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Living Arrangements and Self-Study Time Associated with Ordinary Differential Equations Written-Solution Quality

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ABSTRACT

This study describes the association between students' living arrangements and self-study time with the quality of written solutions in an Ordinary Differential Equations (ODE) course. A descriptive-exploratory quantitative approach was conducted with 18 sixth-semester pre-service mathematics teachers. Data were obtained from final ODE grades, an online questionnaire on living arrangements and estimated weekly self-study hours, and students' written responses to four representative ODE problems (non-exact, first-order linear, Bernoulli, and an exact equation with an initial value). Solution quality was coded into four categories: complete-correct, conceptual error, procedural/calculation error, and blank. Descriptive and correlational analyses were used to identify trends among variables. Results indicate a positive correlation between self-study time and the proportion of complete-correct solutions ($r = 0.4635$) and a negative correlation with conceptual errors ($r = -0.3681$). The proportion of complete-correct solutions also shows a strong correlation with the final ODE grade ($r = 0.8945$). These findings highlight the importance of structured support for self-study and diagnostic assessment based on error types to improve students' understanding in ODE learning.

Keywords: error analysis; living arrangement; ordinary differential equations; self-study; solution quality

INTRODUCTION

Ordinary Differential Equations (ODE) is a foundational course because it provides an entry point for understanding dynamic phenomena through mathematical modeling. In ODE instruction, students are expected not only to execute solution procedures but also to interpret the meaning of a model and connect it to the underlying problem context. Several studies in ODE education suggest that an emphasis on modeling—linking mathematical representations to contextual conditions and interpretations—is more effective for deepening students' understanding than approaches that are predominantly procedural (Buckingham, 2025; Czocher, 2017).

Several studies report that students' difficulties in ODE typically arise at three main stages: (1) selecting an appropriate solution method, (2) executing the procedure correctly (e.g., applying an integrating factor), and (3) maintaining computational accuracy. Consequently, common error patterns include conceptual errors (e.g., choosing an incorrect method) and procedural/computational errors (e.g., incorrect steps or arithmetic mistakes). These findings underscore the importance of evaluating the quality of students' solutions—not merely their final scores—so that instructors can detect misconceptions earlier and provide more targeted feedback (Farlina et al., 2018; Novitasari et al., 2025).

Success in courses that require sustained, continuous practice—such as ODE—is closely related to self-regulated learning (SRL), namely students' ability to independently set goals, select strategies, monitor their understanding, and evaluate their learning. Contemporary SRL literature emphasizes that SRL serves as an overarching framework encompassing cognitive, metacognitive, motivational, and behavioral components. SRL interventions for prospective teachers have been shown to be particularly important, as they influence their competence both as learners and as future educators (Luo & Zhou, 2024; Ortube et al., 2024; Panadero, 2017).

SRL does not operate in isolation; it is shaped by students' learning ecology—one aspect of which is residential status (e.g., living with parents, living independently, in rented accommodation, or in a dormitory). Prior research indicates that living arrangements (such as residing in a dormitory versus at home) may be associated with differences in academic achievement and learning engagement through mechanisms including access to learning resources, the structure of daily routines, social distractions, and students' sense of belonging to the campus community (Reynolds, 2020; Stalmirska & Mellon, 2022).

The novelty of this study lies in a data-driven mapping based on an ODE course that links an external factor (students' living arrangements) and an internal factor (self-study intensity as a proxy for SRL) to indicators of ODE understanding, and then enriches the analysis by classifying solution quality (fully correct, conceptual error, computational error). This approach is particularly relevant for teacher education because it yields more operational recommendations—not merely that "scores are low," but where the difficulties occur and which groups of students require targeted support.

The practical contribution of this study is to provide an evidence base for designing more precise ODE instructional interventions, such as strengthening SRL (learning planning, monitoring, and reflection) and offering structured learning support for students whose living conditions are less conducive to studying—for example, through guided study groups, peer tutoring, or staged diagnostic assessments that specifically target misconceptions and procedural errors (Limone et al., 2020).

