MaPan : Jurnal Matematika dan Pembelajaran
p-ISSN: 2354-6883 ; e-ISSN: 2581-172X
Volume 13, No 2, Dec 2025 (405-428)
DOI: https://doi.org/10.24252/mapan.2025v13n2a9

Analysis of Student Progress in Mathematics Learning at Vocational High Schools to Support the Strengthening of SDGs'

Wikan Budi Utami[1*], Trija Fayeldi[2], Benjamin Laurentino Vaz[3]
[1,2]Universitas PGRI Kanjuruhan Malang
[3]Instituto Superior Cristal, Timor Leste
[1,2]Jl. S. Supriadi No.48, Bandungrejosari, Malang, East Java, Indonesia
[3]Rua, Estrada de Balide, Dili, Timor Leste
Correspondence Email: wikanbudiutami@unikama.ac.id

Received October 23, 2025; Revised December 23, 2025; Accepted December 23, 2025
Available Online December 30, 2025

Abstract:
Student development is a multidimensional cornerstone of vocational education that determines learning effectiveness, yet it is often analyzed through a purely cognitive lens. This study aims to analyze the multidimensional development of students encompassing physical-psychomotor, cognitive, and emotional dimensions and identify the factors influencing their success and difficulties in mathematics learning. Using a descriptive qualitative approach under an interpretivist paradigm, the research focused on three eleventh-grade students at a private Vocational High School (SMK) in Malang, selected through purposive sampling. Data were collected over four weeks through direct observation, semi structured interviews, and diagnostic questionnaires, followed by thematic content analysis using the Miles and Huberman model. The results reveal three distinct developmental profiles, namely subject P1 demonstrates high emotional resilience and stable motor coordination, which facilitates independent problem-solving; subject P2 exhibits significant academic anxiety and motor hesitation, leading to a dependency on concrete scaffolding; and subject P3 shows systematic reasoning supported by strong visual-motor strategies. The study identifies intrinsic motivation and tool proficiency as key supporting factors, while evaluation anxiety and abstract-conceptual gaps act as primary inhibitors. These findings provide a holistic profile of vocational students and offer strategic recommendations for teachers to design inclusive, kinesthetic-based learning. This research directly supports the strengthening of SDG 4 (Quality Education), SDG 3 (Good Health and Well-Being), and SDG 10 (Reduced Inequalities) by advocating for a more humane and adaptive mathematics education framework.

Abstrak:
Perkembangan siswa merupakan landasan multidimensi dalam pendidikan vokasi yang menentukan efektivitas pembelajaran, namun seringkali hanya dianalisis melalui lensa kognitif semata. Penelitian ini bertujuan untuk menganalisis perkembangan multidimensi siswa yang mencakup dimensi fisik psikomotorik, kognitif, dan emosional serta mengidentifikasi faktor-faktor yang memengaruhi keberhasilan dan kesulitan mereka dalam pembelajaran matematika. Menggunakan pendekatan kualitatif deskriptif di bawah paradigma interpretivisme, penelitian ini

berfokus pada tiga siswa kelas sebelas di sebuah Sekolah Menengah Kejuruan (SMK) swasta di Malang, yang dipilih melalui purposive sampling. Data dikumpulkan selama empat minggu melalui observasi langsung, wawancara semi-terstruktur, dan kuesioner diagnostik, yang dilanjutkan dengan analisis isi tematik menggunakan model Miles dan Huberman. Hasil penelitian mengungkapkan tiga profil perkembangan yang berbeda: (1) Subjek P1 menunjukkan resiliensi emosional yang tinggi dan koordinasi motorik yang stabil, yang memfasilitasi pemecahan masalah secara mandiri; (2) Subjek P2 menunjukkan kecemasan akademik dan keraguan motorik yang signifikan, sehingga menyebabkan ketergantungan pada perancah (scaffolding) konkret; dan (3) Subjek P3 menunjukkan penalaran sistematis yang didukung oleh strategi visual-motorik yang kuat. Penelitian ini mengidentifikasi motivasi intrinsik dan kemahiran penggunaan alat bantu sebagai faktor pendukung utama, sementara kecemasan terhadap evaluasi dan kesenjangan konsep abstrak bertindak sebagai penghambat utama. Temuan ini menyajikan profil holistik siswa vokasi dan menawarkan rekomendasi strategis bagi guru untuk merancang pembelajaran berbasis kinestetik yang inklusif. Penelitian ini secara langsung mendukung penguatan SDG 4 (Pendidikan Berkualitas), SDG 3 (Kehidupan Sehat dan Sejahtera), dan SDG 10 (Berkurangnya Kesenjangan) dengan mengadvokasi kerangka kerja pendidikan matematika yang lebih manusiawi dan adaptif.

Keywords:
Student Development, Mathematics Learning, Vocational High School, Multidimensional Analysis, SDGs

How to Cite: Utama, W. B., Fayeldi, T. & Vaz, B. L. (2025). Analysis of Student Progress in Mathematics Learning at Vocational High Schools to Support the Strengthening of SDGs'. *MaPan: Jurnal Matematika dan Pembelajaran*, 13(2), 405-428. https://doi.org/10.24252/mapan.2025v13n2a9.

INTRODUCTION

Students' development is a multifaceted cornerstone of education thatdetermines learning effectiveness, particularly in vocational mathematics, where cognitive, psychomotor, and emotional dimensions must converge. In the context of Sustainable Development Goal (SDG) 4 (Quality Education) and SDG 3 (Good Health and Well Being), mathematics education in Vocational High Schools faces unique challenges; it requires not only computational logic but also the physical precision and emotional resilience necessary for industrial readiness. While previous literature has linked fine motor skills to academic success (Cameron, Cottone, Murrah, & Grissmer, 2016; Gonzalez-DeHass, 2019; Joo, Park, & Kim, 2021; Ravselj, Kerzic, Tomazevic, Umek, Brezovar, Iahad, & Aristovnik, 2025), these dimensions are often treated in isolation. In vocational settings, the neglect of non-cognitive aspects hinders the development of a workforce that is both technically skilled and mentally resilient, thus slowing the achievement of inclusive and equitable education as targeted by SDG 10 (Reduced Inequalities).

