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Learning Analytics-Based Sociology Learning Orchestration for Self-Regulated Learning, Engagement, And Concept Mastery Among Public Senior High School Students

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ABSTRACT

Purpose: This study examined the effectiveness of learning analytics-based sociology learning orchestration in improving students' self-regulated learning, engagement, and sociological concept mastery, addressing limited empirical integration of learning analytics, teacher orchestration, and sociology outcomes in secondary education. **Methods:** A quantitative multi-site quasi-experimental design with a pretest-posttest control group structure was implemented in three public senior high schools in Jakarta. The participants were 209 Grade XI students, comprising 105 students in the experimental group and 104 students in the control group. Data were collected using self-regulated learning and engagement questionnaires, a sociological concept mastery test, a treatment implementation observation sheet, and learning analytics logs. Data were analyzed using descriptive statistics, N-Gain, assumption testing, MANCOVA, and effect size interpretation. **Findings:** The experimental group showed greater improvement than the control group across all measured outcomes. The intervention produced moderate gains, while learning analytics logs indicated active participation in material access, formative quizzes, assignment submission, discussion, and feedback response. MANCOVA confirmed a significant multivariate intervention effect after controlling for pretest scores. **Research Implications**: Learning analytics can strengthen sociology learning when teachers use student data to provide timely feedback, identify learning difficulties, and design adaptive pedagogical interventions. **Originality:** This study contributes to data-informed pedagogy by positioning teachers as learning orchestrators who transform analytics data into adaptive instructional decisions in secondary sociology classrooms.

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INTRODUCTION

Sociology learning at the senior high school level is expected to develop students' ability to understand social realities critically, reflectively, and contextually. Students are not only required to memorize sociological concepts, but also to interpret social phenomena, examine relationships among individuals and groups, and apply sociological theories to real social issues. Therefore, the success of sociology learning should not be measured only through achievement scores, but also through students' ability to regulate their learning, engage actively in classroom activities, and master sociological concepts meaningfully.

A persistent problem in sociology learning is that students' concept mastery often remains superficial. Students may remember terms such as social interaction, social groups, social stratification, social conflict, social mobility, social change, and social institutions, but they often experience difficulties when asked to distinguish, apply, and analyze these concepts in real social cases. This issue becomes more serious when teachers identify students' misconceptions only after summative assessment. In such conditions, instructional intervention may occur too late, while students' misunderstandings may already influence their comprehension of more complex sociological concepts. Therefore, sociology learning requires an instructional approach that enables teachers to detect learning difficulties earlier and provide adaptive support during the learning process.

Learning analytics offers a potential response to this challenge because it enables teachers to monitor students' learning activities through digital data, including material access, formative quiz results, assignment punctuality, discussion participation, answer-error patterns, and feedback responses. Aguilar et al. (2021) showed that exposure to learning analytics dashboards is associated with students' motivation and self-regulated learning because learning progress data can help students become more aware of their learning development. However, learning analytics should not be understood merely as a dashboard or a technical report. Learning data become pedagogically meaningful only when teachers interpret the data and use them to support instructional decisions.

Previous studies have emphasized that the effectiveness of learning analytics depends on its integration with learning design, student support, and teacher decision-making. Blumenstein (2020) highlighted the synergy between learning analytics and learning design in supporting student outcomes, while Fan et al. (2021) showed that learning analytics can reveal relationships between learning design and self-regulated learning. Alhazbi et al. (2024) further explained that learning analytics can measure self-regulated learning through behavioral indicators recorded in digital learning environments. These studies indicate that learning analytics can support students' planning, monitoring, evaluation, and strategic learning behaviors when analytics information is connected to meaningful pedagogical support.

Learning engagement is also central to successful sociology learning. Banihashem et al. (2022) found that constructivist learning design supported by learning analytics can influence students' engagement and self-regulation. Nevertheless, digital activity should not automatically be interpreted as meaningful engagement. Students who frequently access learning platforms may not necessarily demonstrate strong cognitive engagement, while students who are less visible in classroom interaction may still show independent learning patterns through digital traces. Du et al. (2023) showed that online trace data can help identify students' self-regulated learning strategies. In the sociology classroom, such data can help teachers distinguish students who have not participated, students who have made learning efforts but still experience misconceptions, and students who require more advanced conceptual challenges.

