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Analysis of determining factors of 21st century mathematical skills as a basis for designing a differentiated learning model

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ABSTRACT. A differentiated learning model is considered the right solution to meet the diverse needs of students in the context of 21st century mathematical skills. In Indonesia, this issue is particularly relevant within the implementation of the Independent Curriculum, which emphasizes student-centered learning, flexibility, and the development of higher-order thinking skills in mathematics education. However, an in-depth analysis is needed to identify factors that can support the effectiveness of this learning model. Quantitative research with a factor analysis approach is used to identify variables or components that significantly influence students' 21st century mathematics skills. Non-cognitive factor data from questionnaire instruments, and cognitive factor data from test instruments. The research instrument meets the validity criteria regarding content and constructs and was reliable. Data analysis used Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA), and multiple linear regression analysis techniques. The results of the determination analysis show that: The dominant factors influencing students' 21st century mathematics skills (Y) are student motivation (X_1), learning style (X_3), logical-mathematical intelligence (X_7), and creativity in problem-solving (X_8) with the best equation model: $Y = 0.185X_1 + 0.508X_3 + 0.226X_7 + 0.308X_8 + E$. The interaction between student motivation, learning style, logical-mathematical intelligence, and creativity creates an ideal learning ecosystem. Motivation enhances students' capacity to explore learning approaches aligned with their learning preferences, while logical-mathematical intelligence and creativity provide a foundation for effective problem-solving. Within the context of the Indonesian education system, these findings offer an empirical basis for designing differentiated.

Keywords: creative problem solving; factor analysis; independent curriculum; learning preferences; logical intelligence; student motivation.

Análise dos fatores determinantes das competências matemáticas do século XXI como base para a conceção de um modelo de aprendizagem diferenciado

RESUMO. Um modelo de aprendizagem diferenciado é considerado a solução certa para satisfazer as diversas necessidades dos alunos no contexto das competências matemáticas do século XXI. Na Indonésia, esta questão é particularmente relevante na implementação do Currículo Independente, que enfatiza a aprendizagem centrada no aluno, a flexibilidade e o desenvolvimento de competências de pensamento de ordem superior no ensino da matemática. No entanto, é necessária uma análise aprofundada para identificar factores que possam apoiar a eficácia deste modelo de aprendizagem. A investigação quantitativa com uma abordagem de análise fatorial é utilizada para identificar variáveis ou componentes que influenciam significativamente as competências matemáticas dos alunos no século XXI. Dados de fatores não cognitivos dos instrumentos de questionário e dados de fatores cognitivos dos instrumentos de teste. O instrumento de investigação cumpre os critérios de validade em relação ao conteúdo e aos constructos e foi fiável. A análise dos dados recorreu a técnicas de Análise Fatorial Exploratória (AFE), Análise Fatorial Confirmatória (AFC) e análise de regressão linear múltipla. Os resultados da análise de determinação mostram que: Os fatores dominantes que influenciam as competências matemáticas dos alunos no século XXI (Y) são a motivação dos alunos (X_1), o estilo de aprendizagem (X_3), a inteligência lógico-matemática (X_7) e a criatividade na resolução de problemas (X_8), com o melhor modelo de equação: $Y = 0{,}185X_1 + 0{,}508X_3 + 0{,}226X_7 + 0{,}308X_8 + E$. A interação entre a motivação dos alunos, o estilo de aprendizagem, a inteligência lógico-matemática e a criatividade criará um ecossistema de aprendizagem ideal. A motivação aumenta a capacidade dos alunos para explorar abordagens de aprendizagem alinhadas com as suas preferências, enquanto a inteligência lógico-matemática e a criatividade fornecem a base para a resolução eficaz de problemas. No contexto do sistema educativo indonésio, estas descobertas oferecem uma base empírica para o desenvolvimento de práticas de ensino diferenciadas.

Palavras-chave: resolução criativa de problemas; análise fatorial; currículo independente; preferências de aprendizagem; inteligência lógico-matemática; motivação do aluno.

Análisis de los factores determinantes de las habilidades matemáticas del siglo XXI como base para el diseño de un modelo de aprendizaje diferenciado

RESUMEN. Un modelo de aprendizaje diferenciado se considera la solución adecuada para satisfacer las diversas necesidades de los estudiantes en el contexto de las habilidades matemáticas del siglo XXI. En Indonesia, este tema es particularmente relevante dentro de la implementación del Currículo Independiente, que enfatiza el aprendizaje centrado en el estudiante, la flexibilidad y el desarrollo de habilidades de pensamiento de orden superior en la educación matemática. Sin embargo, se requiere un análisis profundo para identificar los factores que pueden sustentar la eficacia de este modelo de aprendizaje. Se utiliza investigación cuantitativa con un enfoque de análisis factorial para identificar variables o componentes que influyen significativamente en las habilidades matemáticas del siglo XXI de los estudiantes. Se obtuvieron datos de factores no cognitivos de cuestionarios y datos de factores cognitivos de pruebas. El instrumento de investigación cumple con los criterios de validez de contenido y constructos, y fue fiable. El análisis de datos utilizó técnicas de Análisis Factorial Exploratorio (AFE), Análisis Factorial Confirmatorio (AFC) y análisis de regresión lineal múltiple. Los resultados del análisis de determinación muestran que los factores dominantes que influyen en las habilidades matemáticas del siglo XXI de los estudiantes (Y) son la motivación (X_1), el estilo de aprendizaje (X_3), la inteligencia lógico-matemática (X_7) y la creatividad en la resolución de problemas (X_8), con el mejor modelo de ecuación: $Y = 0{,}185X_1 + 0{,}508X_3 + 0{,}226X_7 + 0{,}308X_8 + E$. La interacción entre la motivación, el estilo de aprendizaje, la inteligencia lógico-matemática y la creatividad crea un ecosistema de aprendizaje ideal. La motivación mejora la capacidad de los estudiantes para explorar enfoques de aprendizaje alineados con sus preferencias de aprendizaje, mientras que la inteligencia lógico-matemática y la creatividad proporcionan una base para la resolución eficaz de problemas. Dentro del contexto del sistema educativo de Indonesia, estos hallazgos ofrecen una base empírica para diseñar diferenciado.

