VALIDATION OF THE ANTICIPATORY THINKING SKILLS MEASUREMENT MODEL AMONG MALAYSIAN STUDENTS

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Abstract. This study aims to validate the Anticipatory Thinking Skills (ATS) measurement model among Malaysian secondary school students. In an increasingly volatile and complex world, education systems must prepare learners to anticipate and adapt to future challenges. The significance of this research lies in providing a culturally validated, psychometrically sound tool to assess future-oriented cognition among adolescents in Southeast Asia. To validate the model, a quantitative correlational research process was utilized, involving a sample of 320 secondary school students in Malaysia. Data were collected using a 64-item Anticipatory Thinking Skills questionnaire and analyzed via Structural Equation Modeling (SEM) using Confirmatory Factor Analysis (CFA). The overall findings indicate that after iterative refinement by removing underperforming items, the final 34-item, seven-dimension model demonstrated excellent structural validity and good fit indices (CFI = 0.902, RMSEA = 0.049, $\chi^2/df = 1.780$). In conclusion, the validated ATS measurement model serves as a reliable tool for assessing multidimensional anticipatory competencies, offering critical implications for educators and policymakers seeking to integrate future-oriented cognitive skills into the curriculum and objectively evaluate educational interventions.
Keywords: *anticipatory thinking, future-oriented cognition, secondary school students, structural equation modeling, questionnaire development*

Introduction

In an increasingly volatile, uncertain, complex, and ambiguous (VUCA) world, education systems are being called upon to do more than deliver knowledge. They must prepare learners to anticipate and adapt to future challenges. As societies confront unprecedented disruptions driven by technological advances, global health crises, and environmental shifts, the ability to think ahead and make informed, proactive decisions has become a critical life skill (NASEM, 2018). In this context, Anticipatory Thinking Skills (ATS) have gained prominence as a key cognitive competency for youth development (Mróz and Ocetkiewicz, 2024). ATS refer to the mental capacity to envision possible future scenarios and make judgments or take actions that prepare for or influence those outcomes (Amos-Binks and Dannenhauer, 2019). These skills are essential for developing strategic foresight, adaptability, and proactive behavior among adolescents navigating the transition into adulthood. Anticipatory thinking is inherently multidimensional, encompassing both cognitive and behavioral components such as

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awareness, forecasting, adaptability, scenario planning, and risk assessment (Geden et al., 2019). These dimensions support individuals in responding effectively to rapid changes in the environment and in making decisions with long-term implications. The need for such skills is especially pressing among adolescents, who must increasingly navigate complex educational, career, and social landscapes. Moreover, ATS aligns closely with the 21st-century education agenda, which emphasizes future-ready competencies such as critical thinking, adaptability, and resilience (Suhendar et al., 2025; Wiek et al., 2011).

Despite the growing theoretical interest in anticipatory thinking, empirical research on its measurement remains limited, especially in non-Western contexts. Most available instruments have been developed in the United States or Europe, often grounded in military or organizational psychology, and are not always adaptable to educational settings (Amos-Binks et al., 2023). Additionally, many of these tools rely on performance-based or qualitative assessments, such as narrative forecasting or scenario generation, which are labor-intensive and difficult to implement in large-scale educational settings. In Malaysia, and Southeast Asia more broadly, there is a lack of culturally validated, psychometrically sound tools to assess ATS among adolescents. This gap hinders efforts to integrate anticipatory thinking into the curriculum or to evaluate the effectiveness of interventions aimed at building such skills. Within the Malaysian context, education reform efforts have increasingly emphasized student-centered learning, higher-order thinking skills, and future-oriented competencies, yet little empirical evidence exists on how these are internalized by students. Local educators, curriculum designers, and policymakers require valid and reliable instruments that can capture these cognitive dimensions and guide pedagogical practices. The development of a robust measurement model for ATS thus serves both theoretical and practical needs: it advances scholarship on future-oriented cognition and equips stakeholders with tools for evidence-based decision-making.

To date, only a few studies have attempted to validate ATS instruments within secondary school populations using rigorous psychometric techniques such as Structural Equation Modeling (SEM). SEM, particularly Confirmatory Factor Analysis (CFA), allows for the examination of latent constructs and their interrelationships in a statistically robust manner (Brown, 2015; Hair et al., 2014). It provides a powerful framework for testing theoretical models and validating instruments, making it an ideal method for developing a multidimensional scale like ATS. This study addresses these gaps by developing and validating a measurement model of Anticipatory Thinking Skills (ATS) tailored specifically for Malaysian secondary school students. Drawing upon the multidimensional framework proposed by Geden et al. (2019), the instrument includes eight key dimensions: Awareness, Adaptability, Opportunity Recognition, Risk Assessment, Scenario Planning, Forecasting, Skill Development, and Engagement. The model was tested and refined through a combination of expert validation, pilot testing, and SEM-based analysis using data from a diverse sample of Malaysian students.