In this context, learning orchestration is highly relevant. Learning orchestration positions teachers as pedagogical decision-makers who design, monitor, adjust, and direct learning activities based on available evidence. Amarasinghe et al. (2024) emphasized that learning analytics can support teachers in designing and orchestrating learning tasks. This means that teachers do not merely observe student data, but use it to decide when conceptual reinforcement is needed, when learning groups should be reorganized, when individual feedback should be provided, and when remedial or enrichment activities should be implemented. For sociology learning, orchestration is important because teachers need to integrate conceptual explanation, social case analysis, classroom discussion, formative assessment, and feedback.

Although previous studies have shown the potential of learning analytics and orchestration, several research gaps remain. First, many learning analytics studies focus on higher education, online learning, or general digital learning environments, while empirical studies in secondary school sociology learning remain limited. Second, previous studies often examine learning analytics in relation to self-regulated learning or engagement separately, while fewer studies integrate self-regulated learning, learning engagement, and sociological concept mastery in one instructional model. Third, limited attention has been given to how teachers transform learning analytics data into adaptive pedagogical decisions in social science classrooms. Therefore, empirical research is needed to examine learning analytics not only as a monitoring tool, but also as part of teacher-led learning orchestration in sociology learning.

To address this gap, this study examines learning analytics-based sociology learning orchestration among Grade XI students in three public senior high schools in Jakarta. The intervention positions teachers as learning orchestrators who use student learning data to provide feedback, identify learning difficulties, design adaptive interventions, and strengthen case-based sociology learning. The novelty of this study lies in the integration of learning analytics, teacher orchestration, and three learning outcomes within a secondary school sociology context. Therefore, this study aims to examine the effectiveness of learning analytics-based sociology learning orchestration in improving students' self-regulated learning, learning engagement, and sociological concept mastery.

METHOD

Research Design

This study employed a quantitative approach using a multi-site quasi-experimental design with an embedded learning analytics model and a pretest-posttest control group structure. This design was selected because the study was conducted in three different schools and involved naturally formed classroom groups; therefore, individual randomization could not be applied. The quasi-experimental design allowed the researchers to compare the learning outcomes of students who received learning analytics-based sociology learning orchestration with those who received regular sociology instruction.

The term embedded learning analytics refers to the integration of students' digital learning activity data into the pedagogical treatment. In this study, learning analytics data were not treated merely as supplementary information, but were embedded in the instructional process to help teachers monitor learning progress, identify difficulties, provide feedback, and adjust learning activities. The experimental classes received sociology learning orchestration based on learning analytics, whereas the control classes received regular sociology instruction according to the teachers' existing classroom practices.

Measurements were conducted before and after the treatment on three dependent variables: self-regulated learning, learning engagement, and sociology concept mastery. Pretest scores were used to examine baseline equivalence and were also included as covariates in the inferential analysis. This procedure was applied to reduce the influence of initial differences between the experimental and control groups.

