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Profiles of Science Reasoning from Lawson's Perspective: A Comparative Study of Gender, School Location, and Practicum Experience

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Abstract – *Scientific reasoning is a core skill in science education because it allows students to think logically, critically, and systematically when approaching problems and understanding natural phenomena. Yet, international assessments such as PISA and TIMSS have repeatedly shown that Indonesian students lag behind global averages in this area, making it an urgent issue for physics education. This study aimed to assess the scientific reasoning abilities of grade XI students in Surakarta using a motion dynamics testlet adapted from Lawson's Classroom Test of Scientific Reasoning (LCTSR). The research employed a descriptive quantitative design and involved 363 students from three high schools representing different school locations and levels of practicum experience. The testlet, developed through stages of planning, piloting, and validation, was designed to ensure reliability and to capture reasoning indicators such as conservation, proportionality, variable control, probability, correlation, and hypothetico-deductive reasoning. The results revealed that most students were in the concrete (51%) and transitional (47%) stages of operation, with only 2% reaching the formal operational stage. In terms of achievement categories, the majority fell into the fair and lower levels, and none reached the very good level. Statistical analysis showed no significant gender differences, but students from urban schools and those with practicum experience performed significantly better. The novelty of this research lies in contextualizing Lawson's instrument in terms of motion dynamics and adopting a testlet format that efficiently measures reasoning. These findings highlight the central role of the school environment and practical experience in shaping reasoning skills and provide valuable evidence for strengthening physics teaching and policy.*

Keywords: *Lawson's classroom test; motion dynamics; physics education; practicum experience; scientific reasoning*

I. INTRODUCTION

Science education has long been recognized as a fundamental driver for preparing students to understand and engage with the complex world of science, technology, and societal challenges. Beyond transmitting factual knowledge, it cultivates critical thinking, problem-solving abilities, and a deeper appreciation of natural phenomena (Bouckaert, 2023; Uluçınar, 2022). Through well-structured science learning, students develop systematic reasoning skills that allow them to analyze problems, evaluate solutions, and relate scientific principles to real-life contexts (Fitriani et al., 2021; Krell et al., 2022). Scientific reasoning, in particular, plays a pivotal role in enabling learners to move beyond rote memorization of formulas towards evidence-based decision-making and conceptual understanding of science. This competency is essential not only for personal intellectual development but also for equipping young people to address pressing societal issues such as climate change, technological advancement, and public health.

In the context of 21st-century education, scientific reasoning is increasingly emphasized as a key competence. The rapid growth of technology, global interconnectedness, and environmental uncertainties necessitate that individuals think critically, creatively, and systematically (Pradini et al., 2022). High school physics instruction, which often involves abstract concepts and mathematical formalism, provides a particularly fertile ground for fostering scientific reasoning. Students who develop this competency are more capable of planning experiments, interpreting empirical data, and drawing valid conclusions (Ningrum et al., 2024). According to cognitive development theory, high school students should possess the ability to reason abstractly and hypothetically (Piaget, 1972; Kamaluddin et al., 2023). At this level, learners are expected to design experiments, manipulate variables, and apply principles to novel contexts, thereby demonstrating the hallmarks of mature scientific reasoning. However, research indicates that many high school students have not yet fully attained this stage, highlighting a persistent gap between expected and actual cognitive development (Asniar et al., 2022; Yusa et al., 2022).

Despite the recognized importance of scientific reasoning, empirical evidence from large-scale international assessments reveals that students in Indonesia struggle significantly in this domain. Results from PISA 2022 demonstrate that Indonesian students scored an average of 383 in science literacy, a decline from 2018 and substantially below the OECD average of 485 (Riau, 2023; Kemendikbudristek, 2023). This indicates that most students remain at basic proficiency levels, able to handle routine problems but unable to engage in higher-order reasoning. Similarly, TIMSS data show that Indonesian learners consistently perform at the lower end of reasoning categories, with only a small fraction achieving high proficiency (Hadi & Novaliyosi, 2019). These findings suggest a systemic challenge in cultivating scientific reasoning within the school system, raising concerns about students' preparedness to meet the demands of contemporary science and technology.