Accordingly, the objective of this study is to evaluate the factor structure and psychometric properties of the ATS measurement model. Specifically, this research aims to (1) develop an item pool aligned with the theoretical framework, (2) assess content validity through expert review, (3) conduct pilot testing for item refinement, and (4) perform CFA to confirm construct validity and model fit. By providing a validated instrument, this study contributes to the growing field of educational measurement and

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supports ongoing efforts to embed anticipatory thinking in educational systems, particularly within the Malaysian and broader Southeast Asian context.

Materials and Methods

This study employed a quantitative correlational research design to validate the Anticipatory Thinking Skills (ATS) measurement model among Malaysian secondary school students. Structural Equation Modeling (SEM) was used to evaluate the factorial structure of the instrument and examine the relationships among latent constructs. A total of 320 secondary school students participated in the study. Participants were selected from both urban and rural schools across several Malaysian states, including Kuala Lumpur, Selangor, Negeri Sembilan, Perak, Kedah, and Terengganu. Stratified random sampling was used to ensure demographic representation. All participants were enrolled in upper secondary education and provided informed consent prior to their participation. The development of the Anticipatory Thinking Skills (ATS) questionnaire was guided by a comprehensive review of relevant literature, particularly the multidimensional model proposed by Geden et al. (2019), which identifies key cognitive and behavioral components of anticipatory thinking. Grounded in theories of future-oriented cognition and educational psychology, eight dimensions were identified for inclusion: Awareness, Adaptability, Opportunity Recognition, Risk Assessment, Scenario Planning, Forecasting, Skill Development, and Engagement (*Table 1*). Item generation was carried out systematically based on these constructs. Each dimension was represented by eight items, resulting in a 64-item initial pool. Items were designed to reflect real-life anticipatory behaviors relevant to adolescents and were adapted for cultural appropriateness within the Malaysian educational context. Each item was measured on a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

Table 1*. Participant demographic.*

Category	N	%
Gender		
Female	201	62.8
Male	119	37.2
School Location		
Rural	99	30.9
Urban	221	69.1

The first key dimension, which is awareness, refers to a student’s ability to understand how present actions can influence future outcomes. This dimension involves being informed about current events, learning from past experiences, and considering the long-term consequences of decisions. For example, students who recognize that consistent study habits today will impact their performance in future examinations are demonstrating a strong sense of awareness. Adaptability, on the other hand, reflects a student’s capacity to adjust to new situations and overcome unexpected challenges. This includes being open to constructive feedback, resilient in the face of failure, and willing to step outside of their comfort zone to grow. A student who changes their study strategy after receiving poor results, and remains motivated to improve, is showing adaptability. Opportunity Recognition is the ability to identify and seize opportunities that contribute to personal growth, even in challenging circumstances. This skill

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includes being attentive to changes that may open new paths for learning and development. For instance, students who actively seek out enrichment programs, competitions, or school activities to enhance their skills are practicing this competency. Complementing this is the Risk Assessment, which involves the ability to evaluate potential risks before making decisions. It includes considering the consequences of different choices, drawing on past experiences, and using strategies to minimize uncertainty. Students who carefully weigh the benefits and drawbacks of participating in a new activity, and make thoughtful decisions, demonstrate strong risk assessment abilities.

Scenario Planning is the skill of imagining different possible future scenarios and creating plans to handle each of them effectively. This dimension helps students to be prepared for uncertainty by considering multiple outcomes. For example, planning alternative actions based on whether one passes or fails an upcoming exam illustrates effective scenario planning. Furthermore, Forecasting is the ability to anticipate future trends or events based on current knowledge and self-reflection. It involves predicting future academic or personal challenges and taking steps to address them. A student who reflects on their current performance and identifies areas for improvement to achieve future goals is demonstrating forecasting skills. Meanwhile, Skill Development emphasizes a student’s dedication to continuous learning and improvement. This includes seeking feedback, analyzing past performance, and intentionally developing new abilities to face future challenges. Students who actively look for ways to strengthen their skills and prepare for future responsibilities are engaging in effective skill development. Lastly, Engagement refers to how actively and meaningfully students participate in their academic and social environments. It includes showing enthusiasm for learning, taking initiative in group work, building positive relationships, and being responsible for one’s actions. Students who are committed to their tasks and contribute positively to their school community exhibit strong engagement. Each dimension is represented by eight items, yielding a total of 64 items. Responses were recorded using a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Content validity was established through expert review, and construct validity was assessed via Confirmatory Factor Analysis (CFA). *Table 2* shows sample items taken from the ATS questionnaire. These items were grouped into latent constructs, including AWARE (Awareness), ADAPT (Adaptability), SCENAR (Scenario Planning), FORECAST (Forecasting), RISK (Risk Assessment), ENGAGE (Engagement), and SKILL_D (Skill Development).

