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Correlational Study of Motivation and Learning Strategies After GROVE_ALPHA Implementation from a Self-Regulated Learning Perspective

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Abstract: This study investigates the relationship between students' goal orientations (intrinsic and extrinsic) and their use of self-regulated learning strategies following the implementation of GROVE-ALPHA, a gamified, AI-supported formative assessment tool for physics learning. A mixed-methods sequential explanatory design was used, involving 20 high school students for the quantitative phase and follow-up interviews with 8 participants. Quantitative data were collected using the Motivated Strategies for Learning Questionnaire (MSLQ), focusing on intrinsic and extrinsic goal orientation, critical thinking, metacognitive self-regulation, and effort regulation. Kendall's tau correlation analysis indicated that intrinsic goal orientation was more strongly associated with all three self-regulated learning strategies—especially effort regulation ($\tau(20)= .63$, $p < .001$)—than extrinsic goal orientation ($\tau(20)= .49$, $p < .001$). Qualitative findings supported the quantitative results, highlighting that intrinsically motivated students demonstrated greater engagement, persistence, and reflective thinking when interacting with the GROVE-ALPHA system. In contrast, extrinsically motivated students showed inconsistent engagement and shallower learning strategies. These findings suggest that integrating gamification and AI in formative assessment can support students' self-regulated learning, particularly by strengthening intrinsic motivation. The study contributes to understanding how digital tools can influence motivation types and learning behaviors in science education.

Keywords: Extrinsic motivation; Formative assessment; Intrinsic motivation; Learning strategies; Self-regulated learning

Introduction

The learning process is significantly influenced by student motivation and their learning strategies. Motivated students tend to be more independent and driven to explore their learning materials in greater depth. This is similar to physics learning, which requires students to learn consciously and regularly assess themselves to identify and rectify their misconceptions (Huda et al., 2020). This self-assessment is crucial for students to recognize and address existing conceptual misunderstandings, ultimately leading to a deeper and more substantial grasp of physics concepts (Rojas, 2009). Prior studies emphasize that physics instruction should nurture students' metacognitive skills so they can monitor and regulate their own progress. For example, insufficient positive recognition from instructors has been shown to reduce students' self-efficacy and interest in physics, especially among underrepresented groups (Li & Singh, 2023). Similarly, structured approaches that focus on scientific thinking skills have been

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recommended to strengthen conceptual understanding (Mitchell-Polka et al., 2020).

In reality, teachers struggle to provide student-controlled evaluation processes. Evaluation during this process, known as formative assessment, is intended to provide continuous feedback to support student development (Fuller & Dawson, 2017). Yet, giving individualized feedback on students' strengths and weaknesses remains challenging (Kusairi, 2020). Research indicates that, according to teachers, the primary challenges of implementing formative assessment in the classroom are the large number of students, insufficient time, lack of practical knowledge, and inadequate or inappropriate training. Many teachers face obstacles in designing practical formative assessments, primarily due to time and resource constraints (Nadhifah et al., 2023).

This learning situation affected the student's motivation and learning strategies. To examine this, a preliminary study was conducted using the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al., 1991) among 30 students in a Bandung school. The instrument used a seven-point Likert scale ranging from 1 ("Not at All True of Me") to 7 ("Very True of Me"). The results showed that intrinsic goal orientation had a mean of 4.5 (SD = 1.56), metacognitive self-regulation averaged 4.28 (SD = 0.53), and effort regulation scored 4.0 (SD = 0.26). These findings align with other studies indicating that students' motivation and independent learning strategies are generally at a moderate level (Kwarikunda et al., 2021).