Palabras clave: resolución creativa de problemas; análisis factorial; currículo independiente; preferencias de aprendizaje; inteligencia lógica; motivación estudiantil.

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Introduction

Technological developments and globalization have significantly affected the skills needed in education, especially in mathematics (Bravo et al., 2021; Trilling & Fadel, 2009). Students are expected to master 21st century skills that integrate mathematical competence with critical thinking, enabling them to evaluate complex information and make informed decisions in real-world contexts (Costa et al., 2020; Lamb et al., 2017). Collaboration is also important, as students must be able to work effectively in teams to solve cross-disciplinary problems (Binkley et al., 2011; Saavedra & Opfer, 2012). Effective communication is another critical skill, allowing students to explain mathematical concepts coherently to fellow students and teachers (Tinungki et al., 2024). In addition, problem-solving skills are essential to face real-world challenges, where students must apply mathematical reasoning to identify, analyze, and solve problems in dynamic environments (Polya, 2004). Therefore, the integration of 21st century skills into mathematics education is essential to prepare students for the modern, technology-driven world (Voogt et al., 2013).

In this digital era, basic mathematics skills are no longer enough (León et al., 2020). Students must be able to apply mathematical concepts in complex and dynamic real-world situations, where the challenges faced often involve multiple disciplines and require creative solutions (Fatmanissa et al., 2022). Mastery of these skills involves deeper critical thinking and problem-solving skills, as well as the application of mathematical concepts to real-world problems, such as in data analysis or complex system modeling (Garay & Quintana, 2019). In addition, students are also expected to be able to adapt quickly to changing technological developments, so it is important to integrate 21st century skills into mathematics learning to prepare them for dynamic global challenges (Hafni et al., 2020). Thus, mathematics learning not only teaches abstract concepts but also how these concepts are used to solve real problems that are relevant to everyday life and the world of work (Ergen, 2020).

The implementation of the Independent Curriculum has brought a new paradigm to Indonesian education, with a focus on more flexible and student-centered learning (Maisyaroh et al., 2024; Hidayat, 2022). In this curriculum, students are given greater freedom to explore their interests and talents, with teachers acting as facilitators who support a more independent learning process (Murtaqiatusholihat et al., 2023). This approach is designed to adapt to the individual needs of each student, allowing them to learn at their own pace and learning style (Rosnelli & Ristiana, 2023). In addition, the Independent Curriculum also emphasizes the importance of developing 21st century skills, such as critical thinking, collaboration, communication, and creativity, to prepare students to face global challenges in the future (Septianis et al., 2024). Thus, this curriculum seeks to create an adaptive and inclusive learning environment, which is expected to improve overall student learning outcomes.

One of the approaches applied in the Independent Curriculum is differentiated learning, which is designed to adapt the learning process to the unique needs and abilities of each student (Tomlinson, 2017). In differentiated learning, teachers use teaching methods that suit students' learning styles, allowing them to better understand and master the material (Doubet & Hockett., 2015). The content given to students can also be adapted, both in terms of difficulty level and depth of material, to ensure that each student gets challenges that are appropriate to their ability level (Purwanto et al., 2025). In addition, evaluation in differentiated learning is carried out flexibly, considering students' abilities in demonstrating their understanding, allowing them to be evaluated based on their respective strengths and weaknesses (Tomlinson et al., 2015). This approach aims to create a more inclusive learning environment and support the development of optimal skills for each student.

To facilitate the development of 21st century mathematics skills, an adaptive learning model is needed that can adjust to the individual needs of students (Suprayogi et al., 2017; Tomlinson, 2017). One effective approach in this case is differentiated learning, where teachers provide space for the uniqueness of each student, both in terms of interests, learning styles, and ability levels (Doubet & Hockett., 2015; Yudho Prastowo & Elvi, 2023). Through this approach, students can learn at their own pace, and get appropriate challenges to encourage them to think critically and creatively in solving mathematical problems (Purwanto et al., 2025). This differentiated approach also allows students to collaborate more actively in heterogeneous groups so that the communication and collaboration skills needed in the 21st century can be developed optimally (Murtaqiatusholihat et al., 2023). Thus, this adaptive learning model is an important solution in helping students face the challenges of learning mathematics in the era of globalization and increasingly advanced technology (Rachmadtullah et al., 2020).

Mathematics learning is often a challenge for students at the junior high school level, especially when they are introduced to abstract concepts that require deep understanding (Samura & Darhim, 2023). At this stage, students are not only required to memorize formulas but also must be able to understand and apply mathematical concepts in real situations (Schoenfeld, 2010). This can cause difficulties, especially for students who do not yet have a strong foundation in mathematics (Boaler, 2019). In addition, traditional teaching approaches are often inadequate in meeting the diverse learning needs of students, so innovations in learning methods are needed to help students overcome these challenges (Wright et al., 2024). Thus, it is important to implement more interactive and contextual learning strategies to improve students' understanding, skills, and interest in mathematics at the junior high school level.