***Table 2**. Sixty-four items of eight factors of ATS.*

Factor	ID	Theme
Awareness		
1	AW1	I follow the latest trend.
2	AW2	I actively seek new information about current trend.
3	AW3	I am aware that my actions today will have an impact on the future.
4	AW4	I try to understand other people's perspectives in order to anticipate their actions.
5	AW5	I am aware of the challenges that will be faced in the future.
6	AW6	I seek others’ perspectives to understand what is happening at present.
7	AW7	Before making a decision about something, I consider its future benefits.
8	AW8	I learn from past experiences to make future decisions.
Adaptability		
1	AD1	I am comfortable stepping out of my comfort zone to face change.
2	AD2	I adapt quickly to new environments.
3	AD3	I see challenges and changes as opportunities for growth and maturity.
4	AD4	I am open to feedback and willing to make adjustments.
5	AD5	I view failure as a temporary obstacle that can be overcome with the right approach.
6	AD6	I am able to bounce back after experiencing failure.

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7	AD7	I can adjust my plans according to the current situation.
8	AD8	I often challenge my own abilities for personal growth.
Opportunity Recognition		
1	OR1	I often seek new opportunities for self-improvement.
2	OR2	I can identify opportunities even in challenging situations.
3	OR3	I take initiative in seeking opportunities to expand my knowledge.
4	OR4	I can identify developments that may lead to beneficial opportunities.
5	OR5	I view challenges as opportunities to solve problems.
6	OR6	I am aware of changes around me that may bring new opportunities.
7	OR7	I actively seek information to identify potential areas for personal growth.
8	OR8	I am able to identify opportunities that others have overlooked.
Risk Assessment		
1	RA1	I can assess risks before making a decision.
2	RA2	I am able to weigh the rewards and risks in every situation.
3	RA3	I am cautious when facing uncertain situations.
4	RA4	I seek information to assess the potential risks involved.
5	RA5	I am comfortable making risky decisions.
6	RA6	I use various strategies to reduce risk in every situation.
7	RA7	I frequently assess the impact of various risky situations.
8	RA8	I use past experiences to assess risky situations more effectively.
Scenario Planning		
1	SP1	I can envision various future scenarios to prepare for all possibilities.
2	SP2	I am skilled in detailed scenario planning to address various possibilities.
3	SP3	I take multiple factors into account when planning future scenarios.
4	SP4	I am comfortable adjusting scenario plans based on constantly changing circumstances.
5	SP5	I use appropriate scenario planning to anticipate the risks of a situation.
6	SP6	I seek diverse perspectives from others when planning scenarios for a situation.
7	SP7	I actively plan multiple scenarios to prepare for future possibilities.
8	SP8	I am confident in my ability to face uncertainty more effectively through scenario planning.
Forecasting		
1	FC1	I constantly assess my progress in predicting my skills and abilities.
2	FC2	I consistently seek resources and information to improve my ability to predict current and future situations.
3	FC3	I am confident in making accurate predictions about future expectations.
4	FC4	I always observe changes in my environment to enhance my predictive abilities.
5	FC5	I continue learning to acquire new skills and abilities that help me make accurate predictions.
6	FC6	I seek and act on feedback for continuous self-improvement.
7	FC7	I believe that predictive skills and abilities are important to contribute to myself, my family, and society.
8	FC8	I plan various scenarios to be prepared for the many uncertainties of future predictions.
Skill Development		
1	SD1	I constantly seek up-to-date information to predict future changes in the field I am interested in.
2	SD2	I am always involved in scenario planning to prepare for various future possibilities.
3	SD3	I seek feedback from others regarding my ability to predict future challenges.
4	SD4	I analyze past outcomes to improve my predictive skills.
5	SD5	I discuss future possibilities from various perspectives to better develop my forecasting skills.
6	SD6	I am skilled at identifying early risks and opportunities in developing forecasting abilities.
7	SD7	I constantly challenge assumptions and consider multiple possibilities to improve my forecasting skills for the future.
8	SD8	I believe forecasting skills are essential for me to succeed in today’s rapidly changing environment.
Engagement		
1	EN1	I seek opportunities to contribute in areas that I am passionate about.
2	EN2	I am always energetic in facing challenging tasks that require my skills.
3	EN3	I willingly dedicate my time and energy to activities that I find beneficial.
4	EN4	I actively contribute to the group activities I am involved in.
5	EN5	I constantly seek feedback and opportunities to enhance the effectiveness of my involvement in various activities.
6	EN6	I always seek opportunities to learn and grow within a community setting.
7	EN7	I make a conscious effort to build and maintain positive relationships with others.
8	EN8	I always take responsibility for my tasks in an effort to make a meaningful impact on others.