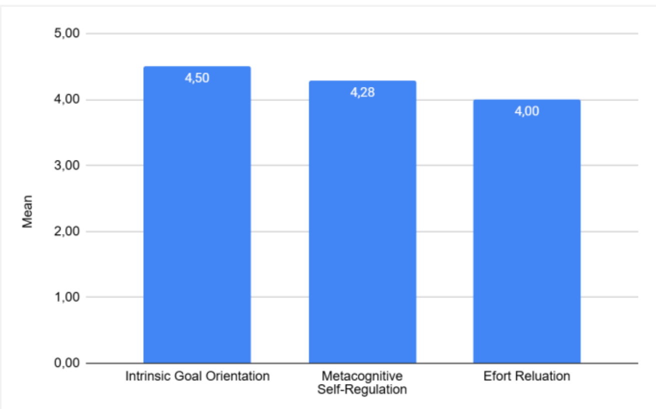

Figure 1. Diagram of student MSLQ result

This poses a problem in physics education: while students need motivation and the ability to evaluate their progress for deeper learning, teachers often struggle to provide opportunities for such self-evaluation. Therefore, innovation in formative assessment is needed that can motivate students and also promote their self-regulation abilities, which can drive students' conceptual change (Veugen et al., 2024). One promising innovation is to combine artificial intelligence (AI) and gamification to strengthen self-regulated learning.

Self-regulated learning (SRL) has been extensively researched as an effective learning strategy. SRL involves three main phases: planning, monitoring, and self-evaluation, which enable students to to set goals, track progress, and adjust their strategies (Zimmerman, 2002). This fosters responsibility and independence in learning. With SRL, students become more aware of their progress, enhancing intrinsic motivation (Sudiyono et al., 2021). They are more motivated to correct mistakes and understand complex concepts, especially in subjects like physics (Paz-Baruch & Hazema, 2023). Thus, SRL provides a strong foundation for designing interventions that improve student motivation and learning outcomes.

Artificial Intelligence (AI) has advanced rapidly in education, with applications such as personalized learning, learning analytics, and instant feedback (Rožman et al., 2023). AI can provide learning material recommendations tailored to individual needs, identify errors, and provide automated feedback. Combined with gamification, it motivates them to continue participating in the learning process (Kamalov et al., 2023). This is why AI offers strong potential for formative assessment that trains SRL. By integrating AI's adaptability with gamification's motivational features, formative assessments can provide feedback that helps students evaluate their progress and build SRL skills.

Building on this rationale, the present research is part of a broader project developing a formative assessment tool that combines AI and gamification, called GROVE_ALPHA (Gamified Reward-Based Online Formative Assessment for Learning Physics with Artificial Intelligence). GROVE_ALPHA consists of Google Spreadsheets and Google Forms incorporating a reward system to track progress and conduct formative assessments. The indicators were developed around Newton's Laws as specified in the independent curriculum for Phase F. What makes this study novel is its dual focus: using GROVE_ALPHA to both implement formative assessment and analyze its role in strengthening SRL. Therefore, this research aims to explore the relationship between student motivation and learning strategies after the GROVE_ALPHA implementation based on self-regulated learning, focusing on intrinsic and extrinsic goal orientation, critical thinking, metacognitive self-regulation, and effort regulation. Specifically, the study addressed three questions: (1) How does intrinsic goal orientation relate to critical thinking, metacognitive self-regulation, and effort regulation? (2) How does extrinsic goal orientation relate to these same variables? and (3) Which SRL strategies show the strongest relationship with student motivation after GROVE_ALPHA?

Method

This research employed a mixed-methods approach with a sequential explanatory design (Creswell & Plano Clark, 2018). The primary objective was to examine the correlations between students' goal orientations (intrinsic and extrinsic) and their learning strategies (critical thinking, metacognitive self-regulation, and effort regulation) after the implementation of GROVE_ALPHA. A total of twenty high school students participated in the study. Following the quantitative data analysis, eight students were selected for in-depth interviews to provide qualitative insights. The stages of the research procedure are illustrated in Figure 2.