Despite its importance, a significant research gap exists in integrating these developmental dimensions within the vocational sector. Current studies often focus strictly on cognitive outcomes, failing to provide a holistic profile of the vocational student. For instance, while Hsu (2021) explored linguistic barriers, Planas, Morgan, and Schutte (2018); Prediger and Meyer (2017) analyzed the transition of mathematical concepts; their focus remained compartmentalized. They documented what students struggle with linguistically or conceptually, but overlooked how the emotional anxiety of psychomotor instability, common in vocational practical task directly disrupts mathematical conceptualization. Furthermore, research remains dominated by quantitative surveys (Ravselj, Kerzic, Tomazevic, Umek, Brezovar, Iahad, & Aristovnik, 2025), which identify trends but leave the deep, subjective experiences of students unexplored. A preliminary study conducted by the researcher in January 2025 at a private Vocational High Schools in Malang revealed that 65% of students reported moderate to high anxiety during math exams, and 40% struggled to articulate logical reasoning despite showing adequate social skills. This paradox suggests that while social-moral development is positive, individual cognitive-emotional barriers remain a primary obstacle to achieving "Quality Education."

This study addresses these gaps by offering a multidimensional analysis of student development in Vocational High Schools mathematics learning through a descriptive qualitative lens. The novelty of this research lies in its integrative framework that moves beyond the fragmented analysis found in the work of. This study aims to analyze the multidimensional development of students encompassing physical psychomotor, cognitive, and emotional dimensions and identify the factors influencing their success and difficulties in mathematics learning.

METHODS

This study employs a descriptive qualitative approach under the interpretivist paradigm. This design was selected to explore the subjective meanings and developmental dynamics experienced by students in their natural classroom environment (Creswell & Poth, 2018).

The research focused on three eleventh grade students selected via purposive sampling. The subjects were chosen based on specific criteria to ensure a representative variety of developmental profiles: (1) academic performance (representing high, middle, and low mathematics achievement), (2) classroom engagement levels, and (3) teacher recommendations. To ensure ethical standards, written informed consent was obtained from all participants and the school administration, ensuring confidentiality and anonymity through the use of pseudonyms (P1, P2, and P3).

The research instruments were developed based on the developmental theories of Agarwal (2017); Anista and Marsigit (2020); Hadipranoto, Satyadi, and Rostiana (2020); Yayuk, Purwanto, As'Ari, and Subanji (2020) and underwent content validation by two expert lecturers. The validation focused on readability and contextual relevance, yielding an average score of 94% (Highly Valid). Data were collected from May 4 to June 18, 2025, using three primary techniques: (a) Direct Observation: conducted four times for each subject (90 minutes per session) to record behavioral patterns and engagement levels. (b) Semi Structured Interviews: conducted in two 45 minute sessions per subject to explore their thinking processes. (c) Diagnostic Questionnaires: administered once to provide a quantitative baseline.

Data analysis followed the Interactive Model by Miles and Huberman (2014); Pambudi, Budayasa, and Lukito (2020); Russell, Baik, Ryan, and Molloy (2022), consisting of three concurrent flows of activity: consisting of three concurrent flows: (a) Data Condensation: raw data were simplified and categorized using thematic coding into three primary themes: physical-psychomotor development, cognitive development, and emotional development. (b) Data Display: coded data were organized into descriptive matrices to visualize patterns across subjects and their alignment with the SDGs. (c) Conclusion Drawing and Verification: the triangulation process was executed by cross referencing statistical trends from questionnaires with narrative interview findings and factual classroom behaviors. For instance, a student's self reported confidence (questionnaire) was verified against their actual performance during whiteboard exercises (observation).

RESULTS AND DISCUSSION

The multidimensional development of students in mathematics learning includes not only conceptual understanding but also the ability to face challenges, communicate effectively, collaborate, and uphold the value of honesty, all of which reflect the interconnection and integration of various developmental dimensions. Observations of three students revealed differences and diversity in three main dimensions: physical psychomotor, cognitive, and emotional. These findings provide a holistic picture of how mathematics learning plays a role in strengthening students' developmental aspects to support the achievement of the SDGs.

1. Analysis of Physical-Psychomotor Development

The dimension of physical-psychomotor development was analyzed by triangulating data from diagnostic questionnaires, direct observation, and semi-structured interviews. The dimension focuses on students' motor coordination, proficiency in using mathematical tools, and their physical and emotional response to classroom tasks in table 1.

Table 1. Physical-Psychomotor Development Instruments

No.	Questions
1.	How do you feel when asked to write answers in front of the class?
2.	Do you find it difficult to use assistive tools such as rulers or calculators?
3.	What do you do when drawing graphs in your notebook or on the whiteboard?

Quantitative Baseline to provide a quantitative foundation. Table 1 presents the summary of student responses from the diagnostic questionnaires, with scores based on a 4 point Likert scale. Detailed Interview and Observation Result. The following section provides a detailed analysis of each subject, correlating observational findings with specific interview evidence.

Subject P1: High Confidence and Motor Stability

P1 demonstrates excellent motor coordination. Observational data showed P1 being active, quick, and responsive during physical tasks, such as drawing graphs on the whiteboard. The proof of this claim is corroborated by the following interview episode:

> *"I do not mind being asked to come forward; in fact, I can identify where the mistakes are. Drawing graphs is fun as long as the lines are straight and I use a ruler to keep them neat."* (Interview transcript, P1-Q3)

Triangulasi shows that P1's high "Visual Motor Comfort" score in the questionnaire (4.0) is consistent with their actual classroom performance. P1 appears to have stable visual motor skills and strong physical endurance, even during the afternoon session.

Subject P2: Axienty Related Psycomotor Hesitation

P2 tends to hesitate and showsmuscle tension when performing in front of the class. This observation is reflected in P2's lower questionnaire score in "Tool Proficiency" and "Visual Motor Comfort" (2.0). The interview result provides direct evidence of this psychomotor barrier:

> *"I am afraid of making mistakes, so if I am not sure, it is better to wait. My heart pounds, and I break out in a cold sweat when asked to come forward, especially if friends are watching*." (Interview transcript, P2-Q1).

Consequently, P2 required more verbal scaffolding and time compared to peers, confirming that emotional factors significantly impact their physical psychomotor output.

Subject P3: Methodical and Independent Precision

P3 displays consistent and meticulous psychomotor skills. Observations show that P3 is not only fast but also precise in using mathematical tools. The questionnaire result showed a perfect score in "Tool Proficiency" (4.0). The following interview response validates P3's cognitive motor synergy:

> *"I am used to using assistive tools. Drawing a graph is easy as long as the scale accuracy is ensured. I like math materials that have pictures because I can visualize the problems and solutions."* (Interview transcript, P3-Q3).