The preliminary items were subjected to expert review to evaluate content relevance, clarity, and cultural alignment. Two experts in educational psychology and assessment reviewed the items for construct representation, linguistic suitability, and potential redundancy. Their qualitative feedback was used to refine the items, ensuring they were contextually appropriate for Malaysian secondary school students. A pilot study involving 31 upper secondary students from two Klang Valley schools was conducted in September 2024. The primary aim was to assess item clarity, readability, and preliminary psychometric properties. Participants completed paper-based questionnaires

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under supervision. Pearson correlation analysis was used to identify item-total relationships, with items yielding a correlation value above 0.278 retained for further validation. Additionally, items were screened based on factor loading thresholds (Hair et al., 2022). Items with loadings below 0.40 were considered for removal, while those in the range of 0.40–0.70 were retained only if they contributed positively to the overall construct reliability and content coverage. Following pilot refinement, the questionnaire was distributed to a larger sample of 320 students. Confirmatory Factor Analysis (CFA) was conducted using Structural Equation Modeling (SEM) in AMOS to assess the construct validity of the ATS model. Model fit was evaluated using standard indices: Comparative Fit Index (CFI > 0.90), Root Mean Square Error of Approximation (RMSEA < 0.06), and chi-square to degrees of freedom ratio (χ^2/df < 3). Adjustments to the model, such as item removal or re-specification, were made based on modification indices, factor loadings, and theoretical alignment.

Internal consistency reliability was assessed using both Cronbach's alpha and composite reliability (CR). A Cronbach's alpha value of >0.60 was considered acceptable for each dimension (Hair et al., 2014). The final retained items demonstrated satisfactory reliability across all eight constructs. Data collection was conducted during school hours at the participating schools. Informed consent was obtained from both the students and their guardians prior to participation. The students were provided with a clear explanation of the study objectives and were guided through the completion of the questionnaires. The data collection process was supervised by trained facilitators to ensure data integrity and accuracy. All responses were anonymized and treated with confidentiality. Data were analyzed using SPSS 24.0 and AMOS software. Descriptive statistics were used to summarize participants' responses, followed by Confirmatory Factor Analysis (CFA) to test the measurement model. Model fit was evaluated using several indices: Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and Chi-Square to degrees of freedom ratio (χ^2/df). Composite Reliability (CR) and Average Variance Extracted (AVE) were calculated to assess reliability and convergent validity.

Descriptive statistics were utilized to provide an overview of the students' anticipatory thinking skills. As shown in *Table 3*, the item means scores range from 3.51 to 4.41, indicating variation in respondents' tendencies across items. The standard deviation (SD) values range from 0.69 to 0.94, reflecting relatively low dispersion and suggesting a moderate level of response homogeneity. To assess data normality, skewness and kurtosis were evaluated. Skewness values range from -1.16 to -0.15, and kurtosis values range from -0.27 to 1.83. Because these values fall within the acceptable thresholds for normal distribution (skewness between -2 and +2, and kurtosis between -7 and +7), the distributions are considered generally normal. Given that the overall item distributions approximate normality, Maximum Likelihood Estimation (MLE) was justified and utilized in the Confirmatory Factor Analysis (CFA), as it assumes multivariate normality in the data for optimal parameter estimation.

Table 3*. Descriptive statistics.*

Item	Mean	SD	Skewness	Kurtosis
AW1	3.51	0.94	-0.34	-0.23
AW3	4.41	0.69	-1.16	1.83
AW5	4.14	0.74	-0.63	0.35
AW6	3.76	0.79	-0.31	-0.06
AW7	4.19	0.74	-0.73	0.54
AD3	4.12	0.74	-0.59	0.30
AD5	4.07	0.85	-0.78	0.44

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AD6	4.05	0.82	-0.73	0.48
AD7	3.98	0.74	-0.43	0.12
AD8	3.89	0.87	-0.57	-0.07
RA1	4.02	0.78	-0.64	0.41
RA2	3.90	0.77	-0.38	-0.04
RA4	3.94	0.77	-0.48	0.16
RA6	3.72	0.81	-0.23	-0.27
RA8	3.99	0.79	-0.60	0.28
EN3	4.04	0.74	-0.53	0.29
EN4	4.14	0.74	-0.69	0.58
AW1	3.51	0.94	-0.34	-0.23
AW3	4.41	0.69	-1.16	1.83
AW5	4.14	0.74	-0.63	0.35
AW6	3.76	0.79	-0.31	-0.06
AW7	4.19	0.74	-0.73	0.54
AD3	4.12	0.74	-0.59	0.30
AD5	4.07	0.85	-0.78	0.44
AD6	4.05	0.82	-0.73	0.48
AD7	3.98	0.74	-0.43	0.12
AD8	3.89	0.87	-0.57	-0.07
RA1	4.02	0.78	-0.64	0.41
RA2	3.90	0.77	-0.38	-0.04
RA4	3.94	0.77	-0.48	0.16
RA6	3.72	0.81	-0.23	-0.27
RA8	3.99	0.79	-0.60	0.28
EN3	4.04	0.74	-0.53	0.29
EN4	4.14	0.74	-0.69	0.58