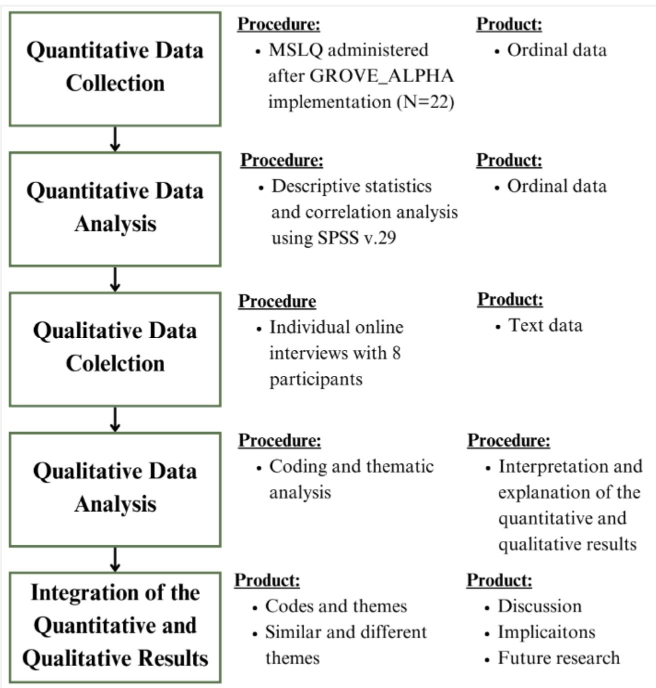

Figure 2. Research method chart based on mixed methods, sequential explanatory design

The instrument used to asses student motivation and learning strategies is the Motivated Strategies for Learning Questionnaire (MSLQ). This questionnaire contains 81 statements and is based on a 7-point Likert scale format ￼. The scale starts from point 1 or "Not at all true for me," to 7, or "Very true for me." The MSLQ has two parts: the motivation section and the learning strategy section. The motivation section includes 31 statements divided into six sub-sections: intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy to learn, performance, and anxiety during exams. The learning strategy section includes 50 statements across nine sub-sections: practice, elaboration, organization, critical thinking, metacognitive self-regulation, learning time and environment, effort regulation, peer learning, and seeking help. The instrument has been proven reliable based on various studies. When first introduced, its Cronbach's alpha values was 0.74 (Pintrich et al., 1991). Other research also show a very high reliability, with Cronbach's alpha values for each subscale ranging from 0.52 to 0.93, and showed significant subscale correlations (Cook et al., 2011). The questionnaire was translated and validated by language experts. In this study, we focus on the sub-sections of intrinsic and extrinsic goal orientation, critical thinking, metacognitive self-regulation, and effort regulation. The questionnaire was administered after the treatment, and its reliability was analyzed using SPSS, with Cronbach's alpha values for these five subscales reaching 0.91.s alpha values for the five subscales are 0.91.

The quantitative data analysis employed the Kendall rank correlation coefficient (tau) with SPSS 29 as the statistical tool. The research utilized this type of correlation due to the data had an ordinal scale and did not meet the normality assumptions for Pearson correlation. As stated in Uden et al. (2023), Kendall's tau correlation (τ), a non-parametric alternative to Pearson's correlation, assesses the strength of dependence or the degree of association between two categorical or ordinal variables. These methods are employed when the dataset violates the assumptions of the parametric Pearson correlation, such as non-normal data distributions or the presence of ordinal data. The interpretation of this correlation were using hypothesis for testing whether there is correlation (measure of strength of dependence or degree of association) between the two specified set of (categorical or ordinal) variables is; if the p-value of the test is less than or equal to 0.05 ($p \leq 0.05$), then we can assume that there is a statistically significant strong dependence or association between the two analyzed variables, and that this is not by chance (H1). Suppose the p-value is greater than 0.05 ($p > 0.05$). In that case, we can conclude that there is no significant dependency or association between the two variables, and any observed dependency or association could only occur by chance (H0) (Okoye & Hosseini, 2024).

The qualitative data analysis was taken from the interview questions that were carefully crafted to explore aspects aligned with the study's goals, including student engagement, autonomy, and the impact of AI-generated feedback in learning. These questions aimed to gather students' thoughts on how the system affected their motivation, responsibility, and independence in physics learning. The interview transcripts were analyzed using thematic analysis (Kushnir, 2025), which involved coding the data, identifying recurring patterns, and developing themes that captured students' shared experiences and perspectives. Analyzing their responses helps triangulate the data and offers a clearer understanding of how and why the GROVE_ALPHA system might promote more effective, student-centered learning over traditional assessment methods.

Result and Discussion

The results showing student motivation in learning physics after using GROVE_ALPHA reveal a generally moderate level. Intrinsic goal orientation had a mean of 5.19 ($SD = 1.03$), slightly higher than extrinsic goal orientation with a mean of 5.11 ($SD = 1.07$). The similar standard deviations indicate an even spread of both goal types among students. However, the slightly higher mean in intrinsic goal orientation suggests a stronger internal motivation to learn driven by personal interest and satisfaction. This pattern indicates that students were more motivated by internal factors than external rewards during their experience with GROVE_ALPHA.