The triangulation of data for P3 indicates that their well-developed skills are supported by a strong ability to visualize abstract problems into physical representations.

These findings show that students' physical-psychomotor development varies from stable skills and confidence to anxiety and dependence, which aligns with previous studies confirming the correlation between fine motor skills and mathematics academic achievement (Gabriel, Buckley, & Barthakur, 2020; Luo, Jose, Huntsinger, & Pigott 2007; Ramirez, Chang, Maloney, Levine, & Beilock 2016).

Based on the perspective of embodied cognition theory (Barsalou, 2008)Physical activities such as drawing graphs are not just simple motor tasks but an important component in strengthening cognitive processes and understanding mathematical concepts. This theory explains that cognition does not only occur abstractly within the brain, but is related to the body's sensorimotor experiences and direct interaction with the environment. (Barsalou, 2008). In other words, the mental representations of mathematical concepts are formed and enriched through sensorimotor simulations that arise when students are physically active in learning activities.

Barsalou (2008) states that simulation is part of the perceptual symbol system, where sensory experiences and bodily actions play a role in the formation of knowledge. In the context of mathematics learning, when students draw graphs, their brains do not merely process numerical data but also perform visual and motor simulations that contribute to a deeper and more integrative understanding of the concepts being studied.

Furthermore, this embodied cognition approach supports kinesthetic learning, which involves physical activities as a medium to internalize and construct knowledge. This approach is especially beneficial for abstract mathematical concepts that require visual-spatial representation and physical manipulation of objects for easier understanding (Barsalou 2008; Pearce & Miller 2025). Therefore, integrating graph-drawing activities in mathematics learning is not merely an enhancement of motor skills but also an effective strategy to improve students' cognitive understanding.

The physical psychomotor dimension is not merely a technical aspect but an important gateway in creating quality and sustainable education. The relevance of the findings to SDG 3 (Good Health and Well Being) and SDG 4 (Quality Education) is very clear, where good physical and psychomotor conditions support overall well being and facilitate active participation in mathematics learning. Conversely, the motor anxiety experienced by some students underscores the need for a safe and inclusive learning environment. In order to achieve SDG 4, these results highlight the importance of inclusive and adaptive education that considers the diversity of students' motor abilities. Teachers are expected to design kinesthetic learning strategies and effectively use assistive tools so that mathematics learning becomes more participatory and meaningful.

2. Analysis of Cognitive Development

The cognitive dimension assessment focuses on students' ability to understand mathematical concepts, apply logical reasoning, and connect multiple representations (symbols, graphs, and words). This selection presents the triangulation of questionnaire score, classroom observations, and interview reflections. The interview instrument is presented in table 2, which is designed to explore students' thinking processes, problem solving strategies, and reflections on their understanding.

Table 2. Cognitive Development Instrument

	Students' Activities
1.	How do you understand a math problem that you encounter for the first time?
2.	What do you do if you do not immediately find the answer?
3.	In your opinion, what is the hardest part of mathematics? How do you overcome the difficulty?

The baseline cognitive standing of the subjects was measured through a diagnostic questionnaire covering four indicators: conceptual understanding, problem-solving persistence, logical reasoning, and representational skills. Scores are based on a 4 point Likert Scale.

Subject P1: Independent strategy and speed

P1 demonstrates a solid ability to understand teacher instruction quickly and formulate independent strategies. Observations show that P1 can connect current problems with previous exercises. This cognitive independence is confirmed by P1's statement during the interview:

> *"For new questions, I usually read them repeatedly and try the method I have used before. If I still can't, I ask the teacher."* (Interview transcript, P1-C1).

Although P1 is persistent, triangulation suggests that P1 occasionally rushes through procedures, as reflected in the moderate "Logical Reasoning" score (3.0).

Subject P2: Concrete Dependent Understanding

P2 struggles with abstract mathematical problems and frequently pauses due to self-doubt. Data triangulation indicates that P2 relies heavily on concrete examples. The interview result provides direct proof of P2's cognitive hesitation:

> *"If the problem is difficult, I get confused first. I usually look at examples in the book, then try slowly. If I am still wrong, I wait for the teacher's explanation."* (Interview Transcript, P2-C2)

This aligns with P2's low questionnaire score (2.0) across all cognitive indicators, showing a need for significant scaffolding and concrete modeling.

Subject P3: Systematic Reasoning and Visualization

P3 stands out with highly systematic reasoning. Observations confirm that P3 is independent in developing strategies and meticulous in reviewing answers. The following interview response validates P3's advanced cognitive spatial strategy:

> *"I like to find another way if there is a difficult problem. Sometimes when I'm stuck, I try to make a drawing or graphs to make it clearer."* (Interview Transcript, P3-C3)

P3's perfect questionnaire score (4.0) is consistent with this ability to use visualization as a tool for logical reasoning. The cognitive dimension includes the ability to understand concepts, solve problems, make logical reasoning, and connect mathematical representations in the form of symbols, graphs, and words (Hutauruk & Priatna, 2017; Jader, Lithner, & Sidenvall, 2020; Lester & Cai 2016; Mania & Alam, 2021; Santos-Trigo, 2014; Schoenfeld, 2016; Scott, 2012). The interview instrument is focused on understanding how students think, formulate strategies, and reflect on their understanding (Ilhan, 2021; Martin, Mcbride, Masterman, Pote, Mokhtar, Oprea, & Sorgenfrei, 2020; Meaney, Severina, Gustavsen, Hoven, & Larsen, 2024; Ozturk, Akkan, & Kaplan, 2020).

Research results show variation in how students understand mathematical concepts, formulate problem solving strategies, and reflect on their learning outcomes. P1 demonstrates fairly good cognitive ability, with a tendency to actively try independent problem-solving strategies before asking for teacher assistance. He reads the problem repeatedly and relates it to previous practice experiences. These findings align with the view that rereading, activating working memory, and using metacognitive strategies can improve the effectiveness of mathematical understanding. (Jader, Lithner, & Sidenvall 2020; McLeod & Schoenfeld, 1987; Santos-Trigo 2014; Schoenfeld 2016). However, P1 sometimes appears rushed in writing procedures; thus, there is a potential for small errors even though the conceptual understanding has been formed.