To further examine and validate the ATS measurement model, Structural Equation Modeling (SEM) was employed using the AMOS software. Confirmatory Factor Analysis (CFA) was used to evaluate the relationships between the observed indicators and their respective latent constructs, such as Awareness and Adaptability. SEM enables the simultaneous examination of multiple relationships among variables and is particularly useful for testing the hypothesized structure of multidimensional constructs such as ATS. This approach allowed for a rigorous assessment of the model's validity and the strength of the connections among theoretical constructs and measured variables. Model fit was assessed using multiple indices to ensure the robustness of the model. The Comparative Fit Index (CFI) was used to compare the hypothesized model with a null model, with values above 0.90 indicating an acceptable fit and values above 0.95 suggesting a good fit. The Root Mean Square Error of Approximation (RMSEA) was evaluated, where values less than 0.08 indicated an acceptable fit, and values below 0.06 were considered excellent. The Chi-Square to degrees of freedom ratio (χ^2/df) was also examined, with values less than 3.0 considered acceptable, and values below 2.0 indicating a good fit. Reliability and validity of the constructs were further assessed using Composite Reliability (CR) and Average Variance Extracted (AVE). CR values above 0.70 were interpreted as evidence of good internal consistency, while AVE values above 0.50 indicated satisfactory convergent validity. Factor loadings were examined to ensure they exceeded 0.40, as lower values would weaken the contribution of individual indicators to the construct.

After confirming the structural validity of the measurement model, internal consistency and convergent validity were evaluated. Reliability was assessed using Cronbach's Alpha and Composite Reliability (CR), while convergent validity was measured via the Average Variance Extracted (AVE). As shown in *Table 4*, the CR values for all dimensions range from 0.729 to 0.835, which exceed the recommended threshold of 0.70, were indicating good internal consistency. Furthermore, the Cronbach's Alpha values range from 0.716 to 0.832, satisfying the >0.60 acceptable criterion. For convergent validity, the AVE values range from 0.347 to 0.505. Although

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the AVE for Awareness, Adaptability, Risk Assessment, Scenario Planning, Forecasting, and Skill Development is below 0.50, the constructs are still acceptable because their CR values are greater than 0.70. Therefore, the final measurement model demonstrates satisfactory reliability and convergent validity. The study adhered to ethical research standards, including obtaining approval from the relevant authorities such as the State Education Department and District Education Office, and ensuring the confidentiality and anonymity of participants. Data was securely stored and used exclusively for research purposes. Participants were informed of their right to withdraw from the study at any time without any consequences.

***Table 4**. Reliability and convergent validity.*

Dimensions	CR	AVE	Cronbach's Alpha
Awareness	0.729	0.347	0.716
Adaptability	0.771	0.403	0.765
Risk Assessment	0.769	0.400	0.765
Scenario Planning	0.779	0.413	0.774
Forecasting	0.781	0.418	0.777
Skill Development	0.751	0.430	0.741
Engagement	0.835	0.505	0.832

Results and Discussion

The initial Structural Equation Modeling (SEM) analysis revealed a model that required refinement (*Figure 1*). The model’s Comparative Fit Index (CFI) was 0.778, which falls below the acceptable threshold (>0.90), indicating suboptimal fit. However, the Root Mean Square Error of Approximation (RMSEA) was 0.056, within the acceptable range (<0.06), and the chi-square to degrees of freedom ratio (χ^2/df) was 1.995, indicating an acceptable model fit. The significant chi-square statistic (CMIN = 3838.281, df = 1924, $p < 0.001$) was expected due to the large sample size (Hair et al., 2022; Brown, 2015; Hair et al., 2014). Certain observed variables, such as AW5 and AW6, displayed low factor loadings (<0.50), suggesting limited contribution to their respective latent constructs. The initial model also demonstrated over-complexity, with numerous weak paths and redundant indicators. These limitations necessitated model refinement, including the removal of underperforming items and the re-specification of certain paths (Hair et al., 2022; Brown, 2015; Hair et al., 2014).