Several interrelated factors contribute to this shortfall. First, science education in Indonesia has often been dominated by content transmission and algorithmic problem-solving, leaving limited room for inquiry-based or exploratory approaches (Setianingsih et al., 2018; Badaun et al., 2020). Second, uneven access to educational resources—particularly laboratories and practicum opportunities—creates disparities in students' learning experiences depending on school location (Nasution, 2021; Sudiro et al., 2024). Students in urban schools typically have more opportunities to conduct experiments and engage with interactive learning, while those in rural schools may encounter limited exposure. Finally, socio-cultural perceptions of physics as abstract and overly mathematical discourage many students from appreciating the subject's conceptual richness and practical relevance (Rizkita & Mufit, 2022). Addressing these systemic issues requires innovative instructional practices and valid, reliable instruments to measure and track the development of scientific reasoning skills.

A widely recognized instrument for measuring scientific reasoning is the Lawson Classroom Test of Scientific Reasoning (LCTSR), which operationalizes reasoning into measurable indicators such as proportional reasoning, probabilistic reasoning, control of variables, correlational reasoning, conservation, and hypothetico-deductive reasoning (Bao et al., 2009; Nabillah et al., 2022). The LCTSR has been extensively validated and applied internationally to assess the extent to which learners can apply scientific thinking in diverse contexts. Using such an instrument provides educators with diagnostic insights into students' cognitive stages and reasoning capabilities, enabling them to implement targeted interventions. Previous studies have demonstrated that students' performance on the LCTSR correlates strongly with mastery of physics concepts and broader academic achievement (Handayani et al., 2020; Mandella et al., 2020). Moreover, this instrument aligns with Piagetian theory, which emphasizes that formal operational thought including the ability to reason abstractly and hypothetically is crucial for scientific problem-solving (Prabowo & Widodo, 2018; Rabindran & Madanagopal, 2020). Consequently, adopting the LCTSR framework in assessing Indonesian students offers a robust methodological foundation for understanding and improving scientific reasoning.

Recent empirical investigations underscore the importance of contextual and experiential learning in enhancing scientific reasoning. Studies indicate that students with more opportunities for laboratory work or practicum activities tend to score higher on reasoning measures, as hands-on experimentation fosters hypothesis testing, variable control, and evidence-based reasoning (Ningrum et al., 2024; Wulandari et al., 2025). Similarly, research comparing urban and rural schools reveals that access to adequate facilities has a significant influence on students' progression from the concrete to the formal operational stage (Nasution, 2021; Sudiro et al., 2024). However, despite the documented relationship between environment, practical engagement, and reasoning development, systematic comparative studies in the Indonesian high school context remain scarce. Prior research has often examined gender differences, yet findings consistently suggest that gender is not a decisive factor in scientific reasoning performance (Hyde, 2005; Nabillah et al., 2022). Therefore, there is a clear need for research that goes beyond gender and focuses instead on structural variables such as school location and practicum experience, which appear more consequential for students' cognitive growth. Additionally, the adaptation of reasoning assessments to specific curriculum materials such as motion dynamics, a core topic in the Indonesian physics curriculum (Kemendikbudristek, 2022; Oktavia et al., 2024) is limited, leaving an important gap in both measurement and pedagogy.

Against this background, the present study aims to assess the scientific reasoning proficiency of grade XI students in the Surakarta region by developing and administering a motion dynamics-based testlet instrument adapted from Lawson's framework. Specifically, this research investigates the relationship between students' reasoning levels and three key variables: gender, school location, and practicum experience. By situating the assessment within the context of motion dynamics, the study not only aligns with the Indonesian physics curriculum but also grounds reasoning evaluation in a conceptually challenging and pedagogically relevant domain. The novelty of this research lies in its combined focus on (a) adapting a validated reasoning instrument to a local curricular topic, (b) employing a testlet format to measure reasoning while minimizing testing fatigue efficiently and (c) conducting a comparative analysis across variables that reflect both individual (gender) and structural (school location, practicum) influences. Through this approach, the study aims to address critical gaps in the literature and provide actionable insights for educators and policymakers seeking to enhance scientific reasoning among Indonesian high school students.