RESEARCH METHODS

This study employed a quantitative approach using a descriptive–exploratory design. The participants were 18 sixth-semester students from the Mathematics Education Program, Faculty of Teacher Training and Education, Suryakancana University, in the 2024–2025 academic year who were enrolled in the ODE course.

Data were collected using a mixed approach, combining secondary and primary sources. The secondary data consisted of students' achievement scores in the ODE course, whereas the primary data—students' living arrangements and self-study duration—were obtained through an online questionnaire.

Data analysis included descriptive statistics, visualizations to identify patterns, and Pearson correlation to examine the direction of associations. Students' solution quality was classified into four categories: fully correct, conceptual error, computational/procedural error, and blank/not attempted.

RESULTS AND DISCUSSION

The descriptive statistics from the data collection are summarized as follows. Most students lived with their parents (61.1%; 11 students), followed by rented accommodation/boarding houses (kos) (22.2%; 4 students), a guardian's home (11.1%; 2 students), and a dormitory (5.6%; 1 student); see Figure 1(a). This pattern suggests that most respondents come from areas where living with family is feasible.

The distribution of self-study time indicates that the majority of students fall within the low-to-moderate range (approximately 5–10 hours per week), with one case of very high self-study time (around 40 hours per week) that appears as a positive outlier; see Figure 1(b). The right-skewed distribution suggests disparities in self-study patterns across students.

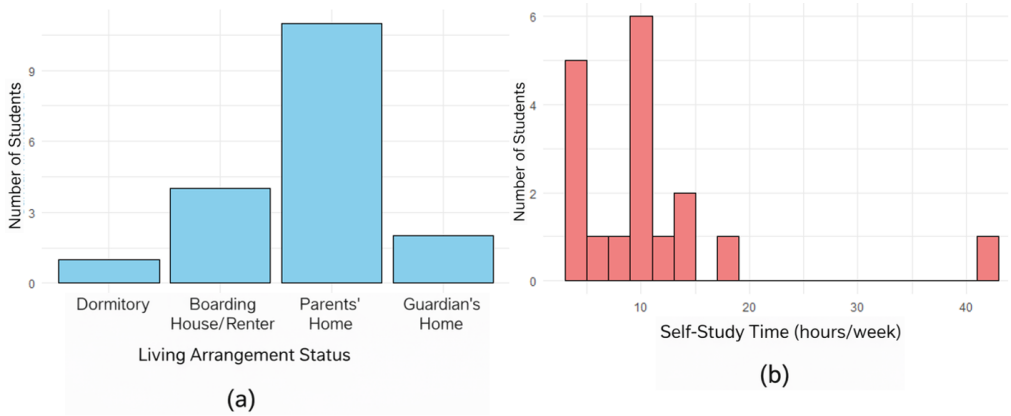

Figure 1. (a) Distribution of living arrangement status, (b) Distribution of self-study time

Figure 2 shows that students living with their parents tend to exhibit a wider spread of scores but a relatively higher median than those living in boarding houses, who display a lower median with a wide score range. This finding provides preliminary evidence that students' living environment may be associated with their academic performance.

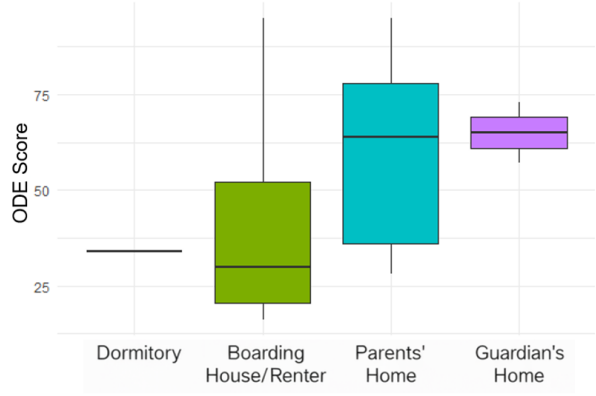

Figure 2. Distribution of ODE scores by Living Arrangement Status

Figure 3 presents the distribution of students' self-study time by living arrangement status, measured in hours per week. The visualization shows notable variation across residential groups in terms of the median, dispersion (interquartile range), and the presence of outliers, collectively indicating complex dynamics in students' out-of-class learning

patterns. Students living in boarding houses exhibit the widest distribution of self-study time, with a median of approximately 9–10 hours per week but a very broad range extending to nearly 20 hours. Moreover, one extreme outlier allocates more than 40 hours per week to self-study.

