://doi.org/10.28926/riset_konseptual.v9i2.1202

Atika Dwi Evitasari, Tri Dewi Pancasari, and G. S. (2025). Penerapan Pembelajaran IPAS Dalam Kurikulum Merdeka di Sekolah Dasar. *Jurnal Riset Pendidikan Dasar*, *08*(April), 1–15. https://doi.org/10.26618/jrpd.v8i1.16681

Ayu, I. G., Dwi, W., Wibawa, I. M. C., & Margunayasa, I. G. (2025). *The Process Oriented Guided Inquiry Learning (POGIL) Model and Self-Efficacy on the Science Learning Outcomes of Grade V Students*. *9*(2), 258–268. https://doi.org/https://doi.org/10.23887/jipp.v9i2.92887

Dionisius, I. M. K., Margunayasa, I. G., & Kusmariyatni, N. N. (2019). *Pengaruh Model Pembelajaran Pogil terhadap Keterampilan Proses Sains*. 271–278. https://doi.org/https://doi.org/10.23887/jjpgsd.v7i3.19464

Diva Fithriya Handayani, S. L. H. (2025). *The Effect of AR Assemblr Edu Media on Critical Thinking Skills on Food Web Material*. *16*, 448–459. https://doi.org/10.31849/prmgc141

Divanggi, A., Mahardika, G., & Putra, C. (2026). *Pengembangan dan Uji Efektivitas Media Diorama Berbantuan Assemblr Edu untuk Meningkatkan Hasil Belajar IPAS Siswa Sekolah Dasar*. *9*, 369–388. https://doi.org/10.30605/cjpe.9.1.2026.8213

Elfi Sukaisih, Nurwalidainismawati, N. R. (2026). *Efektivitas Model Pembelajaran Inkuiri Terbimbing Dalam Meningkatkan Kemampuan Proses Sains Dan Keterampilan Berpikir Kritis Peserta Didik Kelas Iv Sdn Sanolo*. *07*(01), 1–11. https://doi.org/10.56842/jp-ipa.v7i01.779

Etikan, I., & Bala, K. (2017). *Sampling and sampling methods*. *5*(6), 215–217. https://doi.org/10.15406/bbij.2017.05.00149

Fitriah, Daud, F., & Ali, A. (2025). The Effect of Process Oriented Guided Inquiry Learning (POGIL) Model on Critical Thinking Skills and Collaboration Skills of Class XI Students of SMAN 14 Gowa Biology Teaching Material. *Jurnal Penelitian Pendidikan IPA*, *11*(8), 651–660. https://doi.org/10.29303/jppipa.v11i8.12123

Fonseca, X., Spangenberger, P., Baer, M., & Schmidt, R. (2025). *Location-based augmented reality in education : A systematic literature review*. *9*(August). https://doi.org/10.1016/j.caeo.2025.100277

Geçgil, T., & Investigating, H. (2024). *Investigating the Effects of Different Model Based Inquiries on Students ' Science Achievement , Scientific Process Skills and Motivation To cite this article : Investigating the Effects of Different Model Based Inquiries on Students ' Science Achievement*. https://doi.org/https://doi.org/10.46328/ijemst.3997

Ghasemi, A., & Zahediasl, S. (2012). *Normality Tests for Statistical Analysis: A Guide for Non-Statisticians*. *10*(2), 486–489. https://doi.org/10.5812/ijem.3505

Gowa, K., & Tawil, M. (2024). Ekstrapolasi Keterampilan Proses Sains Peserta Didik Kelas VI Sekolah Dasar di Kabupaten Gowa. *JURNAL BASICEDU*, *8*(1), 484–

498. https://doi.org/https://doi.org/10.31004/basicedu.v8i1.7130

Handayani, S. L., & Iba, K. (2020). Karakteristik Tes Keterampilan Proses Sains: Validitas, Reliabilitas, Tingkat Kesukaran dan Daya Pembeda Soal. *Publikasi Pendidikan*, *10*(2), 100. https://doi.org/10.26858/publikan.v10i2.13051

Hanson, D. M., Bunce, D., Creegan, F., Moog, R., Padwa, L., Spencer, J., Straumanis, A., Wolfskill, T., & Hanson, D. M. (n.d.). *Instructor ' s Guide to Guided-Inquiry Learning by With Contributions from other POGIL project personnel : Instructor ' s Guide to Process-Oriented Guided-Inquiry Learning*.

Hawa Salsabila Al-Zahra, S. L. H. (2025). *Empowering Student Creativity Through Problem-Based Learning Assisted by Assemblr Edu: A Study on Metamorphosis in Primary Science*. *9*(4), 2967–2976. https://doi.org/10.31258/jes.9.4.p.2967-2976

Hesvina, E., & Andaryani, E. T. (2026). Development of Assemblr Edu-Based Augmented Reality Learning Media to Improve Learning Outcomes of Fifth Grade Students at SDN Kalibanteng Kidul 01. *Jurnal Penelitian Pendidikan IPA*, *12*(3), 614–623. https://doi.org/10.29303/jppipa.v12i3.14270

Hidayah, F., Paidi, Al-Farisi, F. R., & Husna, N. (2023). Development of Process Oriented Guided Inquiry Learning Worksheets (POGIL) to Improve Critical Thinking Skills and Science Process Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 6568–6576. https://doi.org/10.29303/jppipa.v9i8.3847

Husna, N., Halim, A., Evendi, E., Syukri, M., Nur, S., Elisa, E., & Khaldun, I. (2022). Impact of Science Process Skills on Scientific Literacy. *Jurnal Penelitian Pendidikan IPA*, *8*(4), 2123–2129. https://doi.org/10.29303/jppipa.v8i4.1887