II. METHODS

This study employed a descriptive quantitative design aimed at systematically assessing students' scientific reasoning ability within the framework of Lawson's perspective. Quantitative methodologies are commonly utilized in educational research to generate objective, replicable findings that can reveal trends across large student populations (Creswell & Creswell, 2018). In the context of scientific reasoning, quantitative survey approaches allow researchers to measure the prevalence of cognitive stages and reasoning indicators among students and to compare these across relevant variables such as gender, school location, and practical experience. The chosen design aligns with prior studies that have employed standardized instruments, such as the Lawson Classroom Test of Scientific Reasoning (LCTSR), in large-scale assessments of student cognitive development (Bao et al., 2009; Handayani et al., 2020; Nabillah et al., 2022).

The research procedure followed a structured three-phase instrument development model adapted from Mardapi's framework of test construction (Istiyono, 2020). The stages comprised test planning, test trial, and measurement. In the planning stage, the conceptual framework for scientific reasoning was defined, including the six indicators emphasized in Lawson's model: conservation reasoning, proportional reasoning, control of variables, probabilistic reasoning, correlational reasoning, and hypothetico-deductive reasoning (Bao et al., 2009). Instrument items were designed with reference to these indicators and adapted to the physics curriculum at the senior high school level, specifically focusing on motion dynamics concepts (Kemendikbud, 2022; Oktavia et al., 2024). During the test trial phase, items underwent readability and item analysis tests to assess their suitability for inclusion. Finally, in the measurement phase, the validated instrument was administered to a large student sample for data collection and subsequent statistical analysis. The overall procedure is summarized in Figure 1, which illustrates the flow of test development from planning through to final evaluation.