Various factors influence students' ability to master mathematical skills, both internal and external factors (Pintrich, 2003; Schunk et al., 2014). Internal factors, such as learning motivation, play a major role in determining the extent to which students are committed to understanding mathematical concepts (Deci & Ryan, 1988; Habibullah et al., 2022; Ryan & Deci, 2000). Highly motivated students tend to be more actively involved in the learning process and have resilience in facing challenges (Zimmerman, 1990). In addition, logical-mathematical intelligence is also a key factor that can influence students' ability to solve mathematical problems and understand the relationships between concepts (Gardner, 2011; Shirawia et al., 2023). On the other hand, external factors such as school environmental support, including the quality of teaching and available resources, are also very important in shaping students' mathematical abilities (Wang & Degol, 2016; Wang & Eccles, 2012). Family support, such as parental encouragement and a home learning atmosphere, contribute to the development of students' mathematics skills (Salido et al., 2024; Sirin, 2005). Therefore, a thorough understanding of these factors is essential to designing effective interventions to improve students' mathematics skills.

Analyzing the factors that contribute to the mastery of 21st century mathematics skills is essential to understanding the elements that need to be considered in learning design (Blömeke et al., 2015). By understanding these factors, educators can identify aspects that can support or hinder student learning (Voogt et al., 2013). Research shows that the integration of 21^{st} century skills, such as critical thinking, collaboration, and problem-solving, requires a different learning approach than traditional methods (Dede, 2009; Fullan et al., 2018). In addition, research shows that a supportive and interactive learning environment can increase student motivation and engagement in the mathematics learning process (Alakoski et al., 2024; Soe et al., 2025). Therefore, learning design that considers various factors, including student needs and characteristics, is essential to improving the mastery of mathematics skills that are relevant to the demands of the 21^{st} century.

By identifying the determinants of mathematical skills, this study is expected to be a basis for designing inclusive learning models that are appropriate to the needs of diverse students (Leibel et al., 2021; Tomlinson, 1999). Research shows that understanding the factors that influence students' abilities in mathematics, such as motivation, social support, and individual characteristics, is essential for creating a responsive learning environment (Wang & Degol, 2016; Wang & Eccles, 2012). An inclusive learning model allows for the adjustment of methods and content to meet various learning styles and ability levels of students, thereby increasing engagement and learning outcomes (Tapung, 2025; Tomlinson, 1999). In addition, learning designs that consider these factors can help reduce gaps in mastery of mathematical skills among students from different backgrounds (Thapliyal et al., 2022). Thus, this study aims to contribute to the development of more equitable and effective educational practices in mathematics learning in schools. The study was intentionally designed as a quantitative explanatory investigation aimed at identifying the determinants of 21^{st} century mathematics skills using rigorous statistical procedures. The discussion of differentiated learning is presented as a conceptual implication derived from the empirical findings, rather than as a core theoretical framework.

Research methodology

This study uses a survey type with a quantitative approach to collect data and analyze factors that influence students' 21^{st} century mathematics skills. The quantitative approach allows researchers to measure variables objectively through standardized instruments. This method aims to obtain a broad picture of the factors that influence 21^{st} century mathematics skills. This study was conducted in junior high schools in the Special Region of Yogyakarta, Indonesia, encompassing five districts/cities. Participants were students (aged 13–15) from five public junior high schools (N = 783). Students (n = 224) were randomly selected based on their mathematics ability level, with 60% of students having average ability and the remainder having high and low ability.

The data collection technique was carried out by providing questionnaires and tests. The questionnaire was used to measure five variables, namely learning motivation, student interest in mathematics, student learning styles, supportive learning environments, and technological support. Each variable was developed based on three main indicators, so that the questionnaire consisted of 15 statement items in total. The questionnaire has a five-level rating scale: score 1 = Very Unsuitable, score 2 = Unsuitable, score 3 = Neutral, score 4 = Suitable, and score 5 = Very Suitable. To provide an overview of the instrument used, the following are examples of statement items from each non-cognitive variable, where each item represents one of the predetermined indicators (Table 1).

Table 1. Examples of non-cognitive statement items in the questionnaire.

Variables	Indicators	Code	Example Statement Item
Learning Motivation	Goal Orientation	A1	I study mathematics with the goal of deeply understanding concepts, not just to pass exams.
Student Interest in Mathematics	Desire to Explore Mathematics Beyond the Classroom	B3	I often seek additional materials or practice math problems outside of class to deepen my understanding.
Student Learning Style	Kinesthetic Learning Style	C3	I understand math concepts more easily when I am directly involved in practical activities, such as using physical aids or manipulating objects.
Supportive Learning Environment	Social Support	D2	My math teacher is always ready to help and provide support when I have difficulty understanding the material.
Technological Support	Technology Integration in Learning	E2	I often use the math apps or software provided by my teacher to learn math concepts more deeply.

The test is used to measure three variables: 1) students' initial abilities (indicators: number mastery, arithmetic skills, and conceptual understanding); 2) logical-mathematical intelligence (indicators: logical reasoning, problem-solving, and analytical skills); and 3) creativity in problem-solving (indicators: problem-solving innovation, flexibility of thinking, and mathematical imagination). The test consists of descriptive questions, and students' answers are scored using a holistic rubric with a score of 1–5, considering the overall correctness and completeness of the answers, in accordance with the question-solving guidelines. Example items and their scoring for an item measuring creativity in problem-solving with mathematical imagination as an indicator (Table 2).