P2 appears to be slower in understanding abstract problems. He tends to stop in the middle of the solving process because he doubts the steps taken. However, with the help of concrete examples or visual representations, P2 finds it easier to understand the concepts. This condition emphasizes the importance of teacher scaffolding in guiding the student's zone of proximal development so that problem-solving skills can develop gradually (Hadipranoto, Satyadi, & Rostiana, 2020; Yayuk, Purwanto, As'Ari, & Subanji, 2020). This tendency shows that learning style and confidence level significantly influence cognitive performance in solving math problems (Hsiao, Lin, Chen, & Peng, 2018; Ozturk, Akkan, & Kaplan, 2020).

Unlike the other two, P3 shows a more systematic reasoning pattern. He is accustomed to rechecking his answers, searching for patterns, and using alternative representations such as drawings or graphs to clarify problems. This strategy demonstrates reflective thinking skills as well as creativity in utilizing various mathematical representations, which aligns with the demands of global mathematical literacy (She, Stacey, & Schmidt 2018; Stacey & Turner, 2015). Observations support that P3 is relatively independent in developing his cognitive strategies, although he remains open to discussions with peers or teachers.

These findings align with various studies stating that cognitive development is influenced by both internal and external factors. Internal factors include thinking styles, perseverance, and self-regulation abilities that help students manage the learning process and solve math problems effectively (Hadipranoto, Satyadi, & Rostiana, 2020; Yayuk, Purwanto, As'Ari, & Subanji, 2020). Additionally, learning motivation, confidence, and the use of metacognitive strategies also play a significant role in students' cognitive achievement (Morin, Watson, Hester, & Raver, 2017; Novriani & Surya 2017; Setiawan, Degeng, Sa'dijah, & Praherdhiono, 2020).

This internal factor also includes psychological aspects such as self-perception, learning interest, and verbal-spatial intelligence, which directly influence students' ability to understand mathematical concepts. Research shows that systems with high motivation and strong self-confidence tend to be more persistent and effective in overcoming difficulties in learning mathematics (Irhamna, Amry, & Syahputra, 2020; Liu, Ma, & Chen, 2024; Fernando, Andriani, & Syam 2024; Yunus 2021). Good self-regulation abilities enable students to manage learning strategies and handle stress related to academic challenges.

Meanwhile, external factors such as the learning environment at school and home also have a significant impact. Teacher support through adaptive scaffolding methods, individual guidance, and a positive social environment, including interactions with peers and family, strengthens students' cognitive development in mathematics (Gabriel, Buckley, & Barthakur, 2020; Hsu 2021; Hsu, Yeh, & Wu, 2015; Ilhan 2021; Martin, Mcbride, Masterman, Pote, Mokhtar, Oprea, & Sorgenfrei, 2020; Meaney, Severina, Gustavsen, Hoven, & Larsen, 2024; Ozturk, Akkan, & Kaplan 2020). Additionally, the availability of learning facilities, the use of educational technology, and interactive teaching methods also enhance interest and mastery of concepts (Ally, 2019; Esposito, Tonizzi, Usai, & Giofre, 2025; Korhonen, Mattsson, Inkinen, & Toom 2019; Santos-Trigo, 2014).

Imbalances or deficiencies in factors such as motivation, low support from the learning environment, or high academic stress can hinder cognitive development and trigger learning anxiety, which negatively impacts mathematics performance. (Ashcraft, 2019; Setiawan, Degeng, Sa’dijah, & Praherdhiono). Therefore, understanding the complex interaction of these internal and external factors is very important for designing effective and inclusive learning interventions.

From the perspective of SDG 4 (Quality Education), these research results affirm that effective education does not solely rely on procedural memorization and mechanical mastery of content. Quality education prioritizes the development of critical thinking skills, problem-solving, and mathematical creativity so that graduates are capable of facing complex and dynamic challenges in the real world. (Ally 2019; Khargonekar & Samad 2024; Nordin, Kaida, Othman, Akhir, & Hara 2020; Saha, Hasan, Islam, & Priom, 2024). SDG 4 also demands inclusive and equitable education, providing equal learning opportunities for all individuals without discrimination, and promotes lifelong learning as part of sustainable human resource development.

Teachers' efforts in providing adaptive and differential scaffolding are key to reducing learning achievement gaps among students. Learning strategies that consider differences in students' learning styles and speeds allow the delivery of material tailored to individual needs, which in turn increases student engagement and learning effectiveness (Ernst, Pan, & Carlson, 2024; Gabriel, Buckley, & Barthakur, 2020; Hsu, Yeh, & Wu, 2015; Ilhan, 2021; Meaney, Severina, Gustavsen, Hoven, & Larsen, 2024; Overmyer & Carlson, 2019). The integration of this approach aligns with the goal of SDG 10 (Reduced Inequalities), which is to reduce social and educational disparities by providing fair access and resources to all students, especially those from vulnerable or disadvantaged backgrounds.

Furthermore, to achieve the targets of SDG 4, which include improving literacy and numeracy skills, ensuring inclusive quality education access, and enhancing teacher qualifications (Khargonekar & Samad, 2024; Pawar, 2025), success heavily depends on innovations in teaching methods and assessments that are responsive to the diverse learning needs of students. Education that prioritizes differentiation and personalized learning, supported by technology or active learning methods, has been proven to significantly improve mathematics learning outcomes while also supporting students' psychological well-being (Esposito, Tonizzi, Usai, & Giofre, 2025; Setiawan, Degeng, Sa'dijah, & Praherdhiono, 2020; Zhang, Jackson, Hunt, Carter, Yang, & Emerling, 2022). Therefore, this cognitive aspect can serve as practical and theoretical recommendations for striving toward quality, equitable, and inclusive mathematics education in line with the SDGs' aspirations, providing a framework for teachers, education managers, and policymakers in formulating effective and sustainable learning strategies.

3. Analysis of Emotional Development

The emotional dimension focuses on students' ability to manage feelings, respond to learning challenges, maintain calmness, and build self-confidence. This section presents the triangulation of questionnaire data, classroom observations, and interview responses. The interview instrument in this study is focused on how students express their feelings when facing difficult problems or performing in front of the class, as presented in table 3.

Table 3. Emotional Development Instrument

No.	Students' Activities
1.	What do you feel when asked to come to the front of the class to answer a question?
2.	How do you feel when you can answer a math problem correctly?
3.	What makes you feel confident or nervous in learning mathematics?

Quantitative baseline emotional dimension; to address the requirement for detailed analysis results, table 3 presents the quantitative findings from the diagnostic questionnaires. The scores reflect students' self-assessment of their emotional regulation. Scores are based on a 4 point Likert Scale.