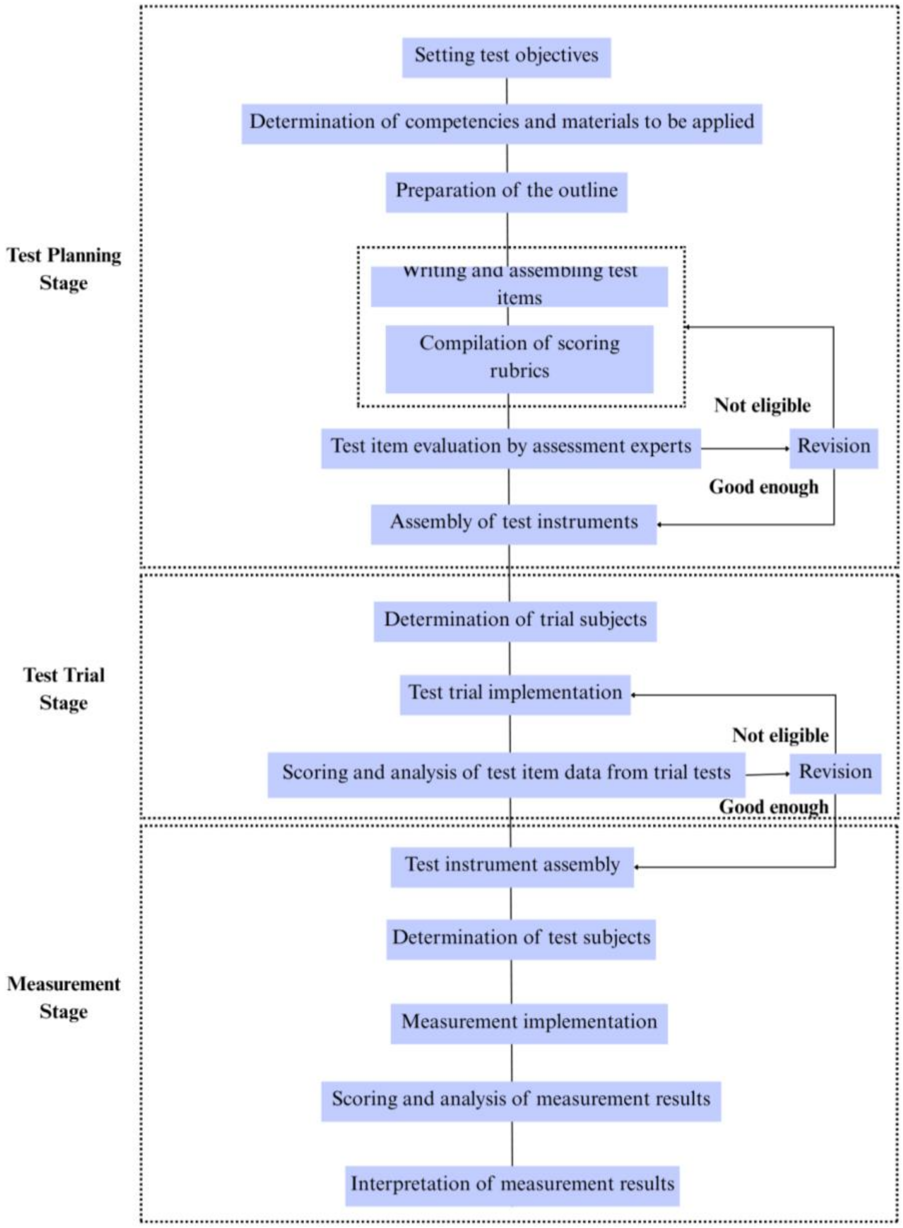

Figure 1. Research procedure flowchart.

The instrument used in this study was a testlet-based adaptation of Lawson's Classroom Test of Scientific Reasoning. Testlet formats combine multiple related items under a single stimulus, which can improve measurement efficiency and reliability while maintaining student engagement (Nova et al., 2016; Murti et al., 2018). Each testlet item required students not only to select an answer but also to provide reasoning, ensuring that the assessment captured both conceptual understanding and logical justification. The instrument consisted of 20 items distributed across the six indicators of scientific reasoning. The item distribution is detailed in Table 1, which presents the mapping of questions to reasoning indicators. Such systematic alignment of items to indicators enhances construct validity and ensures that all aspects of scientific reasoning are adequately represented (Krell et al., 2022).

Table 1. Scatter pattern of the science reasoning test instrument

Scientific reasoning ability indicator	Question number	Number of questions
Conservation reasoning	1.1, 3.1, 6.1	3
Proportional reasoning	1.2, 4.1, 5.3, 6.3	4
Control of variable	1.3, 3.2, 5.1	3
Probabilistic reasoning	2.1, 4.2, 5.2, 6.4	4
Correlational reasoning	2.2, 3.3, 6.2	3
Deductive hypothesis reasoning	2.3, 4.3, 5.4	3

Before large-scale administration, a readability test was conducted to evaluate the clarity, difficulty, and discriminatory power of the items. A sample of 100 students was engaged in this pilot test. Their responses were analyzed using Iteman software, which applies classical test theory principles to determine item performance characteristics (Istiyono, 2020). Items were retained if they met established standards for difficulty and discrimination. The difficulty index (P) classifies items into easy, medium, and difficult categories, with optimal values ranging from 0.3 to 0.7 (Sijabat et al., 2024). These categories are shown in Table 2.

Table 2. Criteria for difficulty level

Difficulty index (P)	
Value	Category
< 0.3	Difficult
0.3 - 0.7	Medium
> 0.7	Easy

The discrimination index was evaluated using the point-biserial correlation coefficient (Rpbis), which measures how well an item differentiates between students with higher and lower abilities (Khumaira et al., 2024). Items with higher Rpbis values are considered more effective at distinguishing between ability levels. Discrimination categories are summarized in Table 3.

Table 3. Differentiation criteria

Item Discrimination (Rpbis)	
Value	Category
≥ 0.4	Very good
0.3 - 0.39	Good
0.20 - 0.29	Fair
< 0.20	Not good

From an initial pool of 40 items, 29 met the criteria for both difficulty and discrimination. After expert consultation, 20 items were selected for the final instrument, ensuring representation across all reasoning indicators. This process strengthened both the content validity and the practical feasibility of the test. Where items were identified as ambiguous or confusing, revisions were made in line with expert feedback and pilot results, ensuring that the language was accessible to students without sacrificing conceptual rigor.