To further understand how these motivational factors relate to learning strategies, a Kendall rank correlation was also conducted to examine the relationships between students' learning motivation (intrinsic and extrinsic goal orientation) and students' learning strategies (critical thinking, metacognitive self-regulation, and effort regulation). Table 1 provides a complete list of correlations, where CT signifies critical thinking, M indicates metacognitive self-regulation, and ER represents effort regulation. Intrinsic goal orientation showed significant positive correlations with all strategies, with the strongest correlation being with effort regulation ($\tau(20) = .63$, $p < .001$). Extrinsic goal orientation showed significant positive correlations with all strategies, with the strongest correlation being with critical thinking ($\tau(20) = .56$, $p < .001$).

Table 1. Correlations for MSLQ result (N=22)

	CT	M	ER
Intrinsic goal orientation	.59**	.56**	.63**
Extrinsic goal orientation	.56**	.52**	.49**

** Correlation is significant at the 0.01 level (2-tailed).

These results indicate that learning strategies are more strongly associated with intrinsic than extrinsic goal orientation, suggesting that internal motivation plays a more decisive role in shaping students' engagement with these strategies. This pattern aligns with previous research showing that mastery or intrinsic goals foster persistence, metacognitive monitoring, and willingness to engage in challenging tasks (Benita & Matos, 2021; Pintrich, 2000; Williams & Gill, 1995). Conversely, performance or extrinsic goals are often linked to attributions of success to ability or external factors, which may weaken students' sustained effort and depth of engagement (Hariri et al., 2021).

To further support the quantitative findings, follow-up interviews were conducted with eight students, focusing on engagement, AI feedback, responsibility, and independence in learning physics. The qualitative feedback revealed several emerging themes, providing richer insights into how GROVE_ALPHA shaped self-regulated learning.

Engagement and Intrinsic Motivation

Many students described the system as "not boring," "like a mini game," or "interactive." These comments indicate a high level of intrinsic motivation, driven by enjoyment and the novelty of the platform. Students reported repeated attempts to revise answers using AI feedback, even when facing challenges like technical issues or lengthy tasks, demonstrating sustained engagement and effort. This aligns with the quantitative finding that intrinsic goal orientation was strongly correlated with effort regulation ($\tau(20) = .63$, $p < .001$).

Metacognition and Critical Thinking

The system encouraged students to reflect on and assess their understanding. Several students noted that their explanations were sometimes incomplete or lacked justification, and the AI's suggestions helped them "structure their answers better" and "connect the concepts more clearly." These behaviors correspond with the quantitative finding of a positive correlation between extrinsic goal orientation and critical thinking ($\tau(20) = .56$, $p < .001$). By prompting students to evaluate their work and revise responses, GROVE_ALPHA supported the development of metacognitive and analytical skills.

Effort Regulation and Persistence

Students highlighted the opportunity to experiment and revise answers multiple times, stating that they could "try multiple times until it's right." This repeated effort reflects intrinsic motivation driving sustained learning and aligns with the observed correlations between intrinsic goals and effort regulation. The system's AI feedback provided timely guidance, helping students maintain focus and commitment to completing tasks effectively.

Responsibility and Extrinsic Motivation

Some students emphasized that having a clear structure, a "system to follow," and records of completed work increased their sense of responsibility. These features illustrate how extrinsic motivation can guide students toward meeting external expectations.

They also support thoughtful reasoning and structured learning. Immediate AI feedback enhanced students' performance, reflection, and self-regulated learning more effectively than traditional methods (Lee et al., 2025).

Across both quantitative and qualitative data, intrinsic motivation emerged as the dominant factor influencing learning strategies, including effort regulation, metacognitive control, and critical thinking. However, extrinsic motivators, such as structured tasks and outcome tracking, also contributed to students' reflective and analytical behaviors. GROVE_ALPHA therefore supports multiple dimensions of self-regulated learning, combining internal and external motivational pathways with cognitive strategies. The qualitative data provide concrete behavioral and emotional examples that corroborate the statistical correlations, demonstrating the system's potential to foster sustained engagement, self-monitoring, and personal ownership of learning.