Table 4. Summary of Questionnaire Result

Subject	Anxienty Management	Self Confidence	Emotional Resilience	Average Score	Category
P1	4.0	4.0	4.0	4.0	Very Good
P2	1.0	2.0	2.0	1.67	Poor
P3	3.0	3.0	4.0	3.33	Good

Qualitative result and data triangulation; The following section provides the detailed interview and observation results to provide proof for the emotional variability among subjects.

Subject P1: High Emotional Resilience

P1 demonstrates stable emotional regulation and high intrinsic motivation. Observational data showed P1 remaining calm even when facing difficult problems. The interview result provides direct proof of P1's resilience:

> *"When I come forward, I feel normal; I can even see where my mistakes are. If I'm wrong, I just try again."* (Interview Transcript, P1-E1)

Triangulation confirms that P1's perfect questionnaire score (4.0) aligns with their ability to view mistakes as a constructive part of the learning process.

Subject P2: Academic Anxiety and Avoidance

P2 shows high vulnerability to academic anxiety. The questionnaire's result in Table 6 shows the lowest score in "Anxiety Management" (1.0). Observation recorded avoidance behaviors, such as looking down and avoiding eye contact. This is supported by P2's interview statement:

> *"I'm afraid of making mistakes; my heart races when I come forward. I'd rather wait for someone else first."* (Interview Transcript, P2-E1).

The triangulation of data indicates that P2's weak self-confidence hinders active participation.

Subject P3: Adaptive Emotional Regulation

P3 exhibits adaptive emotional regulation. While occasionally experiencing nervousness, P3 remains focused on the solution. The interview response validates P3's reflective attitude:

> *"I do get nervous sometimes, but I prefer to try first. If I'm wrong, it can be fixed."* (Interview Transcript, P3-E3).

Observation supports this, showing P3 as a student who chooses to look book for solutions rather than giving up when an answer is incorrect. These findings align with the developmental theory of Agarwal (2017); Hadipranoto, Satyadi, and Rostiana (2020); Yayuk, Purwanto, As'Ari, and Subanji (2020), which emphasizes this phase as a crucial period for developing emotional regulation, courage to face challenges, and learning motivation, which directly affect academic confidence. During this period, adolescents undergo complex biological, cognitive, and socio-emotional changes. Emotions in adolescents are often more dominant and unstable, requiring effective regulation mechanisms so they can manage stress and learning pressure well (Santrock, 2008).

According to Anista and Marsigit (2020) emotional regulation includes adolescents' ability to recognize, understand, and control their emotions in social and academic situations. This ability develops progressively and is a key determinant in personality formation, mature decision-making, and healthy intrapersonal relationships. Hadipranoto, Satyadi, and Rostiana (2020); Yayuk, Purwanto, As'Ari, and Subanji (2020) add that mature emotional regulation helps adolescents face failure, reduce anxiety levels, and increase intrinsic motivation to learn all factors that contribute to better academic outcomes.

The significant differences in emotional regulation abilities among students shown in this study indicate that mathematics learning should pay attention not only to cognitive aspects but also to affective character and students' mental health conditions. This suggests that mathematics learning is not only a medium for cognitive development but also for affective character formation and mental health, which play important roles in the sustainability of the learning process. (Baltrusaitis, Bakshi, Chojnacka, Chuck, Coppens, & Zhang, 2024; Brokes, 1988; Pauliukeviciene & Stankeviciene, 2024; Ramaswamy, Marciniuk, Csonka, Colo, & Saso, 2021) explains that adolescents with good emotional regulation tend to have a greater capacity to overcome academic challenges without excessive emotional pressure, while inadequate emotional regulation can lead to avoidance behaviors, prolonged stress, and even the possibility of depression.

Furthermore, research conducted by Flores and Brown (2019); Jones, Patel, Twigg, and Chaudhuri (2024); Sashittal, Jassawalla, and Markulis (2012) shows that parental and teacher involvement in teaching emotional regulation strategies through social modeling and reinforcement of adaptive behavior is very decisive for the successful emotional development of adolescents. Thus, making the emotional aspect an integral part of the mathematics education process is a strategic step in supporting academic success and psychological well-being simultaneously.

In the context of the SDGs, the emotional aspect is very relevant to SDG 3, which emphasizes the importance of physical, mental, and social health at all ages. SDG 3 aims to ensure healthy lives and promote well-being for all, with a focus on reducing diseases, improving mental health, access to adequate health services, and overall quality of life improvement (Ally, 2019; Rendtorff, 2020). The mental health aspect, which includes the ability to manage stress, anxiety, and emotions, plays a crucial role in students' readiness and success in learning.

A safe, supportive learning environment free from stigma around mistakes is a key factor in reducing performance anxiety and enhancing students' psychological well-being. Research shows that a supportive classroom climate with psychosocial factors, fair treatment, and positive communication can lower stress and academic anxiety levels (Fu, Yang, Liu, Wang, & Chen, 2021; Gu, Shen, Wang, & Beck, 2018; Wang, 2023). Teachers who appreciate students' efforts, provide positive feedback, and apply the growth mindset, the belief that abilities can develop through effort and learning, help build students' confidence and mental resilience (Cavus & Zabadi, 2014; Dweck & Yeager, 2019).

These strategies align with the goals of inclusive and meaningful education, which is the focus of SDG 4 (Quality Education). The implementation of a holistic approach that combines attention to mental health and cognitive aspects supports the optimal functioning of the learning process, helping students not only achieve good academic performance but also maintain excellent mental and social health (Agrusti, Mezzini, & Bonavolonta, 2020; Chu, 2016). Thus, teacher interventions in creating a conducive classroom climate, providing emotional support, and promoting a positive and inclusive learning culture are important strategic steps to simultaneously meet the standards of SDG 3 and SDG 4. These efforts also contribute directly to the development of healthy, productive, and competitive human resources.