‘A company wants to build a circular playground in the center of a city park. The park has a radius of 10 meters. The playground will feature various games, including swings, slides, and a sandpit. Imagine and design a creative playground layout within the circle. Provide an explanation regarding the selection of play positions based on the available space and considerations of children's safety and comfort.’

Steps to solve the question item and its scoring.

Table 2. Example of cognitive test item scoring guidelines.

Solution Steps	Solution Description	Score
Calculating the area of the playground	Circle area $=\pi\times r^2=\pi\times(10\text{ m})^2\approx 314.16\text{ m}^2$	1
Layout design	- Swing: Place on one side of the circle, 2 m away from the edge to give room for movement. - Slide: Place it on the opposite side of the swing, also with a distance of 2 m from the edge of the circle. - Sand play area: Place it in the middle of the park, so children can play safely in a more open area.	2
Safety and comfort considerations	- Make sure each game has a minimum distance of 2 m from other games to avoid accidents. - Consider adding green areas (grass) around the game to provide a sense of comfort and safety for children. - Use safe and harmless materials for slips and swings.	3
Mathematical Imagination	- visualization of problems in real context - Students draw a draft layout and explain the selection of positions based on available area and safety considerations.	4
Conclusion	An effective layout design not only meets the needs of space, but also pays attention to the safety and comfort of children when playing in the park.	5

Validity and reliability measurements aimed at determining whether the instrument used in the study has measured what is intended to be measured (valid) and whether the instrument has consistent properties over time (reliable) have been met in this study. Content validity is carried out through a review of the instrument grid to ensure that the statements submitted in the research instrument have represented or reflected the entire content proportionally, both the suitability of the variables and the suitability of the indicators, in addition, the determination of this proportion has also been based on the opinions (judgments) of experts both in the field of mathematics education learning technology, experts in mathematics education assessment and experts in psychology.

Exploratory Factor Analysis (EFA) is used to identify the relationship between manifest variables or indicator variables in building a construct, while Confirmatory Factor Analysis (CFA) tests whether the indicators that have been grouped based on their latent variables (constructs) are consistent in their constructs. The CFA results show that the factors that influence 21st century mathematics skills, both non-cognitive and cognitive, correlate, although low at 42%. The results of the analysis show that the instrument is valid and reliable (Figure 1).

The first test of multiple regression analysis was conducted to test the influence between independent variables on the 21st century mathematics skills variable. The t-test was used to evaluate the partial significance of the independent variables on the dependent variable. Significance in this test is measured at the 5% level, which means that if the p-value is greater than 0.05, it can be concluded that the influence of the variable is not significant. The F test is used to estimate the influence of variable Y. This can be done if the results of the ANOVA test or the calculated F value have a lower level of significance than the previously determined level of significance. Then testing is carried out to test which factors have a dominant influence by determining the coefficient of determination (R^2), adjusted R^2, and Standard error of variance, which begins with classical assumption analysis, followed by overall testing and residual analysis.

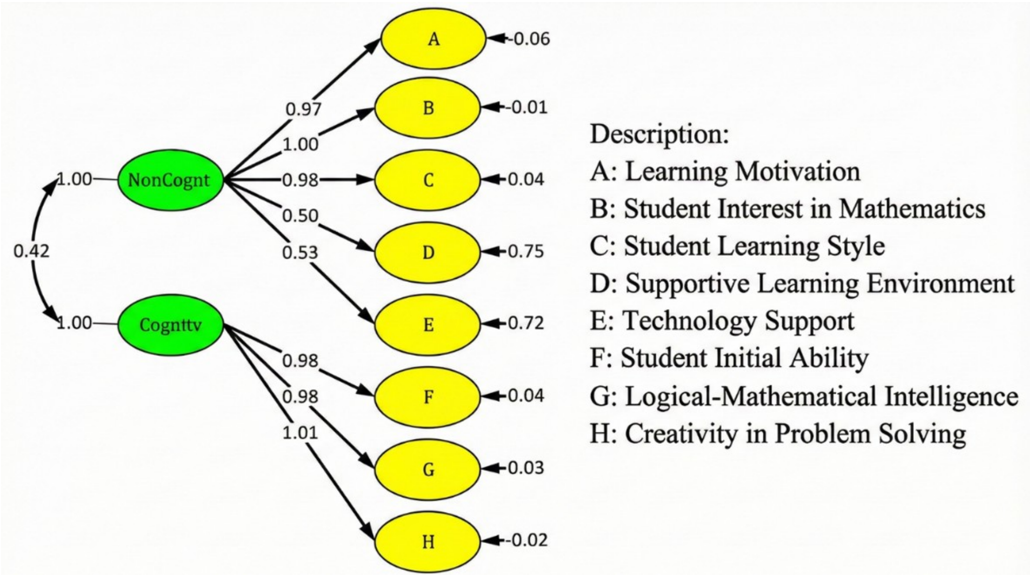

Figure 1. CFA output for aspects – variables of factors influencing 21st century mathematics skills.

Research results

Theoretical studies show that 21st century mathematics skills are influenced by 8 factors (Non-cognitive aspects: 1) Learning Motivation, 2) Student Interest in Mathematics, 3) Student Learning Style, 4) Supportive Learning Environment, and 5) Technology Support; Cognitive aspects: 6) Student Initial Ability, 7) Logical-Mathematical Intelligence, and 8) Creativity in Problem Solving). Based on this framework, this study then presents the results of an empirical analysis to comprehensively describe students' non-cognitive and cognitive profiles. The presentation of these two profiles aims to provide an initial overview of student characteristics that serve as a basis for understanding variations in 21st-century mathematical abilities and as a foundation for developing differentiated learning (Table 3).