Conclusion

This study examined how students' motivation to learn, including both intrinsic and extrinsic goal orientations, relates to their use of self-regulated learning strategies such as critical thinking, metacognitive self-regulation, and effort regulation after implementing GROVE_ALPHA. Findings indicate that intrinsic goal orientation shows a stronger and more consistent positive connection with all three strategies compared to extrinsic orientation. Notably, intrinsic motivation is most strongly linked to effort regulation ($\tau(20)= .63$, $p < .001$), suggesting that intrinsically motivated students are more likely to persevere through academic challenges. Additionally, intrinsic motivation also correlates positively with critical thinking ($\tau(20)= .59$, $p < .001$) and metacognitive self-regulation ($\tau(20)= .56$, $p < .001$), reinforcing existing research that links intrinsic goals to deeper engagement and more effective self-regulated learning behaviors. In contrast, extrinsic goal orientation showed weaker links to the same learning strategies, with its highest link found in critical thinking ($\tau(20)= .56$, $p < .001$), though still relatively modest. This indicates that students driven by extrinsic motivations might use surface-level strategies more often, but they are less likely to employ metacognitive ($\tau(20)= .52$, $p < .001$) or effortful approaches ($\tau(20)= .49$, $p < .001$) regularly. Among the three learning strategies studied, effort regulation showed the strongest link with students' intrinsic motivation, underscoring its key role in maintaining engagement and persistent learning. These findings highlight the importance of cultivating intrinsic motivation to improve students' ability for self-regulated learning. The GROVE_ALPHA tool—a gamified, AI-supported formative assessment platform—appears to facilitate this by motivating students to engage more thoroughly with their learning processes.

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Author Contributions
Conceptualization, V. V., I. R. S, and E. S.; methodology, V. V. and I. R. S.; validation, I. R. S and E. S.; formal analysis, V. V.; investigation, V. V.; resources, I. R. S and E. S.; data curation, V. V.: writing—original draft preparation, V. V.; writing—review and editing, V. V., I. R. S, and E. S. All authors have read and agreed to the published version of the manuscript.

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Conflict of Interest
The authors declare no conflict of interest.

References

Benita, M., & Matos, L. (2021). Internalization of Mastery Goals: The Differential Effect of Teachers' Autonomy Support and Control. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.599303

Cook, D. A., Thompson, W. G., & Thomas, K. G. (2011). The Motivated Strategies for Learning Questionnaire: Score validity among medicine residents: Score validity of the MSLQ. *Medical Education*, *45*(12), 1230–1240. https://doi.org/10.1111/j.1365-2923.2011.04077.x

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research*. SAGE.

Fuller, J. S., & Dawson, K. M. (2017). Student Response Systems for Formative Assessment: Literature-based Strategies and Findings from a Middle School Implementation. *Contemporary Educational Technology*, *8*(4). https://doi.org/10.30935/cedtech/6206

Hariri, H., Karwan, D. H., Haenilah, E. Y., Rini, R., & Suparman, U. (2021). Motivation and Learning Strategies: Student Motivation Affects Student Learning Strategies. *European Journal of Educational Research*, *10*(1), 39–49. https://doi.org/10.12973/eu-jer.10.1.39

Huda, S., Hartono, & Masturi. (2020). The development of authentic scientific inquiry assessment to measure the laboratory skills. *Journal of Physics: Conference Series*, *1567*(2), 022071.