The sample population consisted of 363 grade XI students from three high schools in the Surakarta region: SMA Negeri 4 Surakarta, SMA Negeri 8 Surakarta, and SMA Negeri 3 Boyolali. These schools were selected to represent diversity in school location, spanning from urban to more rural contexts. In total, 15 classes were involved, each with approximately 33 to 36 students. This relatively large sample size provided sufficient statistical power for subgroup analyses across gender, school location, and practicum experience. Before survey administration, permissions were obtained from school administrators, and participation was voluntary, with assurances of confidentiality, in accordance with standard research ethics protocols in educational settings (Cohen et al., 2018).

The scoring system adopted a dichotomous approach consistent with Lawson's framework: responses were awarded one point if both the answer and reasoning were correct, and zero if either or both were incorrect. The cumulative score for each student was then categorized according to Lawson's stages of reasoning development—concrete operational, transitional operational, and formal operational—based on Piagetian cognitive theory (Piaget, 1972; Handayani et al., 2020). The thresholds for classification are presented in Table 4, which shows the correspondence between score ranges and cognitive stages.

Table 4. Scientific reasoning cognitive ability category

No	Score	Category
1	0 - 6	Concrete operational
2	7 - 13	Transitional operational
3	14 - 20	Formal operational

In addition to these developmental stages, students' overall performance was also evaluated using categorical levels of scientific reasoning ranging from very good to very less. This evaluative categorization allowed the researchers to interpret student performance not only in terms of developmental stage but also in terms of achievement level across the population. The classification system, adapted from Arikunto (2010), is presented in Table 5.

Table 5. Category of scientific reasoning level

No	Score	Category
1	81-100	Very good
2	61-80	Good
3	41-60	Fair
4	21-40	Less
5	0-20	Very less

For data analysis, descriptive statistics were first applied to calculate frequencies, percentages, and distributions across reasoning levels. Comparative studies were then conducted using independent-samples t-tests to examine differences between groups based on gender, school location, and practicum experience. This statistical approach has been widely used in similar studies to assess mean differences across categorical variables in educational data (Hyde, 2005; Nabillah et al., 2022). A significance threshold of $p < 0.05$ was adopted. The analysis was supported by Microsoft Excel for data management and visualization, ensuring clarity in the presentation of results through tables and charts.

III. RESULTS AND DISCUSSION

The survey data on scientific reasoning ability among senior high school students in the Surakarta region were analyzed descriptively and comparatively. Student responses were classified by reasoning level and cognitive development stages. The following subsections present the findings based on the variables of gender, school location, and practicum experience. The overall distribution of students across the five categories of reasoning achievement is presented in Table 6. The majority of students were concentrated in the fair and less categories, while a smaller number fell into the good category.

Table 6. Scientific reasoning level analysis result

Variable	Group	Scientific reasoning level				
		VG	G	F	L	VL
Area	Surakarta	0	17	120	178	48
Gender	Male	0	3	35	55	12
	Female	0	14	85	123	36
School Location	City center	0	19	49	59	10
	Far from the city center	0	2	69	117	38
Practicum Experience	Ever practicum	0	17	115	158	31
	Never practicum	0	0	5	20	17

When viewed by gender, both male and female students were predominantly in the fair and less categories. Female students showed a slightly higher proportion in the good category compared to male students. With respect to school location, students from city-center schools were more evenly distributed across the categories of good, fair, and less, while students from schools located farther from the city center were concentrated in the fair and less categories, with fewer in the good category. For the variable of practicum experience, students who had engaged in practicum activities were distributed across good, fair, and less categories, whereas students without practicum experience were mostly concentrated in the less and very less categories. To further analyze group differences, an independent-samples t-test was conducted. The results are presented in Table 7.

Table 7. T-Test analysis results

Variable	Group	Average	p-value
Gender	Male	37.81	0.821
	Female	38.18	
School Location	City center	41.97	0.000
	Far from the city center	35.66	
Practicum Experience	Ever practicum	39.55	0.000
	Never practicum	26.79	

The t-test results indicated that the mean scores of male and female students were almost identical, with no statistically significant difference. In contrast, the mean score of students from city-center schools was higher than that of students from schools farther from the city, with a statistically significant difference. Similarly, students who had practicum experience achieved a substantially higher mean score than those without practicum experience, with a highly significant difference.

In addition to reasoning level categories, the distribution of students' cognitive development stages was examined. The overall results are displayed in Figure 2.