Table 3. Profile of non-cognitive aspects of students that influence 21st century mathematics skills.

Non-Cognitive Factors	Construct Meaning	Mean	SD	Category Percentage	Dominant Tendency
A: Learning Motivation	Goal orientation, persistence, self-efficacy	3.71	0.58	High = 52.0% Medium = 38.6% Low = 9.4%	High
B: Interest in Mathematics	Interest & enthusiasm	3.70	0.57	High = 53.1% Medium = 37.8% Low = 9.1%	High
C: Learning Style	Visual, auditory, kinesthetic	3.64	0.61	High = 46.7% Medium = 42.1% Low = 11.2%	Medium–High
D: Learning Environment	Facilities, social support, culture	3.73	0.52	High = 56.7% Medium = 35.4% Low = 7.9%	High
E: Technological Support	Technology Access & Integration	3.72	0.55	High = 54.4% Medium = 36.9% Low = 8.7%	High

The results of the analysis of students' non-cognitive profiles indicate that, in general, students have a positive tendency across all measured factors. The average score for each factor is in the high category, particularly for the learning environment, technological support, learning motivation, and interest in learning mathematics, which is dominated by more than half of the students in the high category. This indicates that most students have strong self-confidence, good internal motivation, and a relatively conducive learning environment. Meanwhile, the learning style factor shows a moderate to high tendency, with a still quite large proportion of students in the medium category, indicating significant variation in learning preferences among students. The relatively moderate variation in standard deviation values across factors indicates that although students' general tendencies are positive, there are still individual differences that need to be accommodated. These findings emphasize the importance of implementing differentiated learning that not only considers students' cognitive abilities, but also considers non-cognitive factors such as motivation, technological support, interests, and diverse learning styles as a foundation for creating more inclusive and effective mathematics learning (Figure 2).

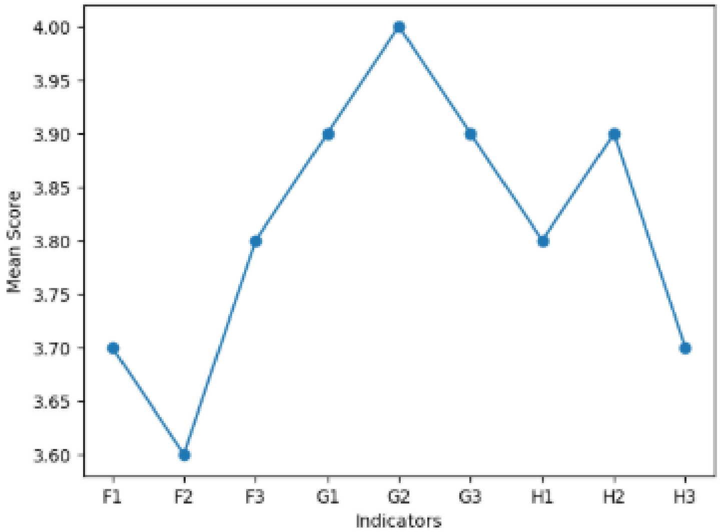

Figure 2. Profile of cognitive aspects of students that influence 21st century mathematics skills.

The analysis of students' cognitive profiles indicates that logical–mathematical intelligence emerges as the most dominant cognitive factor, followed by creativity in problem-solving, while initial mathematical ability shows relatively lower and more varied levels across students. This pattern suggests that most students possess adequate higher-order thinking capacities, particularly in logical reasoning and analytical processes, which are essential for addressing complex mathematical tasks in the context of 21st century skills. However, the uneven distribution of foundational mathematical abilities implies that not all students have equivalent readiness to fully engage in advanced problem-solving activities. The coexistence of strong reasoning skills and moderate creativity with heterogeneous basic competencies highlights the presence of cognitive diversity within the classroom. These findings underscore the necessity of differentiated mathematics instruction that not only challenges students with higher-order tasks but also provides targeted scaffolding to strengthen foundational skills, thereby enabling all learners to optimally develop their cognitive potential.

Determination analysis is used to determine factors that significantly influence 21st century mathematics skills. Assumption tests in determination analysis include normality tests, heteroscedasticity tests, multicollinearity tests, and autocorrelation tests. The normality test aims to evaluate whether the distribution of disturbance variables or residues in the regression model follows a normal distribution. One method used to test data normality is through the Kolmogorov-Smirnov (K-S) nonparametric statistical test. The results of the normality test show Kolmogorov-Smirnov Z = 0.535 with asymp.sig.(2-tailed) = 0.937 > 0.05, so it can be concluded that the residuals have a normal distribution.

The heteroscedasticity test is used to evaluate whether there is non-uniformity in the residual variance from one observation to another in the regression model. When the data does not experience heteroscedasticity, then there is no clear pattern visible, and the data points are evenly distributed above and below the zero value on the Y-axis. The heteroscedasticity test using the Glejser test (Table 4) shows that the sig.value > 0.05, then it can be said that there is no symptom of heteroscedasticity in the regression model.

The multicollinearity test is used to evaluate whether, in the regression model, there is a high or perfect correlation between independent variables. An effective (good) multiple regression model is a model in which the independent variables do not show a high correlation or do not experience multicollinearity problems, which can be identified through the tolerance value and Variance Inflation Factor (VIF). Based on the tolerance and VIF values (Table 5), it can be concluded that there are no symptoms of multicollinearity or there is no strong relationship between variables or there is no correlation between independent variables.