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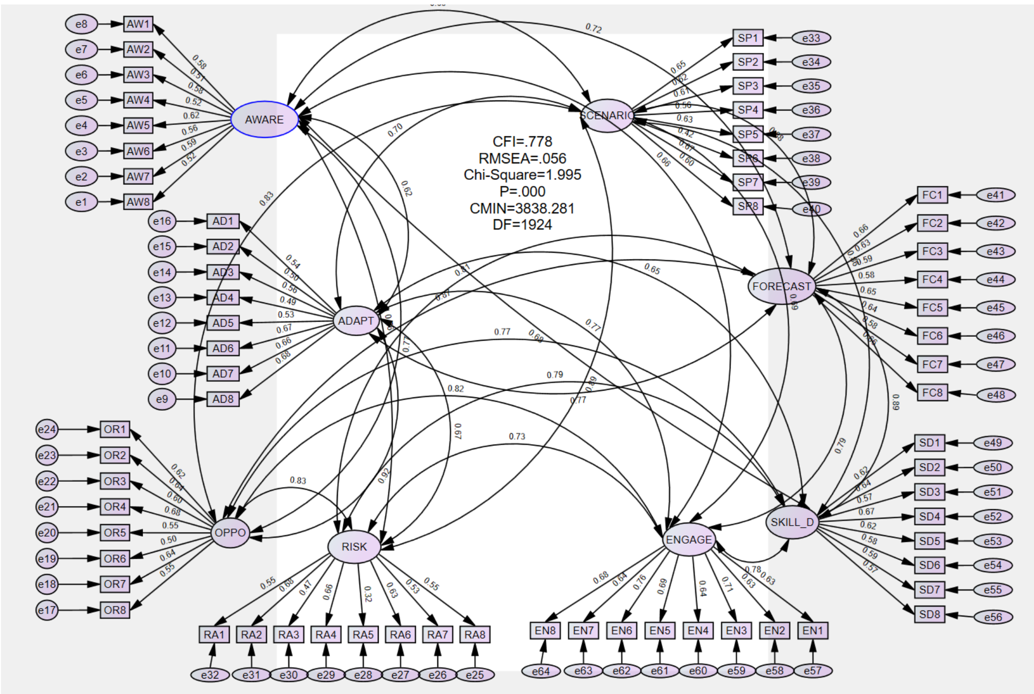

__Figure 1.__ The initial Structural Equation Modeling (SEM) analysis.

After refinement, the model showed substantial improvement. The CFI increased to 0.902, exceeding the threshold for good fit. RMSEA decreased to 0.049, indicating excellent fit, and the χ^2/df ratio improved to 1.780. Although the chi-square statistic remained significant (CMIN = 900.776, df = 506, $p < 0.001$), improvements in other indices confirmed a more valid and parsimonious model (Hair et al., 2022; Brown, 2015; Hair et al., 2014). The revised model (*Figure 2*) demonstrated stronger standardized loadings, particularly for constructs such as Awareness, Adaptability, and Engagement. The relationships among latent variables, such as between Scenario Planning and both Forecasting and Risk Assessment, were clearer and theoretically coherent. These refinements affirm the structural validity and robustness of the final ATS measurement model.

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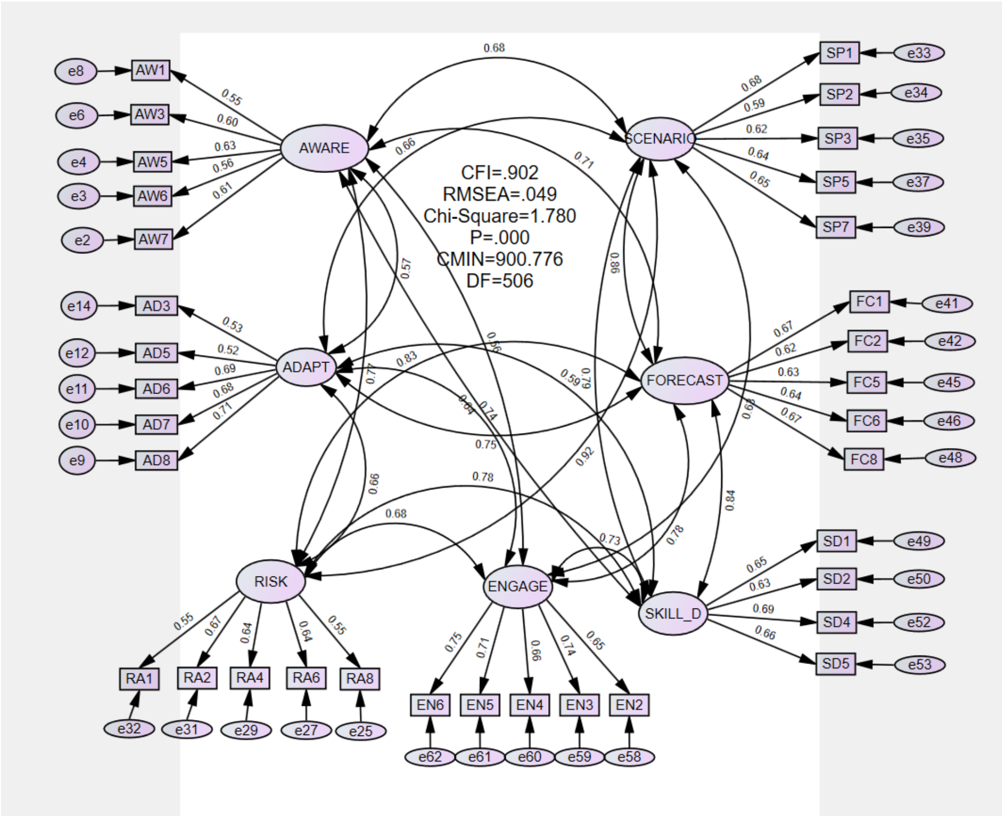