Idul, J. J. A., & Caro, V. B. (2022). *Does process-oriented guided inquiry learning (POGIL) improve students ' science academic performance and process skills ?* https://doi.org/10.1080/09500693.2022.2108553

Joseph, K., Jodi, C., Austen, A., Joseph, K., & Jodi, C. (2024). Molecule World: Enhancing chemistry education through web based augmented reality using Assemblr. *Procedia Computer Science*, *245*, 1249–1258. https://doi.org/10.1016/j.procs.2024.10.354

Maya Eka Purwanti, Radeni Sukma Indra Dewi, I. S. R. (2025). Implementasi Assemblr Edu Pada Pembelajaran IPA di Sekolah Dasar: Systematic Literature Review. *Pendas : Jurnal Ilmiah Pendidikan Dasar*, *10*. https://doi.org/https://doi.org/10.23969/jp.v10i04.37739

Moog, R. S., & Spencer, J. N. (n.d.). *Chapter 1 POGIL : A n Overview*. 1–13. https://doi.org/https://pubs.acs.org/sharingguidelines

Muangbangyung, S., Panjaburee, P., & Chaipidech, P. (2026). *Social Sciences & Humanities Open Understanding students ' adoption of a web-enhanced inquiry learning common for science literacy : An affordance-based PLS-SEM analysis*. *14*(June). https://doi.org/https://doi.org/10.1016/j.ssaho.2026.103169

Muhammad Khairul Wazni, B. F. (2022). Study of Science Process Skills Student Using Worksheet based on Science Process Skills. *Jurnal Penelitian*

Pendidikan IPA, *8*(2), 436–443. https://doi.org/10.29303/jppipa.v8i2.1281

Mumtaza, M. F., & Zulfiani, Z. (2023). Development of Student Worksheets Based on Science Process Skills on Excretory System Concepts. *Jurnal Penelitian Pendidikan IPA*, *9*(1), 265–272. https://doi.org/10.29303/jppipa.v9i1.1474

Safitri, D., Marini, A., Irwansyah, P., & Sudrajat, A. (2025). Transforming environmental education with augmented reality: A model for learning outcome. *Social Sciences and Humanities Open*, *12*(July), 101796. https://doi.org/10.1016/j.ssaho.2025.101796

Saputra, E., Bentri, A., & Rahmi, U. (2026). *Development of a Multimedia-Oriented Problem-Based Learning Model to Support SDG 4 : Quality Education for Grade IV Elementary School Students*. *12*(6), 83–88. https://doi.org/10.29303/jppipa.v12i6.15059

Setyani Wijaya, S. L. H. (2021). Pengaruh Process Oriented Guided Inquiry Learning (POGIL) terhadap Kemampuan Berpikir Kritis Siswa di Sekolah Dasar. *Jurnal Basicedu*, *5*(5), 3(2), 524–532. https://doi.org/https://doi.org/10.31004/basicedu.v5i4.1227

Sri Wahyuni, Irmawanty, H. H. (2024). *Keterampilan Proses Sains untuk Meningkatkan Hasil Belajar IPA Siswa Sekolah Dasar*. *3*(2), 85–95. https://doi.org/10.51574/judikdas.v3i2.1229

Subhaktiyasa, P. G., Ayu, S., Candrawati, K., Sumaryani, N. P., & Sunita, W. (2025). *Penerapan Statistik Deskriptif: Perspektif Kuantitatif dan Kualitatif*. 96–104. https://doi.org/10.59672/emasains.v14i1.4450

Suciati, E., Djufri, E., & Supriadi, D. (2026). *Effectiveness of Science Evaluation Questions on Animal Classification Material on Learning Outcomes and Problem Solving of Third Grade Elementary School Students*. *12*(6), 1006–1012. https://doi.org/10.29303/jppipa.v12i6.14535

Sugiyono. (2023). *Penelitian Metode Kuantitatif Kualitatif dan R&D* (2023rd ed.).

Sumanti, F., Anwar, K., & Sari, N. (2023). *Improving Science Process Skills and Student Cooperation Skills Using the POGIL Model Assisted by Animated Media*. *6*(3), 469–478. https://doi.org/https://doi.org/10.23887/jlls.v6i3.61997

Susilawati, A., Dari, U., & Sabaruddin. (2026). Deep Approach to Learning through Constructivism: Enhancing Science Process Skills and Scientific Attitudes for SDG 4 Quality Education in Physics. *Jurnal Penelitian Pendidikan IPA*, *12*(2), 59–65. https://doi.org/10.29303/jppipa.v12i2.13750

Titik Handayani, S. S. A. (2024). *Penerapan Media Augmented Reality Menggunakan Assemblr Edu untuk Meningkatkan Prestasi Akademik Bidang IPAS di Tingkat Sekolah Dasar*. *33*(2), 129–146. https://doi.org/10.17977/um009v33i22024p129-146

Walker, L., & Warfa, A. M. (2017). *Process oriented guided inquiry learning (POGIL ®) marginally effects student achievement measures but substantially increases the odds of passing a course*. 1–17. https://doi.org/https://doi.org/10.1371/journal.pone.0186203

Yustitia, V., Kusmaharti, D., Anggraini, M., & Pattiasina, P. J. (2023). *Process-Oriented Guided-Inquiry Learning Model and Critical Thinking Ability of Elementary School Students*. *56*, 207–216. https://doi.org/https://doi.org/10.23887/jpp.v56i1.59650