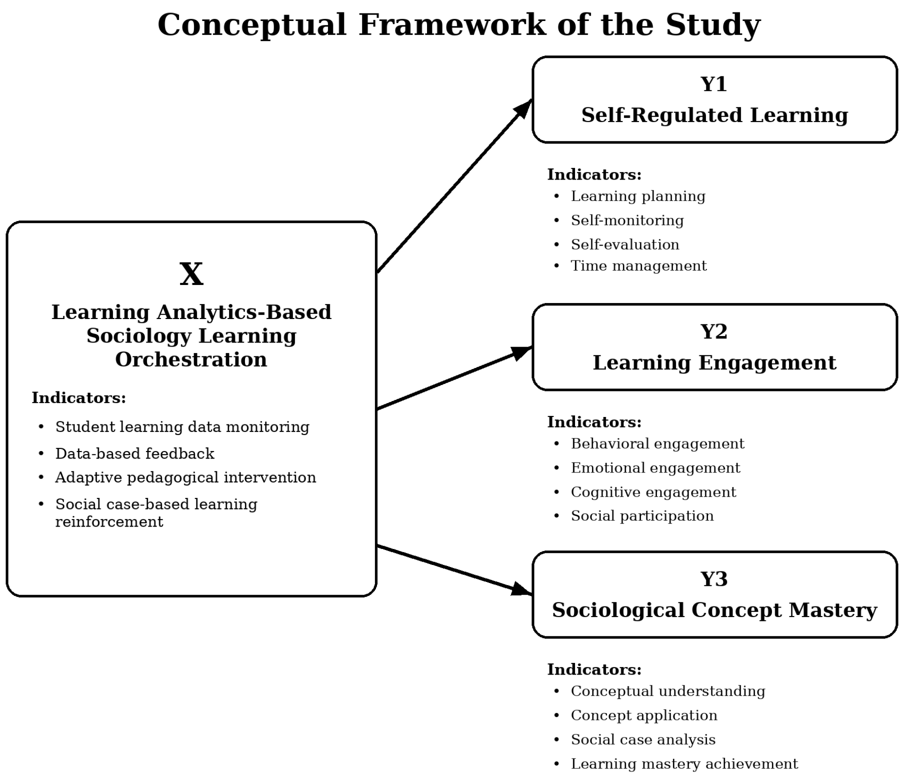

Figure 1. Conceptual Framework of the Study

Figure 1 shows that sociology learning orchestration based on learning analytics is positioned as the main treatment variable. The treatment includes monitoring student learning data, providing data-informed feedback, implementing adaptive pedagogical interventions, and reinforcing learning through social cases. The effects of the treatment are examined on three learning outcomes, namely self-regulated learning, learning engagement, and sociology concept mastery.

Research Site, Population, and Sample

The study was conducted among Grade XI or Phase F students who took sociology subjects at three public senior high schools in Jakarta, namely SMA Negeri 70 Jakarta, SMA Negeri 34 Jakarta, and SMA Negeri 11 Jakarta. These schools were selected purposively by considering the availability of sociology subjects, the presence of parallel classes, readiness to use digital learning platforms, and teachers' willingness to implement learning scenarios supported by learning analytics.

The population consisted of all Grade XI or Phase F students taking sociology at the three schools. The sample was determined using intact group sampling because the treatment unit was a naturally existing classroom group. In each school, two parallel classes with relatively comparable academic characteristics were selected, consisting of one experimental class and one control class. The final sample consisted of 209 students, including 105 students in the experimental group and 104 students in the control group.

To reduce selection bias, the researchers considered class comparability based on grade level, subject enrolment, school context, teacher confirmation, and pretest scores. Baseline equivalence testing was also conducted before the main analysis to ensure that differences in posttest outcomes were not simply caused by initial group differences.

Table 1. Research Group Design

School	Experimental Class	Control Class	Treatment
SMA Negeri 70 Jakarta	XI/Phase F Sociology 1	XI/Phase F Sociology 2	Sociology learning orchestration based on learning analytics
SMA Negeri 34 Jakarta	XI/Phase F Sociology 1	XI/Phase F Sociology 2	Sociology learning orchestration based on learning analytics
SMA Negeri 11 Jakarta	XI/Phase F Sociology 1	XI/Phase F Sociology 2	Sociology learning orchestration based on learning analytics

Treatment Procedure

The treatment was implemented over six to eight meetings on sociology topics that required conceptual understanding and social case analysis. At the initial stage, students in both experimental and control classes completed a sociology concept mastery pretest and filled out self-regulated learning and learning engagement questionnaires. These initial data were used to identify baseline equivalence between groups and served as covariates in the MANCOVA analysis.

In the experimental classes, teachers implemented learning analytics-based orchestration through four main mechanisms. First, teachers monitored student learning data, including material access, punctuality of assignment submission, formative quiz scores, discussion activity, patterns of incorrect answers, and responses to feedback. Second, teachers provided data-informed feedback to help students recognize the strengths and weaknesses of their learning. Third, teachers carried out adaptive pedagogical interventions, such as concept reinforcement, learning group formation, targeted remedial instruction, reflective assignments, and enrichment activities. Fourth, teachers strengthened learning through relevant social cases so that students were not only able to remember concepts, but also to apply and analyze sociological concepts in social contexts.

The control classes received regular sociology instruction without the use of learning analytics data as the basis for instructional decision-making. Teachers continued to deliver content, assign tasks, facilitate classroom activities, and conduct evaluation according to existing classroom practices. However, they did not use dashboards or digital activity records to design individual or group interventions.