Table 4. Heteroscedasticity test.

Coefficients[a]					
Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
1 (Constant)	.246	.434		.566	.572
Learning_Morivation	.060	.040	1.48	1.478	.141
Student_Interest	-.004	.046	-.010	-.048	.933
Learning_Styles	.003	.047	.007	.066	.948
Learning_Environment	.034	.042	.078	.810	.419
Technology_Support	.005	.037	.013	.127	.899
Studentes_Initial_Abilities	.050	.042	.121	1.171	.243
Logical_Mathematical_Intelligence	-.050	.048	-.129	-1.055	.293
Creativity_in_Problem_Solving	.006	.047	.016	.129	.897

a. Dependent Variable: Abs Res.

Table 5. Multicollinearity test and partial significance test of independent variables on dependent variables.

Coefficients[a]							
Model	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1 (Constant)	.817	.738		1.107	**.270**		
Learning_Morivation	.179	.069	.154	2.613	.010	.439	2.277
Student_Interest	.001	.078	.001	.008	**.993**	.336	2.977
Learning_Styles	.483	.079	.405	6.107	.000	.345	2.899
Learning_Environment	-.048	.071	-.038	-.676	**.500**	.479	2.086
Technology_Support	.085	0.63	.077	1.343	**.181**	.456	2.192
Studentes_Initial_Abilities	.125	.072	.105	1.743	**.083**	.415	2.409
Logical_Mathematical_Intelligence	.174	.081	.154	2.149	.033	.296	3.382
Creativity_in_Problem_Solving	.256	.080	.244	3.178	.002	.306	3.267

a. Dependent Variable: Mathematica Skills in the 21st Century.

An autocorrelation test is conducted to determine whether there is a correlation between data arranged in time series. The autocorrelation test uses the Durbin-Watson method. If the Durbin-Watson value (d) is greater than the upper limit value (du) and also greater than the lower limit value (dw), then it can be concluded that the regression model does not experience autocorrelation problems (Table 6), either positive autocorrelation or negative autocorrelation.

Table 6. Autocorrelation test.

Model Summary[b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Drubin-Watson
1	.821[a]	.674	.662	1.75653	1.465

a. Predictors: (Constant), Creativity in Problem Solving, Learning Motivation, Learning Environmente, Learning Styles, Studens Initial Abilities, Technology Support, Student Interes, Logical Mathematical Intelligente. b. Dependent Variable: Mathematica Skills in the 21st Century.

The t-test is used to determine the partial significance of the independent variable on the dependent variable. Significance in this test is measured at the 5% level, which means that if the p-value is greater than 0.05, it can be concluded that the influence of the variable is not significant. Table 5, the results of the t-test (sig. > 0.05) show that: student interest, technology support, and student initial abilities have a positive but insignificant relationship. The results of the t-test (sig. > 0.05) show that: the learning environment has a negative but insignificant relationship. The results of the t-test (sig. < 0.05) show that: learning motivation (X_1), learning styles (X_3), logical mathematical intelligence (X_7), and creativity in problem-solving (X_8) have a significant positive relationship. Table 7 shows the regression coefficient after the significant factors are eliminated so that the multiple linear regression equation is obtained: $Y= 0.185X_1 + 0.508X_3 + 0.226X_7 + 0.308X_8 + E$.

The F test is used to estimate the effect of variable Y. This can be done if the ANOVA test results or the calculated F value have a lower significance level than the previously determined significance level. The sig.value is 0.000 < 0.05 (Table 8), so it can be said that the value of the independent variable has a simultaneous relationship to the dependent variable. It can be concluded that 21st century mathematics skills influence 8 variables, namely learning motivation, student interest, learning styles, learning environment, technology support, student initial abilities, logical-mathematical intelligence, and creativity in problem-solving.

Table 7. Partial significance test by eliminating significant factors.

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
1 (Constant)	1.100	.670		1.641	.102
Learning_Morivation	.185	.064	.159	2.890	.004
Learning_Styles	.508	.066	.426	7.676	.000
Logical_Mathematical_Intelligence	.226	.075	.199	3.023	.003
Creativity_in_Problem_Solving	.308	.076	.269	4.046	.000

a. Dependent Variable: Mathematica Skills in the 21st Century.

Table 8. Anova test of the effect of variable Y on variable X simultaneously.

ANOVA[a]

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	1.356.155	4	339.039	109.227	.000[b]
Residual	679.733	219	3.104		
Total	2035.929	223			

a. Dependent Variable: Mathematica Skills in the 21st Century. b. Predictors: (Constant), Creativity in Problem Solving, Learning Motivation, Learning Styles, Logical Mathematical Intelligente.

The coefficient of determination test (Adjusted R^2) is used to measure the extent to which the independent variable can explain the variation in the dependent variable. The R^2 value = 0.66 (Table 9), so it can be said that the independent variables (learning motivation, learning styles, logical-mathematical intelligence, and creativity in problem-solving) influence 66% on the dependent (mathematical skills in the 21st century). The remaining 34% can be influenced by other factors such as students' interest in learning. Student interest also plays a crucial role, because students who have a high interest in the material tend to be more motivated and active in the learning process, thus contributing to improving their mathematical skills (Boadu & Boateng, 2024).

Table 9. Coefficient of determination test.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.816[a]	.666	.660	1.76181

b. Predictors: (Constant), Creativity in Problem Solving, Learning Motivation, Learning Styles, Logical Mathematical Intelligente.