CONCLUSION

This study concludes that student development in mathematics learning at the vocational level is characterized by distinct multidimensional profiles with three key patterns, namely physical-psychomotor stability and tool proficiency directly support confidence in task execution; cognitive systematic reasoning is often enhanced by visual-spatial strategies; and emotional regulation acts as a critical filter, where high academic anxiety leads to motor hesitation and cognitive blockage. The study identifies that the primary supporting factors for successful development are high intrinsic motivation and the ability to use assistive mathematical tools effectively. Conversely, the inhibiting factors include acute evaluation anxiety and a lack of concrete-to-abstract scaffolding, which hinder students' active participation. These detailed variations suggest that vocational mathematics success is not solely a cognitive matter but is deeply intertwined with physical comfort and emotional resilience. Directly contributing to SDG 4 (Quality Education), this research provides evidence that inclusive education requires adaptive strategies tailored to students' diverse motor and emotional baselines. Furthermore, the findings align with SDG 3 (Well-Being) by demonstrating that managing academic stress is essential for students' mental health in learning environments. By addressing these developmental gaps, this study supports SDG 10 (Reduced Inequalities) through the promotion of a learning model that accommodates diverse physical and psychological needs. However, the qualitative nature of this research limits the generalizability of the findings, so further research is recommended to involve a wider sample, conducting longitudinal studies to observe how these developmental dimensions evolve over a full academic year, and integrating social and language dimensions more explicitly to complete the holistic profile of the vocational learner.

ACKNOWLEDGMENT

Thank you to DP3M Universitas PGRI Kanjuruhan Malang for providing funding support for this research.

DECLARATION

Author Contribution	:	WBU: Conceptualization, Writing-Review, Editing, Methodology, Validation, and Supervision. TF and BLV: Review-Editing and Formal Analysis
Funding Statement	:	This research was funded by the DP3M of Universitas PGRI Kanjuruhan Malang for providing research funding through contract number 516/C2/I.3/DP3M-UK/VII.2025.
Conflict of Interest	:	The authors declare no conflict of interest.
Additional Information	:	Additional information is available from the corresponding author upon reasonable request.

REFERENCES

Agarwal, A. (2017). Knowing "knowledge" and "to know": An overview of concepts. *International Journal of Research Granthaalayah*, *5*(11), 86–94. https://doi.org/10.29121/granthaalayah.v5.i11.2017.2331.

Agrusti, F., Mezzini, M., & Bonavolonta, G. (2020). Deep learning approach for predicting university dropout: a case study at roma tre university. *Journal of E-Learning and Knowledge Society*, *16*(1), 44–54. https://doi.org/10.20368/1971-8829/1135192.

Ally, M. (2019). Competency profile of the digital and online teacher in future education. *International Review of Research in Open and Distance Learning*, *20*(2), 302–318. https://doi.org/10.19173/irrodl.v20i2.4206.

Anista, R., & Marsigit, M. (2020). Direct identification of borobudur temple artefacts for learning flat shapes concepts. *Journal of Physics: Conference Series*, *1613*(1), 1–7. https://doi.org/10.1088/1742-6596/1613/1/012021.

Ashcraft, M. H. (2019). Models of math Aanxiety. In I. C. Mammarella, S. Caviola, & A. Dowker (Eds.). *Mathematics anxiety: What is known and what is still to be understood*, 1-19. https://doi.org/10.4324/9780429199981-1.

Baltrusaitis, J., Bakshi, B., Chojnacka, K., Chuck, C. J., Coppens, M. O., & Zhang, L. (2024). Sustainability science and technology in 2024 and beyond: equitable publishing aligned with united nations' sustainable development goals. *Sustainability Science and Technology*, *1*(1), 010201. https://doi.org/10.1088/2977-3504/ad555a.

Barsalou, L. W. (2008). Grounded cognition. *Annu. Rev. Psychol.*, *59*(1), 617-645. https://doi.org/10.1146/annurev.psych.59.103006.093639.

Brokes, A. (1988). *Individualization and autonomy in language learning*. Hong Kong: ELT Documents.

Cameron, C. E., Cottone, E. A., Murrah, W. M., & Grissmer, D. W. (2016). How are motor skills linked to children's school performance and academic achievement? *Child Development Perspectives*, *10*(2), 93–98. https://doi.org/10.1111/cdep.12168.

Cavus, N., & Zabadi, T. (2014). A comparison of open source learning management systems. *Procedia - Social and Behavioral Sciences*, *143*, 521–526. https://doi.org/10.1016/j.sbspro.2014.07.430.

Chu. (2016). 21st century skills development through inquiry-based learning: From theory to practice. *21st Century Skills Development Through Inquiry-Based Learning: From Theory to Practice*, *January*, 1–204. https://doi.org/10.1007/978-981-10-2481-8.

Creswell, J. W., & Poth. (2018). *Research design : qualitative, quantitative, and mixed methods approaches* (5th ed.). New York: Sage Publications.

Dweck, C. S., & Yeager, D. S. (2019). Mindsets: a view from two eras. *Perspectives on Psychological Science*, *14*(3), 481–496. https://doi.org/10.1177/1745691618804166.

Ernst, J. R., Pan, S. E., & Carlson, S. M. (2024). Remote assessment of the association between early executive function and mathematics skills. *Infant and Child Development*, *33*(5), 1–18. https://doi.org/10.1002/icd.2534.

Esposito, L., Tonizzi, I., Usai, M. C., & Giofre, D. (2025). Understanding the role of cognitive abilities and math anxiety in adolescent math achievement. *Journal of Intelligence*, *13*(4). https://doi.org/10.3390/jintelligence13040044.

Fernando, Y., Andriani, P., & Syam, H. (2024). Pentingnya motivasi belajar dalam meningkatkan hasil belajar siswa. *Alfihris: Jurnal Inspirasi Pendidikan*, *2*(3), 61-68.. https://doi.org/10.59246/alfihris.v2i3.843.

Flores, M. E., & Brown, C. G. (2019). An examination of student disengagement and reengagement from an alternative high school. *School Leadership Review*, *14*(1), 62–77.

Fu, L., Yang, M., Liu, Y., Wang, Z., & Chen, Y. (2021). Mobile learning on students' learning interest and achievement based on apt teaching model. *International Journal of Electrical Engineering and Education*. https://doi.org/10.1177/00207209211004200.

Gabriel, F., Buckley, S., & Barthakur, A. (2020). The impact of mathematics anxiety on self-regulated learning and mathematical literacy. *Australian Journal of Education*, *64*(3), 227–242. https://doi.org/10.1177/0004944120947881.

Gonzalez-DeHass, A. R. (2019). Self-regulated learning. *Parent Involvement for Motivated Learners*, *3*, 83–103. https://doi.org/10.4324/9781351021906-5.

Gu, D., Shen, J., Wang, X., & Beck, J. E. (2018). *Deep learning project report*.