To ensure treatment consistency, the researchers prepared a learning scenario, treatment implementation sheet, and observation checklist. Teachers in the experimental classes received orientation regarding the use of learning analytics data for instructional orchestration. During the implementation, classroom observations were conducted to monitor whether the treatment was delivered according to the planned procedure. The same sociology topics, learning duration, and posttest instruments were used across the experimental and control groups to control possible procedural differences. After all treatment sessions were completed, all students took a sociology concept mastery posttest and completed the final self-regulated learning and learning engagement questionnaires.

Variables, Instruments, and Indicators

The independent variable in this study was sociology learning orchestration based on learning analytics. The dependent variables consisted of self-regulated learning, learning engagement, and sociology concept mastery. Self-regulated learning was measured through indicators of learning planning, self-monitoring, self-evaluation, and time management. Learning engagement was measured through behavioral engagement, emotional engagement, cognitive engagement, and social participation. Sociology concept mastery was measured through conceptual understanding, concept application, social case analysis, and mastery learning achievement.

Table 2. Research Variables, Indicators, and Instruments

Variable	Position	Main Indicators	Instrument
Sociology learning orchestration based on learning analytics	Independent variable	Learning data monitoring, data-informed feedback, adaptive intervention, social case reinforcement	Treatment implementation sheet and learning activity log
Self-regulated learning	Dependent variable 1	Learning planning, self-monitoring, self-evaluation, time management	Self-regulated learning questionnaire
Learning engagement	Dependent variable 2	Behavioral, emotional, cognitive engagement, and social participation	Learning engagement questionnaire
Sociology concept mastery	Dependent variable 3	Conceptual understanding, concept application, social case analysis, mastery learning achievement	Sociology concept mastery test

The research instruments consisted of a sociology concept mastery test, a self-regulated learning questionnaire, a learning engagement questionnaire, a treatment implementation observation sheet, and learning analytics log data from the digital learning platform. The sociology concept mastery test was developed using reasoned multiple-choice items and short essay questions to measure students' understanding, application, and analysis of sociological concepts. The self-regulated learning and learning engagement questionnaires used a Likert scale with graded response options. Learning analytics log data were used as process data to verify whether the treatment was implemented through the monitoring of students' digital learning activities.

Instrument Validity and Reliability

Instrument validity and reliability were examined before the instruments were used in the main study. Content validity was assessed through expert judgment involving a sociology learning expert, an educational evaluation expert, and an educational technology expert. The experts reviewed the alignment between items and indicators, clarity of wording, relevance to the sociology learning context, appropriateness for Grade XI students, and suitability of the instruments for measuring the intended constructs.

The expert judgment results were used to revise unclear, overlapping, or less relevant items before the instruments were tested in a limited try-out. The try-out was conducted with students who had similar characteristics to the research participants but were not included in the main sample. The validity of the sociology concept mastery test items was examined through item-total correlation, item difficulty, and item discrimination analysis. Items that did not meet the required criteria were revised or removed.

The reliability of the concept mastery test was analyzed using KR-20 or Cronbach's Alpha, depending on the item format. The self-regulated learning and learning engagement questionnaires were examined using construct validity procedures and Cronbach's Alpha reliability analysis. The instruments were considered feasible when they showed acceptable validity and reliability indicators. In addition, the treatment implementation observation sheet was reviewed to ensure that it could consistently capture the main stages of learning analytics-based orchestration across the three schools.

Control of Confounding Variables

Several procedures were applied to control potential confounding variables. First, the study used parallel classes within the same schools to reduce differences in school environment, curriculum implementation, and student academic level. Second, pretest scores were used to examine baseline equivalence between the experimental and control groups. Third, pretest scores were included as covariates in the MANCOVA analysis to control students' initial ability before treatment.

Fourth, the treatment was implemented using the same sociology topics, similar learning duration, and comparable assessment instruments across schools. Fifth, teacher implementation was monitored using observation sheets to ensure that the experimental treatment followed the planned orchestration procedure. Sixth, the analysis included school effect testing or school fixed effect consideration to ensure that the observed differences were not merely caused by differences among the three school contexts. These procedures were used to strengthen internal validity and reduce the possibility that the findings were influenced by uncontrolled external factors.