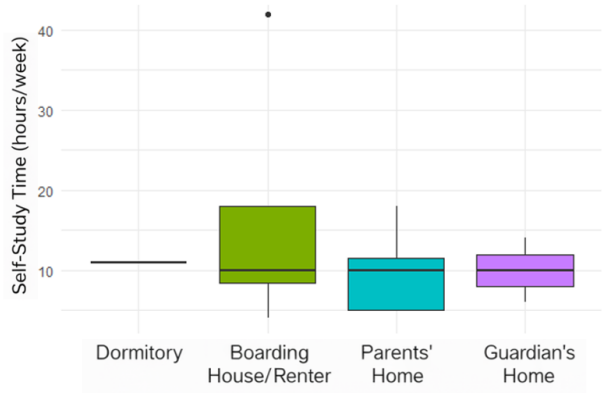

Figure 3. Distribution of self-study time by Living Arrangement Status

Figure 4 indicates a positive association between self-study time and achievement in the ODE course, although the pattern is not entirely strong or perfectly linear. The upward-sloping regression line suggests that students who allocate more time to self-study tend to obtain higher ODE scores. This supports the hypothesis that self-study intensity is an important factor in promoting academic achievement, particularly in courses that require conceptual understanding and sustained effort, such as ODE.

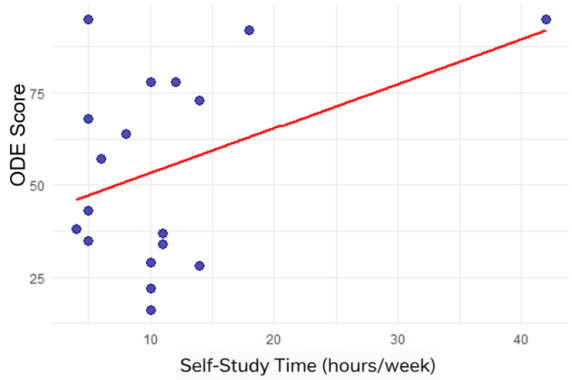

Figure 4. Relationship Between ODE Scores and Self-Study Time

Figure 5. Average Proportion by Response Category

The distribution of responses indicates that computational errors dominate compared with conceptual errors and fully correct solutions (see Figure 5), suggesting that many students experience difficulties related to procedural accuracy.

From an exploratory correlational perspective, the results indicate linear associations between each response category and self-study time. The correlation coefficients between each response category and ODE scores, as well as self-study duration, are presented in Table 1.

Table 1. Correlation Between Response Category and ODE Scores and Self-Study Time

Response Category	ODE Scores	Self-Study Time
Fully Correct	0.8945	0.4635
Conceptual Error	− 0.6977	− 0.3681
Computational Error	− 0.4029	− 0.2496

The findings of this study indicate that self-study duration is positively associated with ODE achievement and with a higher proportion of fully correct responses, whereas the proportions of conceptual errors and computational/procedural errors tend to decline as study time increases. This pattern is consistent with the SRL literature, which emphasizes that learning success is shaped not only by exposure to course content but also by self-regulatory processes such as planning, strategy selection, monitoring of understanding, and self-evaluation (Panadero, 2017). In higher education contexts, reviews and empirical studies show that SRL strategies—particularly time management, metacognition, and effort regulation—are positively correlated with academic achievement, including in learning environments that require high levels of student initiative (Broadbent, 2017; Broadbent & Poon, 2015). In line with these findings, recent meta-analytic evidence also indicates that SRL interventions/support yield a moderate effect on learning outcomes, making it reasonable that variation in self-study intensity (as a proxy for SRL practice) is associated with variation in student achievement in courses that demand consistent practice, such as ODE (Guntur & Purnomo, 2024).