Hadipranoto, H., Satyadi, H., & Rostiana. (2020). The application of gratitude group program to increase quality of life among indonesian elderly in residential home x Jakarta. *In* The 2nd Tarumanagara International Conference on the Applications of Social Sciences and Humanities (TICASH 2020), 503–507. https://doi.org/10.2991/assehr.k.201209.077.

Hsiao, H. S., Lin, C. Y., Chen, J. C., & Peng, Y. F. (2018). The influence of a mathematics problem-solving training system on first-year middle school students. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(1), 77–93. https://doi.org/10.12973/ejmste/77902.

Hsu, Y. S. (2021). Development of science teachers' TPACK. *Paper Knowledge . Toward a Media History of Documents*, *3*(2), 6-18. https://doi.org/10.5281/zenodo.4661154.

Hsu, Y. S., Yeh, Y. F., & Wu, H. K. (2015). The TPACK-P framework for science teachers in a practical teaching context. In *Development Of Science Teachers' TPACK: East Asian Practices*. https://doi.org/10.1007/978-981-287-441-2_2.

Hutauruk, A. J. B., & Priatna, N. (2017). Mathematical resilience of mathematics education students. *Journal of Physics: Conference Series*, *895*(1), 0–6. https://doi.org/10.1088/1742-6596/895/1/012067.

Ilhan, A. (2021). The impact of game-based, modeling, and collaborative learning methods on the achievements, motivations, and visual mathematical literacy perceptions. *SAGE Open*, *11*(1). https://doi.org/10.1177/21582440211003567.

Irhamna, I., Amry, Z., & Syahputra, H. (2020). Contribution of mathematical anxiety, learning motivation and self-confidence to student's Mathematical Problem Solving. *Budapest International Research and Critics in Linguistics and Education (BirLE) Journal*, *3*(4), 1759–1772. https://doi.org/10.33258/birle.v3i4.1343.

Jader, J., Lithner, J., & Sidenvall, J. (2020). Mathematical problem solving in textbooks from twelve countries. *International Journal of Mathematical Education in Science and Technology*, *51*(7), 1120–1136. https://doi.org/10.1080/0020739X.2019.1656826.

Jones, S., Patel, J. P., Twigg, M. J., & Chaudhuri, K. R. (2024). What is known about the challenges people with Parkinson's disease experience with their medicines and what solutions have been explored to overcome them? A scoping review. *The International Journal of Pharmacy Practice*, *32*(6), 431–445. https://doi.org/10.1093/ijpp/riae051.

Joo, H., Park, J., & Kim, D. (2021). Visual representation fidelity and self-explanation prompts in multi-representational adaptive learning. *Journal of Computer Assisted Learning*, *37*(4), 1091–1106. https://doi.org/10.1111/jcal.12548.

Khargonekar, P. P., & Samad, T. (2024). The United nations sustainable development GOALS: An IFAC agenda. *IFAC-PapersOnLine*, *58*(3), 153–158. https://doi.org/10.1016/j.ifacol.2024.07.142.

Korhonen, V., Mattsson, M., Inkinen, M., & Toom, A. (2019). Understanding the multidimensional nature of student engagement during the first year of higher education. *Frontiers in Psychology*, *10*(MAY). https://doi.org/10.3389/fpsyg.2019.01056.

Lester, F., & Cai, J. (2016). Posing and solving mathematical problems. *Posing and Solving Mathematical Problems*, *March 2016*. https://doi.org/10.1007/978-3-319-28023-3.

Liu, Y., Ma, S., & Chen, Y. (2024). The impacts of learning motivation, emotional engagement and psychological capital on academic performance in a blended learning university course. *Frontiers in Psychology*, *15*(May), 1–12. https://doi.org/10.3389/fpsyg.2024.1357936.

Luo, Z., Jose, P. E., Huntsinger, C. S., & Pigott, T. D. (2007). Fine motor skills and mathematics achievement in east asian american and european american kindergartners and first graders. *British Journal of Developmental Psychology*, *25*(4), 595–614. https://doi.org/10.1348/026151007X185329.

Mania, S., & Alam, S. (2021). Teachers' perception toward the use of ethnomathematics approach in teaching math. *International Journal of Education in Mathematics, Science and Technology*, *9*(2), 282–298. https://doi.org/10.46328/IJEMST.1551.

Martin, J., Mcbride, T., Masterman, T., Pote, I., Mokhtar, N., Oprea, E., & Sorgenfrei, M. (2020). *Covid-19 and early intervention: Evidence, challenges and risks relating to virtual and digital delivery*. *April*, 1–71.

McLeod, D. B., & Schoenfeld, A. H. (1987). Mathematical problem solving. *The College Mathematics Journal*. https://doi.org/10.2307/2686811.

Meaney, T., Severina, E., Gustavsen, M., Hoven, C. S., & Larsen, S. B. (2024). Mathematical and computational thinking in children's problem solving with robots. In *Teaching Mathematics as to be Meaningful – Foregrounding Play and Children's Perspectives*. https://doi.org/10.1007/978-3-031-37663-4_8.

Miles, M. B., & Huberman, A. M. (2014). *Qualitative data analysis: a methods sourcebook, third edition*. Sage Publications: Inc.

Morin, L. L., Watson, S. M. R., Hester, P., & Raver, S. (2017). The use of a bar model drawing to teach word problem solving to students with mathematics difficulties. *Learning Disability Quarterly*, *40*(2), 91–104. https://doi.org/10.1177/0731948717690116.

Nordin, N. H., Kaida, N., Othman, N. A., Akhir, F. N. M., & Hara, H. (2020). Reducing food waste: strategies for household waste management to minimize the impact of climate change and contribute to malaysia's sustainable development. *IOP Conference Series: Earth and Environmental Science*, *479*(1), 0–8. https://doi.org/10.1088/1755-1315/479/1/012035.

Novriani, M. R., & Surya, E. (2017). Analysis of student difficulties in mathematics problem solving ability at MTs swasta ira medan. *International Journal of Sciences: Basic and Applied Research (IJSBAR) International Journal of Sciences: Basic and Applied Research*, *33*(3), 63–75.

Overmyer, T., & Carlson, E. B. (2019). Literature review: design thinking and place. *Journal of Business and Technical Communication*, *33*(4), 431–436. https://doi.org/10.1177/1050651919854079.