Figure 2. *The revised model.*

Comparison and final interpretation

The refinement process between the pre- and post-adjustment models resulted in a substantial improvement in fit indices and structural clarity. The initial model, while showing some acceptable fit metrics such as RMSEA and χ^2/df, struggled with a low CFI and weaker observed variable loadings, which indicated a lack of coherence in the relationships between constructs. By addressing these weaknesses, the adjusted model achieved a good fit across all indices, including a CFI above 0.90 and RMSEA below 0.05, reflecting a significant reduction in measurement error and improved model specification (Hair et al., 2022; Brown, 2015; Hair et al., 2014). The adjustments likely included removing weakly associated indicators, simplifying complex paths, and ensuring that the retained variables contribute meaningfully to their constructs. As a result, the adjusted model provides a more accurate and reliable representation of the relationships between the latent variables and their indicators, aligning well with theoretical and statistical expectations. This refined model is better positioned to support inferences and interpretations in the context of the study, making it a more robust and valid tool for further analysis. *Table 5* shows the items with high factor loadings after the model is adjusted.

Table 5*. Thirty-four items of seven factors of ATS.*

Factor	ID	Theme
Awareness		
1	AW1	I follow the latest trend.
2	AW3	I am aware that my actions today will have an impact on the future.
3	AW5	I am aware of the challenges that will be faced in the future.
4	AW6	I seek others' perspectives to understand what is happening at present.
5	AW7	Before making a decision about something, I consider its future benefits.

Adaptability		
1	AD3	I see challenges and changes as opportunities for growth and maturity.
2	AD5	I view failure as a temporary obstacle that can be overcome with the right approach.
3	AD6	I am able to bounce back after experiencing failure.
4	AD7	I can adjust my plans according to the current situation.
5	AD8	I often challenge my own abilities for personal growth.
Risk Assessment		
1	RA1	I can assess risks before making a decision.
2	RA2	I am able to weigh the rewards and risks in every situation.
3	RA4	I seek information to assess the potential risks involved.
4	RA6	I use various strategies to reduce risk in every situation.
5	RA8	I use past experiences to assess risky situations more effectively.
Scenario Planning		
1	SP1	I can envision various future scenarios to prepare for all possibilities.
2	SP2	I am skilled in detailed scenario planning to address various possibilities.
3	SP3	I take multiple factors into account when planning future scenarios.
4	SP5	I use appropriate scenario planning to anticipate the risks of a situation.
5	SP7	I actively plan multiple scenarios to prepare for future possibilities.
Forecasting		
1	FC1	I constantly assess my progress in predicting my skills and abilities.
2	FC2	I consistently seek resources and information to improve my ability to predict current and future situations.
3	FC5	I continue learning to acquire new skills and abilities that help me make accurate predictions.
4	FC6	I seek and act on feedback for continuous self-improvement.
5	FC8	I plan various scenarios to be prepared for the many uncertainties of future predictions.
Skill Development		
1	SD1	I constantly seek up-to-date information to predict future changes in the field I am interested in.
2	SD2	I am always involved in scenario planning to prepare for various future possibilities.
3	SD4	I analyze past outcomes to improve my predictive skills.
4	SD5	I discuss future possibilities from various perspectives to better develop my forecasting skills.
Engagement		
1	EN2	I am always energetic in facing challenging tasks that require my skills.
2	EN3	I willingly dedicate my time and energy to activities that I find beneficial.
3	EN4	I actively contribute to the group activities I am involved in.
4	EN5	I constantly seek feedback and opportunities to enhance the effectiveness of my involvement in various activities.
5	EN6	I always seek opportunities to learn and grow within a community setting.

The present study successfully developed and validated a multidimensional model for Anticipatory Thinking Skills (ATS) among secondary students. After an initial CFA indicated only moderate fit, iterative refinements were made (such as removing or rewording poorly fitting items), yielding a final model with good fit indices (CFI = 0.902, RMSEA = 0.049). This improvement suggests that seven of the proposed dimensions, namely awareness, adaptability, risk assessment, scenario planning, forecasting, skill development, and engagement, coherently capture the underlying construct of students' anticipatory thinking. In other words, the ATS framework demonstrates solid structural validity, confirming that these facets work together to represent a distinct "future-oriented" cognitive competence. This finding addresses a noted gap in educational measurement: previous authors have emphasized that while future-oriented thinking is widely acknowledged as critical, reliable instruments to assess such skills in school contexts have been limited (Suhendar et al., 2025). Our validated model thus provides a timely tool for both researchers and educators to quantify and better understand students' capacity to think about and prepare for the future. Although the original theoretical framework proposed eight dimensions, the Opportunity Recognition construct was excluded from the final measurement model during the Confirmatory Factor Analysis (CFA) refinement process. The items within this construct failed to meet the required factor loading thresholds, indicating potential issues with convergent validity. This finding suggests that for Malaysian secondary school students, opportunity recognition may not be conceptualized as a distinct anticipatory cognitive process. Instead, it may conceptually overlap with other dimensions such as adaptability or awareness. Further evaluation of the items within this dimension is warranted in future studies to ensure the indicators accurately reflect the intended construct within this specific cultural context.