Data Collection Techniques

Data were collected through tests, questionnaires, observation, and digital activity records. Tests and questionnaires were administered at the pretest and posttest stages to identify changes in self-regulated learning, learning engagement, and sociology concept mastery. Observation was conducted during the treatment to ensure that teachers implemented the learning orchestration stages according to the prepared scenario.

Digital activity records were used to obtain process data, including material access, formative quiz completion, punctuality of assignment submission, forum participation, patterns of incorrect answers, and students' responses to feedback. This combination of data sources allowed the study to measure not only final learning outcomes, but also learning processes that occurred during the intervention.

Data Analysis

Data analysis was conducted in several stages. First, descriptive statistics were used to describe the mean, standard deviation, minimum score, and maximum score of each variable. Second, prerequisite tests were conducted, including normality, homogeneity, linearity, equality of covariance matrices, homogeneity of regression slopes, and baseline equivalence tests between the experimental and control groups. These tests were conducted to ensure that the data met the assumptions required for multivariate analysis.

Third, the N-Gain Score was used to examine the improvement of self-regulated learning, learning engagement, and sociology concept mastery in each group. Fourth, the main analysis used MANCOVA with pretest scores as covariates. MANCOVA was selected because the study involved three dependent variables tested simultaneously: self-regulated learning, learning engagement, and sociology concept mastery. This analysis was used to determine whether there were significant differences in posttest outcomes between the experimental and control groups after controlling for students' initial scores.

Since the data were collected from three schools, the analysis was also complemented by school effect testing or school fixed effect consideration to ensure that the differences in outcomes were not merely influenced by school characteristics. The magnitude of the treatment effect was reported using effect size measures, such as partial eta squared or Cohen's d, so that the interpretation of the findings was based not only on statistical significance, but also on practical significance.

RESULTS

This section presents the empirical results of the multi-site quasi-experimental study conducted in three public senior high schools in Jakarta. The analysis focuses on four core components: descriptive changes in the research variables, the learning analytics activity profile of the experimental group, N-Gain and assumption testing, and the multivariate effect of learning analytics-based sociology learning orchestration on students' self-regulated learning, learning engagement, and sociological concept mastery. All scores were transformed into a 0-100 scale to support comparability across instruments.

A. Descriptive Results of Research Variables

The study involved 209 students from SMA Negeri 70 Jakarta, SMA Negeri 34 Jakarta, and SMA Negeri 11 Jakarta. The experimental group consisted of 105 students, while the control group consisted of 104 students. Before the intervention, the mean scores of the experimental and control groups were relatively comparable across the three dependent variables. After the intervention, the experimental group showed a larger increase in self-regulated learning, learning engagement, and sociological concept mastery than the control group.

Table 1. Descriptive Statistics of Pretest and Posttest Scores

Variable	Group	n	Pretest M (SD)	Posttest M (SD)	Mean Difference
Self-Regulated Learning	Experimental	105	68.45 (6.82)	82.31 (7.04)	13.86
Self-Regulated Learning	Control	104	67.92 (6.75)	74.18 (7.22)	6.26
Learning Engagement	Experimental	105	70.12 (7.10)	84.07 (6.88)	13.95
Learning Engagement	Control	104	69.85 (7.21)	75.46 (7.34)	5.61
Sociological Concept Mastery	Experimental	105	64.38 (8.05)	83.24 (7.18)	18.86
Sociological Concept Mastery	Control	104	63.91 (8.11)	72.35 (8.02)	8.44

Note. M = mean; SD = standard deviation. Scores were converted to a 0-100 scale.

Table 1 shows that the experimental group experienced a stronger improvement across all variables. The largest increase was found in sociological concept mastery, indicating that the orchestration of sociology learning through learning analytics was not only associated with better learning behavior, but also with more substantial conceptual improvement. Meanwhile, the control group also improved, but the magnitude of improvement was smaller, suggesting that regular learning was less able to produce comparable changes in students' learning processes and conceptual outcomes.