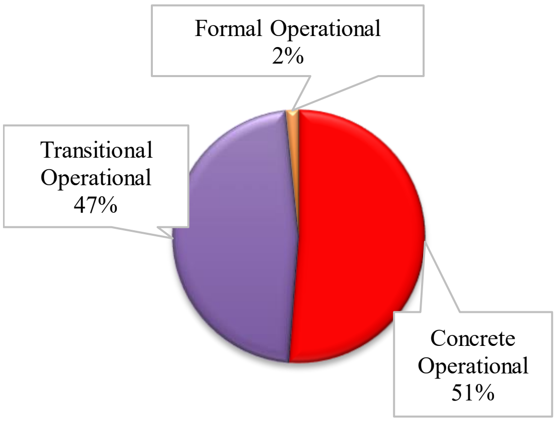

Figure 2. Cognitive ability distribution of senior high school students in the Surakarta region

The analysis shows that 51% of students were at the concrete operational stage, 47% at the transitional operational stage, and only 2% at the formal operational stage. This distribution indicates that most students were concentrated in the lower cognitive stages, with only a very small proportion reaching the highest level of abstract and formal reasoning.

The distribution of students' cognitive abilities was further examined in relation to gender, school location, and practicum experience. When analyzed by gender, the results are displayed in Figure 3.

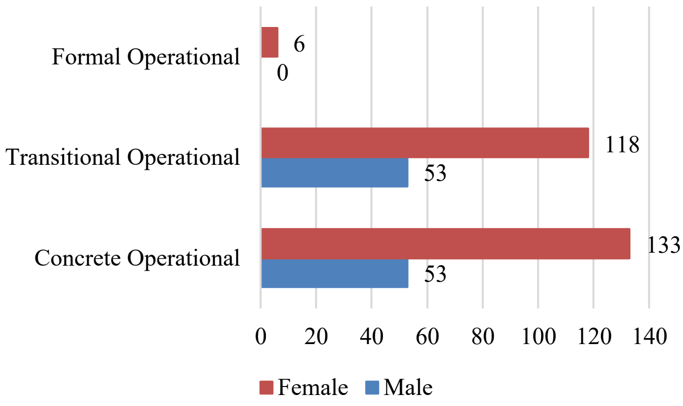

Figure 3. Cognitive ability distribution based on gender

The diagram shows that most female students were categorized in the concrete operational stage. A small number of female students had reached the formal operational stage. Male students, in contrast, were more evenly distributed between the concrete and transitional operational stages. However, no male student was classified as having attained the formal operational stage. Overall, the data indicate that the majority of both male and female students were situated in the lower stages of cognitive development, with a slightly higher proportion of female students progressing toward the formal stage. When considering the school location, the results are summarized in Figure 4.

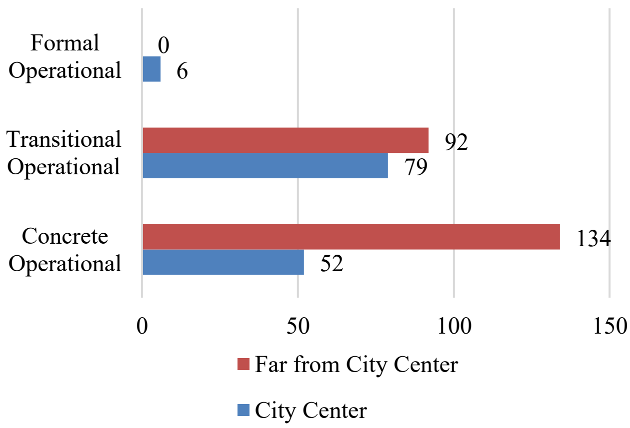

Figure 4. Cognitive ability distribution based on school location

The diagram illustrates that most students attending schools located farther from the city center were concentrated in the concrete operational stage, followed by the transitional stage, with none reaching the formal operational stage. In comparison, students from schools in the city center were more evenly distributed between the concrete and transitional stages, and a small proportion had advanced to the formal operational stage. This pattern indicates that students in city-center schools demonstrated a relatively higher proportion of advanced cognitive development stages compared to those from schools located farther away. Cognitive abilities were also analyzed based on students' practicum experience, as shown in Figure 5.