Analysis of the determination factors of 21st century mathematical skills provides the basis for developing a differentiated learning model design (Figure 3).

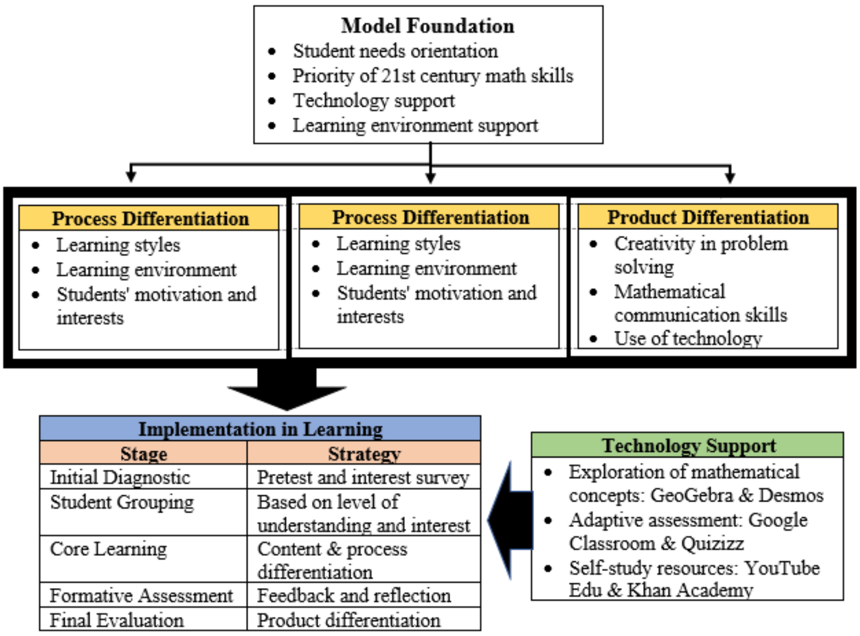

Figure 3. Differentiated mathematics learning model design.

Discussion

Differentiated learning in the Independent Curriculum requires the development of in-depth 21st century mathematics skills. This includes the ability to integrate technology into mathematics learning (Das & Sahay, 2022). In addition, students need to be able to think critically and creatively in solving complex mathematical problems (Organisation for Economic Co-operation and Development, 2018). Learning should also encourage collaboration between students to solve real-world mathematical problems in everyday life contexts (Boaler, 2016; Boaler et al., 2022). The importance of a deep understanding of basic mathematical concepts is also a major focus, which includes problem-solving, modeling, and application in different contexts (León et al., 2020).

The 21st century mathematics skills are influenced by a variety of interrelated cognitive and non-cognitive factors. Cognitive factors such as students' prior abilities play an important role in determining students' success in understanding more complex mathematics material (Siegler & Braithwaite, 2017). Logical-mathematical intelligence helps students to think analytically and logically, which is necessary for solving advanced mathematics problems (Shirawia et al., 2023). In addition, creativity in problem-solving allows students to generate innovative solutions and think 'out of the box' in the context of mathematics (Hansen, 2022).

On the other hand, non-cognitive factors such as learning motivation influence how much students engage and put effort into learning mathematics (Ryan & Deci, 2020). Students' interest in mathematics also plays a crucial role in improving their learning outcomes, as strong interest increases resilience and enthusiasm in facing challenges (Hannula, 2006). Students' varying learning styles also influence how they absorb and apply mathematical concepts, indicating the importance of an approach that suits individual learning styles (Joswick et al., 2023). A supportive learning environment, including positive interactions with teachers and peers, helps students feel more motivated and safe to learn (Alakoski et al., 2024; Soe et al., 2025). Technological support is becoming increasingly important in 21st-century mathematics learning, as digital tools can enhance students' understanding of abstract and complex concepts (Khasawneh, 2024; Turmuzi et al., 2025).

The results of the study showed that training and technical support and interest in mathematics materials were the two lowest indicators of non-cognitive factors that affect junior high school students' 21st century mathematics skills. Low training and technical support indicate that students do not get enough resources or guidance in developing their mathematics skills (Hodges et al., 2020). On the other hand, low interest in mathematics materials indicates a lack of intrinsic motivation for students to learn mathematics, which impacts their engagement in learning (Hannula, 2006). In contrast, learning culture and goal orientation were the two highest indicators of non-cognitive factors. A positive learning culture helps create a supportive environment for students to learn effectively (Soe et al., 2025), while goal orientation provides a clear direction for students to achieve desired learning outcomes (Ryan & Deci, 2020).

In the cognitive factor, problem-solving innovation and number mastery are the two lowest indicators. Students have difficulty applying innovative approaches to problem-solving, which hinders their ability to think creatively in mathematics (Hansen, 2022). In addition, low number mastery indicates students' limitations in understanding basic mathematical concepts, which negatively impacts their abilities in more complex mathematics (Siegler & Braithwaite, 2017). However, flexibility of thinking and problem-solving ability are recorded as the two highest indicators in the cognitive factor. Flexibility of thinking allows students to see problems from multiple perspectives, which is an important skill in 21st century mathematics (Dewanti et al., 2020). Meanwhile, good problem-solving ability indicates that students can face mathematical challenges with effective strategies (Hiltrimartin et al., 2024).