B. Learning Analytics Activity Profile

To verify that the intervention was implemented as a data-informed instructional process, the learning analytics activity profile was analyzed for the experimental group. The indicators included material access, formative quiz completion, assignment punctuality, discussion participation, and feedback response. These indicators were selected because they represented the main components used by teachers to monitor students' learning patterns and determine adaptive pedagogical interventions during the learning process.

Table 2. Learning Analytics Activity in the Experimental Group

Learning Analytics Indicator	Mean Percentage	Interpretation
Material access	86.40%	High
Formative quiz completion	88.75%	High
Assignment punctuality	82.15%	High
Discussion participation	79.60%	Moderate to high
Feedback response	84.30%	High

Note. The percentage values represent the aggregated activity logs of students in the experimental group during the intervention period.

The results in Table 2 indicate that the experimental group demonstrated a generally high level of digital learning activity. The highest score was found in formative quiz completion, followed by material access and feedback response. This pattern suggests that students did not merely access the learning platform administratively, but also interacted with instructional activities that were directly connected to monitoring, feedback, and conceptual reinforcement. Discussion participation was categorized as moderate to high, indicating that social and cognitive engagement still required teacher facilitation through structured prompts and case-based sociology tasks.

C. N-Gain and Assumption Testing

The N-Gain analysis was used to examine the magnitude of improvement from pretest to posttest. In addition, assumption testing was conducted before the inferential analysis to ensure the suitability of the data for MANCOVA. The assumption tests included normality, homogeneity of variance, equality of covariance matrices, and linearity. The results indicated that the data met the required assumptions for multivariate analysis.

Table 3. N-Gain Score and Assumption Test Summary

Analysis Component	Variable/Test	Experimental Group	Control Group	Decision
N-Gain	Self-Regulated Learning	0.43 (Moderate)	0.19 (Low)	Experimental group higher
N-Gain	Learning Engagement	0.46 (Moderate)	0.18 (Low)	Experimental group higher
N-Gain	Sociological Concept Mastery	0.53 (Moderate)	0.23 (Low)	Experimental group higher
Normality	Shapiro-Wilk	p > .05	p > .05	Fulfilled
Homogeneity	Levene's test	p = .112-.184	p = .112-.184	Fulfilled
Covariance equality	Box's M	p = .137	-	Fulfilled
Linearity	Deviation from linearity	p > .05	p > .05	Fulfilled

Note. N-Gain categories were interpreted as low, moderate, and high. The assumption tests show that the data were appropriate for MANCOVA analysis.

The N-Gain results show that the experimental group obtained moderate improvement in all three variables, whereas the control group remained in the low category. The highest N-Gain in the experimental group was found in sociological concept mastery, followed by learning engagement and self-regulated learning. This finding indicates that learning analytics-based orchestration was particularly effective in strengthening students' conceptual understanding while also improving the learning behaviors that supported the achievement of conceptual mastery.

D. MANCOVA and Effect Size Results

MANCOVA was employed to test the simultaneous effect of learning analytics-based sociology learning orchestration on the three dependent variables after controlling for students' initial scores. The multivariate test showed a significant effect of the intervention, Wilks' Lambda = 0.724, $F(3, 201) = 18.652$, $p < .001$, partial eta squared = 0.276. This result indicates that the intervention had a statistically significant simultaneous effect on self-regulated learning, learning engagement, and sociological concept mastery. The school effect was not significant at the .05 level, suggesting that the effect of the intervention was relatively consistent across the three schools.

Table 4. Summary of MANCOVA and Effect Size Results

Dependent Variable	Adjusted Mean Experimental	Adjusted Mean Control	F	p	Partial Eta Squared	Interpretation
Self-Regulated Learning	82.08	74.41	21.384	< .001	0.174	Significant
Learning Engagement	83.91	75.62	24.219	< .001	0.191	Significant
Sociological Concept Mastery	83.02	72.57	31.706	< .001	0.236	Significant

Note. Adjusted means were estimated after controlling for pretest scores. Partial eta squared indicates the magnitude of the intervention effect.

Table 4 confirms that the experimental group outperformed the control group in all three dependent variables after controlling for initial differences. The largest effect size was observed for sociological concept mastery, followed by learning engagement and self-regulated learning. This means that the intervention had its strongest impact on students' ability to understand, apply, and analyze sociological concepts. The moderate-to-large effect sizes also suggest that the model had practical significance, not merely statistical significance.