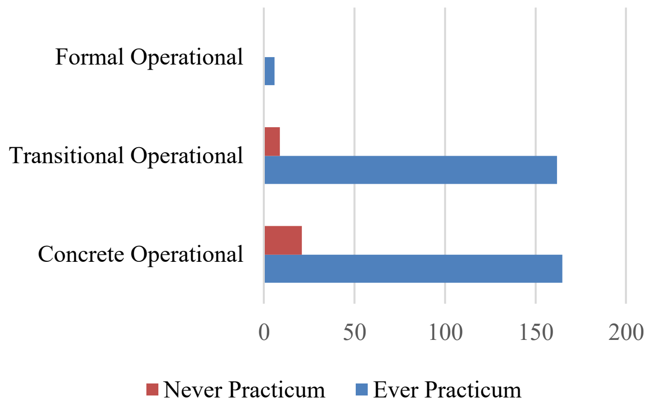

Figure 5. Cognitive ability distribution based on practicum experience

Among students who had participated in practicum activities, the largest proportion was at the concrete operational stage (165 students), followed closely by those at the transitional stage (162 students). A small group of six students in this category reached the formal operational stage. In contrast, among students with no practicum experience, the majority were at the concrete operational stage (21 students), with a smaller number at the transitional stage (9 students). None of the students without practicum experience attained the formal operational stage. These results demonstrate clear differences in the distribution of cognitive development stages, depending on whether students had prior practicum experience.

The findings of this study offer valuable insights into the scientific reasoning abilities of high school students in the Surakarta region, particularly in the context of learning motion dynamics. The descriptive results revealed that none of the students achieved the Very Good category of scientific reasoning, with most falling into the Fair and Less categories. This outcome suggests that the majority of students have not yet mastered higher-order reasoning processes. Similar trends have been documented in international assessments such as PISA and TIMSS, where Indonesian students consistently performed below the global average in science literacy and reasoning (Riau, 2023; Hadi & Novaliyosi, 2019). The persistence of these outcomes highlights systemic challenges in science education, where learning often emphasizes content memorization and formula application over inquiry and reasoning (Setianingsih et al., 2018; Badaun et al., 2020).

Analysis by gender indicated no statistically significant differences in scientific reasoning scores, with male and female students performing at nearly the same level. This result aligns with prior studies suggesting that gender differences in cognitive development and reasoning ability are relatively small or insignificant (Hyde, 2005). Wulandari et al. (2025) further demonstrated that male and female students typically possess comparable reasoning capabilities, with variations more likely attributable to factors such as instructional quality, learning environments, and pedagogical strategies rather than inherent gender differences. Nabillah et al. (2022) also reported that scientific reasoning is not determined by gender but is more strongly influenced by the teaching methods applied in the classroom. These findings collectively reinforce the interpretation that gender is not a determining factor for reasoning ability, a conclusion also supported by the non-significant p-value obtained in the present study.

By contrast, significant differences were observed in relation to school location. Students from city-center schools performed better than those in schools located farther from the city. This disparity can be attributed to differences in educational facilities and access to resources. Schools in urban areas are often equipped with laboratories, information technology, and teaching materials that enable more interactive and inquiry-based learning (Nasution, 2021). Sudiro et al. (2024) similarly found that disparities in facilities between urban and rural schools contribute to differences in students' cognitive achievement, including scientific reasoning. In the context of Bronfenbrenner's ecological systems theory, the school environment plays a critical role in shaping cognitive development by providing access to opportunities, tools, and experiences that foster reasoning growth (Bronfenbrenner, 1979). The presence of adequate infrastructure, supportive learning environments, and exposure to diverse learning strategies in urban schools thus facilitates the transition from concrete to formal operational thinking stages among students.