https://doi.org/10.1088/1742-6596/1567/2/022071
Kamalov, F., Santandreu Calonge, D., & Gurrib, I. (2023). New Era of Artificial Intelligence in Education: Towards a Sustainable Multifaceted Revolution. *Sustainability*, *15*(16), 12451. https://doi.org/10.3390/su151612451
Kusairi, S. (2020). A web-based formative feedback system using isomorphic items to support Physics learning. *Journal of Technology and Science Education*, *10*(1), 117. https://doi.org/10.3926/jotse.781
Kushnir, I. (2025). Thematic analysis in the area of education: A practical guide. *Cogent Education*, *12*(1), 2471645. https://doi.org/10.1080/2331186X.2025.2471645
Kwarikunda, D., Schiefele, U., Ssenyonga, J., & Muwonge, C. M. (2021). Secondary School Students' Motivation Profiles for Physics Learning: Relations with Cognitive Learning Strategies, Gender, Attitudes and Individual Interest. *African Journal of Research in Mathematics, Science and Technology Education*, *25*(2), 197–210. https://doi.org/10.1080/18117295.2021.1956720
Lee, Y.-F., Hwang, G.-J., & Chen, P.-Y. (2025). Technology-based interactive guidance to promote learning performance and self-regulation: A chatbot-assisted self-regulated learning approach. *Educational Technology Research and Development*. https://doi.org/10.1007/s11423-025-10478-x
Li, Y., & Singh, C. (2023). Impact of perceived recognition by physics instructors on women's self-efficacy and interest. *Physical Review Physics Education Research*, *19*(2). https://doi.org/10.1103/physrevphyseducres.19.020125
Mitchell-Polka, K., Lindsay, W. E., Martins, J. S., & Otero, V. K. (2020). The physics classroom as a space for empowerment. *Physics Education Research Conference Proceedings*, 340–345. https://doi.org/10.1119/perc.2020.pr.mitchell-polka
Nadhifah, I. N., Adila, A. S. D., & Lestari, A. (2023). Description of Comprehension, Perceptions, and Challenges of Science Teachers' Formative Assessment Practice in Wonosobo. *PENDIPA Journal of Science Education*, *7*(1), 14–23. https://doi.org/10.33369/pendipa.7.1.14-23
Okoye, K., & Hosseini, S. (2024). *R Programming: Statistical Data Analysis in Research*. Springer Nature Singapore. https://doi.org/10.1007/978-981-97-3385-9
Paz-Baruch, N., & Hazema, H. (2023). Self-Regulated Learning and Motivation Among Gifted and High-Achieving Students in Science, Technology, Engineering, and Mathematics Disciplines: Examining Differences Between Students From Diverse Socioeconomic Levels. *Journal for the Education of the Gifted*, *46*(1), 34–76. https://doi.org/10.1177/01623532221143825
Pintrich, P. R. (2000). The Role of Goal Orientation in Self-Regulated Learning. In *Handbook of Self-Regulation* (pp. 451–502). Elsevier. https://doi.org/10.1016/b978-012109890-2/50043-3
Pintrich, P. R., David A. F. Smith, Teresa Garcia, & Wilbert J. McKeachie. (1991). *A Manual for the Use of the Motivated Strategies for Learning Questionnaire (MSLQ)* (91-8-004 NCRIPTAL-91-B-004). National Center for Research to Improve Postsecondary Teaching and Learning, Ann Arbor, MI. Retrieved from https://files.eric.ed.gov/fulltext/ED338122.pdf
Rojas, S. (2009). *On the teaching and learning of physics: A Criticism and a Systemic Approach* (arXiv:0902.1151). arXiv. https://doi.org/10.48550/arXiv.0902.1151
Rožman, M., Tominc, P., & Vrečko, I. (2023). Building skills for the future of work: Students' perspectives on emerging jobs in the Data and AI Cluster through artificial intelligence in education. *Environment and Social Psychology*, *8*(2). https://doi.org/10.54517/esp.v8i2.1670
Sudiyono, Kurniawati, M., & Nugraha, D. A. (2021). The Role Self-Regulated Learning on Project-Based Learning to Natural Science Learning Outcome. In *5th Asian Education Symposium 2020 (AES 2020)* (pp. 263-269). Atlantis Press. https://doi.org/10.2991/assehr.k.210715.056
Uden, L., & Liberona, D. (2023). *Learning Technology for Education Challenges: 11th International Workshop, LTEC 2023, Bangkok, Thailand, July 24–27, 2023, Proceedings*. Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-34754-2
Veugen, M. J., Gulikers, J. T. M., & den Brok, P. (2024). Secondary School Teachers' Use of Formative Assessment Practice to Create Co-regulated Learning. *Journal of Formative Design in Learning*, *8*(1), 15–32. https://doi.org/10.1007/s41686-024-00089-9
Williams, L., & Gill, D. L. (1995). The Role of Perceived Competence in the Motivation of Physical Activity. *Journal of Sport and Exercise Psychology*, *17*(4), 363–378. https://doi.org/10.1123/jsep.17.4.363
Zimmerman, B. J. (2002). Becoming a Self-Regulated Learner: An Overview. *Theory Into Practice*, *41*(2), 64–70. https://doi.org/10.1207/s15430421tip4102_2