E. Summary of Main Findings

Overall, the results indicate that students who participated in learning analytics-based sociology learning orchestration demonstrated greater improvement in self-regulated learning, learning engagement, and sociological concept mastery than students who received regular sociology learning. The learning analytics activity profile further showed that students in the experimental group actively accessed materials, completed formative quizzes, submitted assignments on time, participated in discussions, and responded to teacher feedback. These activities provided teachers with actionable data for monitoring learning progress and delivering adaptive pedagogical interventions.

The strongest empirical effect was found in sociological concept mastery, indicating that the use of learning analytics as a basis for instructional orchestration can strengthen students' conceptual understanding in sociology. At the same time, improvements in self-regulated learning and learning engagement suggest that the intervention supported both learning processes and learning outcomes. Therefore, the findings support the argument that learning analytics should not be treated merely as a monitoring tool, but as a pedagogical basis for designing feedback, intervention, and concept reinforcement in sociology learning.

DISCUSSION

This study examined the effectiveness of learning analytics-based sociology learning orchestration in improving students' self-regulated learning, learning engagement, and sociological concept mastery. The findings show that students in the experimental group achieved greater improvement than those in the control group across the three measured outcomes. The strongest improvement was found in sociological concept mastery, followed by learning engagement and self-regulated learning. These results indicate that learning analytics can support sociology learning when student data are not treated merely as digital records, but are used by teachers to guide feedback, identify learning difficulties, and design adaptive instructional responses. However, because this study used a quasi-experimental design, the findings should be interpreted as evidence of a significant intervention effect within the research context, rather than as absolute causal evidence equivalent to a fully randomized experiment.

The improvement in self-regulated learning suggests that learning analytics-based orchestration helped students become more aware of their learning behavior. Data on material access, formative quiz completion, assignment punctuality, and feedback response provided students with clearer information about their learning progress and weaknesses. This encouraged students to plan their learning, monitor their understanding, manage time, and evaluate their learning strategies before the final assessment. This finding is consistent with (Matcha et al., 2020) who showed that learning analytics dashboards can support learners in monitoring progress and interpreting learning activities in relation to expected goals. It also supports (Jivet et al., 2020) emphasized that learning analytics becomes pedagogically meaningful when students can make sense of analytics information and connect it to their learning goals. In line with (Kizilcec et al., 2017) and (Yang et al., 2025) the present study shows that self-regulated learning can be strengthened when analytics information is accompanied by teacher guidance, feedback, and opportunities for corrective action.

The findings also indicate that learning engagement improved more substantially in the experimental group. This suggests that learning analytics-based orchestration created a more responsive and participatory learning environment. Students were encouraged not only to access learning materials and complete quizzes, but also to participate in discussions, respond to feedback, and apply sociological concepts to social cases. This interpretation is consistent with (Henrie et al., 2015) who argued that engagement in technology-mediated learning should be understood as a multidimensional construct involving behavioral, emotional, cognitive, and social dimensions. In this study, digital activity was not interpreted as engagement by itself. Instead, material access was connected to reading tasks, quiz performance was connected to conceptual reinforcement, and discussion participation was connected to case-based learning. This finding also supports (Rets et al., 2021) and (Susnjak et al., 2022), who emphasized that learning analytics becomes useful when it provides actionable insights that help learners and teachers take corrective action.

The strongest improvement was found in sociological concept mastery. This result is important because sociology learning requires students not only to define concepts such as social interaction, social groups, social stratification, conflict, social change, and social institutions, but also to apply these concepts in analyzing real social phenomena. Learning analytics helped teachers detect conceptual difficulties earlier through formative quiz scores, answer-error patterns, assignment responses, and discussion participation. These data enabled teachers to provide conceptual reinforcement, remedial instruction, reflective tasks, and case-based discussion before students reached the final assessment. This finding supports Mangaroska and (Mangaroska & Giannakos, 2019), who argued that learning analytics has stronger instructional value when connected to learning design. It also aligns with (Rodríguez-Triana et al., 2021) who emphasized the importance of aligning analytics with instructional intentions, and with Tzimas and Demetriadis (2024), who showed that analytics-based guidance can support learning performance when students receive structured direction. In the context of sociology, this structured direction is essential because students often need support in connecting abstract concepts with concrete social realities, as also indicated by (Ramadhan et al., 2024).