The variable of practicum experience emerged as the most significant determinant of scientific reasoning. Students who had participated in practicum activities displayed significantly higher scores and were more likely to reach transitional and formal operational stages compared to those without such experiences. This finding underscores the role of experiential learning in developing reasoning skills. Piaget's cognitive development theory emphasizes that hands-on experiences and experimentation are essential for the transition to formal operational thought, where abstract and hypothetical reasoning can be applied (Piaget, 1972). This view is corroborated by Fosnot and Perry (2005), who argue that constructivist learning environments—where students actively engage in inquiry and experimentation—enhance the acquisition of higher-order thinking skills. Empirical studies have further confirmed that practicum and laboratory experiences contribute significantly to reasoning development by encouraging hypothesis formulation, variable control, and evidence-based decision-making (Ningrum et al., 2024; Anjani et al., 2020). The strong statistical effect observed in this study, with a p-value approaching zero, provides compelling evidence of the critical role of practical engagement in fostering scientific reasoning.

The distribution of cognitive stages among the students also offers a crucial perspective. The majority of students were classified in the concrete and transitional operational stages, with only 2% reaching the formal operational stage. Given that high school students, based on their age, are expected to be capable of formal operational reasoning (Piaget, 1972; Rabindran & Madanagopal, 2020), the results highlight a significant developmental gap. Similar outcomes have been observed in prior Indonesian studies, where students' reasoning abilities often lag behind the expected developmental trajectory (Yusa et al., 2022; Rizqiyati et al., 2023). The limited proportion of students achieving formal reasoning suggests that many have not been adequately supported in progressing toward abstract and systematic thinking. This may be linked to the predominant reliance on traditional, teacher-centered pedagogies that prioritize procedural problem solving rather than inquiry and reasoning (Pradini et al., 2022; Krell et al., 2022).

The subgroup analyses further reinforced these observations. In terms of gender, female students showed a slightly higher proportion reaching the formal operational stage, though the numbers remained small. Male students were distributed more evenly across the concrete and transitional stages, with none attaining the formal stage. The results based on school location indicated that students in urban schools were more likely to be in transitional or formal stages. In contrast, students from rural schools were concentrated in the concrete stage of development. Similarly, students with practicum experience were represented across all three stages, including the formal stage, while those without practicum experience were confined to the lower stages. These results strongly emphasize that contextual and experiential factors, rather than inherent characteristics such as gender, are more decisive in shaping the cognitive development of scientific reasoning.

Overall, the findings of this study highlight both the challenges and opportunities in fostering scientific reasoning among Indonesian high school students. The challenges are evident in the predominance of students in the lower reasoning categories and the minimal attainment of the formal operational stage. At the same time, the opportunities are demonstrated by the significant effects of practicum experience and school location, which reveal that access to resources, experiential learning, and enriched environments can effectively promote higher-order reasoning. Addressing these disparities requires intentional educational strategies that integrate inquiry-based instruction, laboratory work, and contextualized problem solving into physics education. By doing so, educators can support students in progressing toward formal reasoning stages, thereby aligning cognitive development with both curricular goals and the demands of 21st-century scientific literacy (Nurhalimah et al., 2024; Dusturia et al., 2024).

IV. CONCLUSION AND SUGGESTION

This study examined the scientific reasoning abilities of senior high school students in the Surakarta region using a testlet-based instrument adapted from Lawson's framework on motion dynamics material. The findings showed that the majority of students were categorized at the concrete (51%) and transitional (47%) stages of operation, with only 2% reaching the formal operational stage. Students' reasoning levels were mostly within the fair and less categories, with none achieving the very good level. Gender was not a significant factor influencing scientific reasoning, as male and female students demonstrated comparable performance. In contrast, school location and practicum experience were found to significantly affect reasoning ability, with students from urban schools and those with practicum experience showing higher levels of reasoning compared to their counterparts.

This study, however, is limited by its focus on a single region and by the reliance on cross-sectional survey data, which may not capture the longitudinal development of reasoning skills. Future research should involve broader and more diverse samples across different regions of Indonesia, as well as longitudinal or intervention-based studies that investigate the effects of specific teaching methods on the development of reasoning. Despite these limitations, the present research makes a significant contribution to the field of physics education by providing empirical evidence on the current state of students' scientific reasoning and by highlighting the critical role of school resources and practicum activities. These insights can inform the design of instructional strategies and educational policies aimed at promoting higher-order reasoning, thereby supporting students' progression toward formal operational thinking and strengthening their readiness for scientific and technological challenges.

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