The 21st century mathematics skills include critical thinking, creativity, communication, and collaboration skills, highly relevant in the era of globalization and rapidly developing technology (Dewanti et al., 2020). Dominant factors such as student motivation, learning styles, logical-mathematical intelligence, and creativity in problem-solving play a key role in supporting the development of these skills (Ardianik et al., 2020; Bariyah & Retnowati, 2024; Evans et al., 2021; Schukajlow et al., 2022). Research shows that learning approaches that consider these factors can increase student engagement and learning effectiveness, especially in mathematics. In the context of the Independent Curriculum, a differentiated learning approach designed based on these factors provides opportunities to meet individual student needs while encouraging optimal achievement of 21st century skills.

Learning motivation plays an important role in the success of 21st century mathematics learning. Students with high motivation tend to be more focused, persistent, and proactive in facing mathematical challenges. Research shows that intrinsic motivation supported by a positive learning environment can increase student engagement in mathematical activities (Ryan & Deci, 2020). In differentiated learning, teachers can design activities that suit students' interests to keep their motivation high. Students' learning styles, including visual, auditory, and kinesthetic, affect how they understand mathematical concepts (Joswick et al., 2023). Adapting learning strategies to students' learning style preferences can improve their understanding of the material (Cardino Jr. & Ortega-Dela Cruz, 2020). In the Independent Curriculum, differentiated learning provides teachers with the flexibility to design materials and methods that are aligned with students' learning styles.

Logical-mathematical intelligence, which includes the ability to think analytically and process information logically, is a key cognitive factor that supports mathematical skills. Students with this intelligence tend to excel in complex problem-solving and systematic thinking (Gardner, 2011). Differentiated learning models can provide mathematical challenges that are appropriate to this level of intelligence, such as using logic puzzles or mathematical case studies. Creativity allows students to find innovative solutions in complex mathematical situations (Sadak et al., 2022). Mudinillah et al. (2024) stated that the ability to think 'out of the box' is very important in the context of 21st century learning, where traditional approaches are not always adequate. In differentiated learning, activities such as collaborative projects or open-ended assignments can be designed to encourage student creativity.

The interaction between student motivation, learning styles, logical-mathematical intelligence, and creativity creates an ideal learning ecosystem. Motivation can strengthen students' ability to explore learning methods that suit their learning styles, while logical-mathematical intelligence and creativity provide a framework for effective problem-solving (Zimmerman, 1990). In the Independent Curriculum, this integration can be achieved through activities that combine various learning approaches. Teachers have a central role in implementing a differentiated learning model, which requires a deep understanding of the factors that influence student learning (Syofyan et al., 2025). In the context of differentiated learning, teachers are required to recognize the characteristics, needs, and learning preferences of each student to develop appropriate strategies (Rintayati et al., 2024; Tomlinson & Imbeau, 2023). Research shows that when teachers understand various factors, such as motivation, learning styles, and student backgrounds, they can design more effective and inclusive learning experiences. In addition, teachers skilled in differentiated learning can create a learning environment that supports collaboration and interaction between students, which further enriches the learning process (Wan et al., 2023). Therefore, investment in training and professional development for teachers is essential to ensure the successful implementation of differentiated learning models in today's educational context.

Differentiated learning allows teachers to design adaptive activities, according to the individual needs of students. Students with low motivation can be given activities that build self-confidence, while students with high logical-mathematical intelligence can be given advanced challenges (Palomares-Ruiz & García-Perales, 2020; Prastika et al., 2021). Research by (Syofyan et al., 2025; Tomlinson, 1995; Wan et al., 2023) emphasizes that a student-centered differentiation approach can significantly improve learning outcomes. The Independent Curriculum provides flexibility for teachers to implement differentiated learning, with a focus on developing 21st century skills (Purwanto et al., 2025). By utilizing data on students' motivation, learning styles, logical-mathematical intelligence, and creativity, teachers can design learning experiences that are not only relevant but also immersive. This is in line with the objectives of the Independent Curriculum to create personalized and competency-based learning (Rosnelli & Ristiana, 2023).

The Independent Curriculum provides opportunities for teachers to design more creative and flexible learning, which can support the development of 21st century mathematics skills. With an approach that focuses on student needs, teachers can implement innovative and adaptive methods in teaching mathematical concepts, allowing students to be more involved in the learning process. Research shows creative and contextual learning can increase student motivation and facilitate a deeper understanding of mathematical concepts (Maker et al., 2021). In addition, this curriculum supports collaboration between students, which is an essential element in 21st century learning, where cooperation and communication skills are key to solving complex problems (Abdu & Schwarz, 2020). Therefore, through the Independent Curriculum, it is hoped that teachers can create a more dynamic and responsive learning environment to the needs of mathematics skills that are relevant to the demands of the times.

Conclusion

The dominant factors influencing students' 21st century mathematics skills (Y) are student motivation (X_1), learning style (X_3), logical-mathematical intelligence (X_7), and creativity in problem-solving (X_8) with the best equation model: $Y = 0.185X_1 + 0.508X_3 + 0.226X_7 + 0.308X_8 + E$. The interaction between student motivation, learning style, logical-mathematical intelligence, and creativity creates an ideal learning ecosystem. Motivation can strengthen students' ability to explore learning methods that suit their learning style, while logical-mathematical intelligence and creativity provide a framework for effective problem-solving. These factors play an important role in helping to design a differentiated learning model in the Independent Curriculum to improve 21st century mathematics skills in junior high school students. Understanding these factors helps teachers adjust learning methods to suit the diverse needs and abilities of students, thus creating more effective and inclusive learning.

Data availability

Further information regarding research instruments and research data can be accessed on GDrive at the following link https://docs.google.com/document/d/1ky7ymU74BC-61eTquJlNcSuO3NSrmgEF/edit

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