A key contribution of this study lies in positioning teacher orchestration as the central mechanism that makes learning analytics pedagogically meaningful. Learning analytics does not automatically improve students' self-regulated learning, engagement, or concept mastery. Its value depends on how teachers interpret data and transform it into instructional decisions. In this study, teachers used analytics information to identify students who needed support, provide feedback, organize group activities, design remedial instruction, and strengthen students' understanding through social cases. This interpretation is consistent with (Holstein et al., 2019), who emphasized the importance of teacher-AI complementarity in classroom orchestration. It also supports (Prieto et al., 2019) who argued that learning analytics requires classroom-level use and communication among stakeholders. Furthermore, the findings align with (Saint et al., 2022) who highlighted the importance of temporally focused analytics in understanding learning processes. By monitoring student activity across learning stages, teachers were able to provide timely support before learning difficulties became final achievement gaps.

Despite these positive findings, several potential biases should be considered. First, the study used intact classroom groups rather than individual random assignment. Although baseline equivalence testing and covariate control were applied, selection bias cannot be fully eliminated. Differences in classroom culture, student motivation, prior achievement, digital literacy, or teacher-student relationships may have influenced the results. Second, teacher effects may also have contributed to the intervention outcomes because teachers differed in their ability to interpret analytics data, provide feedback, manage classroom interaction, and implement adaptive instruction. Third, the possibility of a novelty or Hawthorne effect should be acknowledged. Students in the experimental group may have shown higher participation partly because they experienced a new learning approach and were aware that their learning activities were being monitored. Fourth, learning analytics logs mainly represent observable digital behavior, such as access frequency, assignment submission, and quiz completion, but they do not fully capture the depth of students' cognitive engagement or sociological reasoning.

This study also has several limitations that should guide future research. The research was conducted in three public senior high schools in Jakarta, where digital infrastructure and teacher readiness may be better than in less digitally supported contexts. Therefore, the generalization of the findings to other school settings should be made cautiously. In addition, the intervention was implemented over a limited number of meetings, so the study cannot determine whether the improvements in self-regulated learning, engagement, and sociological concept mastery are sustained over a longer period. Future research should use longitudinal designs, involve more diverse school contexts, compare different learning analytics platforms, and examine the specific contribution of each intervention component, such as dashboard use, teacher feedback, formative assessment, remedial instruction, and case-based discussion. Mixed-methods research is also recommended to explore how students and teachers experience analytics-based orchestration in actual classroom practice.

Overall, this study contributes to the development of data-informed pedagogy in secondary social science education. The findings suggest that learning analytics can strengthen sociology learning when teachers use student data as a basis for reflection, feedback, participation support, and conceptual reinforcement. Practically, sociology teachers can use learning analytics to identify learning difficulties earlier, provide more timely support, and design adaptive interventions that connect sociological concepts with real social cases. Theoretically, this study extends learning analytics research by demonstrating its relevance beyond higher education, online learning, and STEM-oriented contexts. The value of learning analytics lies not in data collection alone, but in how teachers transform data into pedagogical decisions that support meaningful learning.

CONCLUSION

This study concludes that learning analytics-based sociology learning orchestration can improve students' self-regulated learning, learning engagement, and sociological concept mastery in public senior high school contexts. The main contribution of this study lies in positioning teachers as learning orchestrators who transform student learning data into pedagogical decisions through feedback, formative assessment, adaptive intervention, and case-based conceptual reinforcement. Rather than treating learning analytics merely as a digital monitoring tool, this study shows that analytics becomes meaningful when used to identify learning difficulties earlier and support more responsive sociology learning. However, this study has several limitations, including the use of a quasi-experimental design with intact classroom groups, the limited context of three public senior high schools in Jakarta, possible teacher implementation differences, and the use of learning analytics logs and questionnaires that may not fully capture students' cognitive engagement and sociological reasoning. Therefore, future studies should involve more diverse school contexts, apply longitudinal or mixed-methods designs, compare different learning analytics platforms, and examine which components of the intervention, such as teacher feedback, formative assessment, dashboard use, or case-based discussion, contribute most strongly to students' learning outcomes.

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