Ozturk, M., Akkan, Y., & Kaplan, A. (2020). Reading comprehension, Mathematics self-efficacy perception, and Mathematics attitude as correlates of students' non-routine Mathematics problem-solving skills in Turkey. *International Journal of Mathematical Education in Science and Technology*, *51*(7), 1042–1058. https://doi.org/10.1080/0020739X.2019.1648893.

Pambudi, D. S., Budayasa, I. K., & Lukito, A. (2020). The role of mathematical connections in mathematical problem solving. *Jurnal Pendidikan Matematika*, *14*(2), 129–144. https://doi.org/10.22342/jpm.14.2.10985.129-144.

Pauliukeviciene, G., & Stankeviciene, J. (2024). Trends in current interfaces between fintech, sustainable development and methods: a scientific review. *Virtual Economics*, *7*(3), 42–58. https://doi.org/10.34021/ve.2024.07.03(3).

Pawar, M. (2025). United nations, world social report 2025: a new policy consensus to accelerate social progress. *The International Journal of Community and Social Development*, *7*(2), 327–329. https://doi.org/10.1177/25166026251342388.

Pearce, Z. R., & Miller, S. E. (2025). Embodied cognition perspectives within early executive function development. *Frontiers in Cognition*, *4*. https://doi.org/10.3389/fcogn.2025.1361748.

Planas, N., Morgan, C., & Schutte, M. (2018). Mathematics education and language: lessons and directions from two decades of research. *Developing Research in Mathematics Education. Twenty Years of Communication, Cooperation and Collaboration in Europe*, *38*(3), 196–210.

Prediger, S., & Meyer, A. S. (2017). Fostering the mathematics learning of language learners: Introduction to trends and issues in research and professional development. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(7), 4049–4056. https://doi.org/10.12973/eurasia.2017.00801a.

Ramaswamy, M., Marciniuk, D. D., Csonka, V., Colo, L., & Saso, L. (2021). Reimagining internationalization in higher education through the united nations sustainable development goals for the betterment of society.

Journal of Studies in International Education, *25*(4), 388–406. https://doi.org/10.1177/10283153211031046.

Ramirez, G., Chang, H., Maloney, E. A., Levine, S. C., & Beilock, S. L. (2016). On the relationship between math anxiety and math achievement in early elementary school: The role of problem solving strategies. *Journal of Experimental Child Psychology*, *141*, 83–100. https://doi.org/10.1016/j.jecp.2015.07.014.

Ravselj, D., Kerzic, D., Tomazevic, N., Umek, L., Brezovar, N., Iahad, N. A., & Aristovnik, A. (2025). Higher education students' perceptions of chatGPT: a global study of early reactions. In *Plos One, 20*(2). https://doi.org/10.1371/journal.pone.0315011.

Rendtorff, J. D. (2020). Corporate citizenship, stakeholder management and sustainable development goals (sdgs) in financial institutions and capital markets. *Journal of Capital Markets Studies*, *4*(1), 47–59. https://doi.org/10.1108/JCMS-06-2020-0021.

Russell, J. M., Baik, C., Ryan, A. T., & Molloy, E. (2022). Fostering self-regulated learning in higher education: making self-regulation visible. *Active Learning in Higher Education*, *23*(2), 97–113. https://doi.org/10.1177/1469787420982378.

Saha, S., Hasan, A. R., Islam, K. R., & Priom, M. A. I. (2024). Sustainable development goals (SDGs) practices and firms' financial performance: Moderating role of country governance. *Green Finance*, *6*(1), 162–198. https://doi.org/10.3934/GF.2024007.

Santos-Trigo, M. (2014). Problem solving in mathematics education. In *Encyclopedia of Mathematics Education*. https://doi.org/10.1007/978-94-007-4978-8_129.

Santrock, J. W. (2008). Psikologi pendidikan. In *Penerjemah: Tri Wibowo B. S.* Jakarta: Kencana.

Sashittal, H. C., Jassawalla, A. R., & Markulis, P. (2012). Students' perspective into the apathy and social disconnectedness they feel in undergraduate business classrooms. *Decision Sciences Journal of Innovative Education*, *10*(3), 413–446. https://doi.org/10.1111/j.1540-4609.2012.00346.x.

Schoenfeld, A. H. (2016a). Learning to think mathematically: problem solving, metacognition, and sense making in mathematics (reprint). *Journal of Education*. https://doi.org/10.1177/002205741619600202.

Schoenfeld, A. H. (2016b). Mathematical thinking and problem solving. *Mathematical Thinking and Problem Solving*, *January 1989*. https://doi.org/10.4324/9781315044613.

Scott, P. (2012). The intellectual contributions of ubiratan d'ambrosio to ethnomathematics. *Cuadernos de Investigación y Formación En Educación Matemática*, *7*(10), 241–246.

Setiawan, A., Degeng, I. N. S., Sa'dijah, C., & Praherdhiono, H. (2020). The effect of collaborative problem solving strategies and cognitive style on students' problem solving abilities. *Journal for the Education of Gifted Young Scientists*, *8*(4), 1618–1630. https://doi.org/10.17478/jegys.812781.

She, H. C., Stacey, K., & Schmidt, W. H. (2018). Science and mathematics literacy: PISA for better school education. *International Journal of Science and Mathematics Education*, *16*. https://doi.org/10.1007/s10763-018-9911-1.

Stacey, K., & Turner, R. (2015). Assessing mathematical literacy: the PISA experience. *Assessing Mathematical Literacy: The PISA Experience*, 1–321. https://doi.org/10.1007/978-3-319-10121-7.

Wang. (2023). When adaptive learning is effective learning: comparison of an adaptive learning system to teacher-led instruction. *Interactive Learning Environments*, *31*(2), 793–803. https://doi.org/10.1080/10494820.2020.1808794.

Yayuk, E., Purwanto, As'Ari, A. R., & Subanji. (2020). Primary school students' creative thinking skills in mathematics problem solving. *European Journal of Educational Research*, *9*(3), 1281–1295. https://doi.org/10.12973/eu-jer.9.3.1281.

Yunus. (2021). The influence of online project collaborative learning and achievement motivation on problem-solving ability. *European Journal of Educational Research*, *10*(2), 813–823. https://doi.org/10.12973/EU-JER.10.2.813.

Zhang, L., Jackson, H. A., Hunt, T. L., Carter, R. A., Yang, S., & Emerling, C. R. (2022). Maximizing learning management systems to support mathematical problem solving in online learning. *Teaching Exceptional Children*, *54*(3), 192–201. https://doi.org/10.1177/0040059921996730.