In addition, the predominance of procedural/computational errors over conceptual errors suggests that in ODE students do not always fail at the stage of selecting an appropriate method; rather, they often stumble in executing the steps (e.g., transformations, algebraic manipulations, integration, and applying initial conditions). This pattern aligns with arguments in differential equations education research emphasizing the need to strengthen mathematical sense-making and to connect procedures with meaning, rather than relying solely on mechanistic practice. Czocher (2017), for example, shows that emphasizing mathematical modeling principles in differential equations courses can help students link procedures to the structure of the problem and improve the quality of their understanding. Accordingly, the findings of this study reinforce the need for ODE assessment that goes beyond final scores and incorporates diagnostic evaluation of solution quality to distinguish conceptual from procedural errors as a basis for instructional improvement.

The descriptive finding that students living with their parents/guardians tend to achieve better outcomes than those living in boarding houses or dormitories can be interpreted through the lens of learning-environment support. Social–emotional support and

a more structured study environment at home may facilitate consistency in SRL, whereas living in kos/dormitories can increase demands for self-management and exposure to social distractions. Empirical evidence in the Indonesian context indicates that parental support is associated with academic emotions, learning strategies, and achievement among first-year university students (Amalia & Latifah, 2019). More broadly, experimental studies in Indonesia also suggest that increasing parental engagement can change learning-support practices at home and communication with schools, although effects on numeracy scores may depend on the intervention design and implementation context (Tresnatri et al., 2022). Thus, residential status in this study is reasonably viewed as an indicator of micro-level environmental conditions that may strengthen or weaken students' independent learning practices.

Practically, the implications of these findings point to the need for ODE instructional strategies that target two dimensions simultaneously: (1) strengthening SRL through the design of structured independent-learning tasks (e.g., scaffolded practice schedules, strategy reflection, and process-based feedback), and (2) improving procedural quality through practice that emphasizes step verification, error-checking, and explicit links between concepts and procedures. These efforts align with evidence that strong SRL is associated with academic performance in learning environments that demand high levels of student autonomy (Broadbent, 2017; Broadbent & Poon, 2015) and that SRL support generally improves learning outcomes (Guntur & Purnomo, 2024). Accordingly, ODE instruction that integrates error diagnosis, SRL enhancement, and attention to the broader learning environment has the potential to improve achievement as well as the professional readiness of prospective mathematics teachers.

CONCLUSION

This study shows that students' learning outcomes in Ordinary Differential Equations (ODE) are influenced not only by formal mastery of course content but also by regulated independent learning practices and the conditions of students' learning environments. Self-study duration is positively associated with ODE achievement and with a higher proportion of fully correct responses, and negatively associated with conceptual errors and procedural errors. These findings underscore the importance of self-regulated learning (SRL) as a foundation for success in courses that require deep conceptual understanding and sustained practice, such as ODE.

In addition, students' living arrangements appear to function as an environmental context that shapes the effectiveness of independent learning. Students living with parents or guardians tend to demonstrate higher academic achievement and better solution quality than those living in boarding houses or dormitories, who face greater demands for self-management and greater exposure to potential distractions. This indicates that the micro-level learning environment should be taken into account when designing instructional strategies and academic support in higher education.

Overall, the novelty of this study lies in an evaluative approach that does not rely solely on final scores, but also incorporates an analysis of solution quality as a diagnostic indicator of students' conceptual and procedural understanding, while simultaneously considering the roles of SRL and living arrangements. These findings offer practical

implications for ODE instruction, particularly the need for process-based assessment, the strengthening of independent learning strategies, and the provision of more context-sensitive learning support to enhance instructional quality and the professional readiness of prospective mathematics teachers.

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