Interpretation of the ATS measurement model

The SEM model shows that every dimension significantly contributes to the overall construct of ATS. This could be seen from the results of data analysis, which indicate strong factor loadings of the indicator variables. In particular, the laten variables of Awareness, Adaptability, and Engagement that exhibit clear and robust relationships with the corresponding variables. This suggests that these aspects are particularly important in the context of anticipatory thinking. Additionally, the structural paths within the model uncover significant relationships between the latent constructs. For instance, the path from Scenario Planning to Forecasting and Risk Assessment highlights the logical progression from imagining future possibilities to predicting outcomes and evaluating potential risks. This finding is in agreement with the theoretical perspective that underscores the importance of future-oriented thinking in effective decision-making (Amos-Binks et al., 2023; Amos-Binks and Dannenhauer, 2019). In short, the ATS measurement model offers a comprehensive and valid representation of anticipatory thinking skills in secondary school students. The SEM model supports the notion that ATS is not a single construct, but rather a complex interplay of various cognitive and behavioral competencies.

Model fit and validity

Model fit assessment is vital for determining the validity of the proposed ATS measurement model (Hair et al., 2022; Brown, 2015; Hair et al., 2014). The refined model demonstrates considerably improved fit indices compared to the original, indicating a more accurate data representation. Specifically, the Comparative Fit Index (CFI) increased from 0.778 to 0.902, surpassing the recommended threshold of 0.90. This indicates that the refined model accounts for a substantial portion of the covariance in the observed data, suggesting a good fit. The Root Mean Square Error of Approximation (RMSEA) decreased from 0.056 to 0.049, falling below the 0.05 threshold for excellent fit. This suggests that the model's approximation error is minimal, further supporting the model's validity. Additionally, the Chi-Square to Degrees of Freedom Ratio ($\chi 2/df$) improved from 1.995 to 1.780, falling within the acceptable range (below 2 or 3). This indicates that the model is parsimonious and that the discrepancy between the model and the observed data is reasonable. While the Chi-Square statistic remained significant, this is common in models with large sample sizes and is less of a concern given the improvements in other fit indices (Hair et al., 2022; Brown, 2015; Hair et al., 2014). Overall, these results provide strong evidence for the structural validity of the refined ATS measurement model. The improved fit indices confirm that the model accurately captures the underlying relationships between the dimensions of anticipatory thinking skills among secondary school students in Malaysia.

Comparison with existing literature

These results are consistent with and build upon previous research on anticipatory and future-oriented thinking. Anticipatory thinking is defined as “thinking ahead, looking for potential challenges, and recognizing threats and opportunities” (NASEM,

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2018), and it encompasses more than simple prediction. In fact, it is conceptualized as a deliberate cognitive process of exploring alternative future states, distinct from mere forecasting of a single outcome (Geden et al., 2019; Amos-Binks and Dannenhauer, 2019). The eight dimensions in our model capture this breadth. For example, risk assessment and opportunity recognition correspond to the dual emphasis on potential threats and possibilities highlighted in the literature (NASEM, 2018). Similarly, the inclusion of scenario planning and forecasting as distinct dimensions reflects their prominence as strategies in foresight research and practice. Organizations across domains ranging from business to national security routinely employ these approaches to reduce the risk of strategic surprise (Mróz and Ocetkiewicz, 2024). The dimension of adaptability, defined as students' ability to adjust to new conditions, aligns with 21st-century skills frameworks that emphasize flexibility in the face of rapid change. Meanwhile, awareness (of current trends and systems) and engagement (active involvement in future-oriented thinking) relate to what some have termed "futures consciousness" or an empowered future orientation in students.

Notably, our study's focus on adolescents complements recent efforts to measure future-thinking competencies in youth populations. For example, Geden et al. (2019) developed the Anticipatory Thinking Assessment (ANTA) for adults, which required participants to generate possible future outcomes in response to scenarios. Their results demonstrated that anticipatory thinking skill can be validly measured and is supported by cognitive factors like divergent thinking. Our findings build on this by confirming that a structured self-report instrument can capture similar competencies among secondary students. In the educational domain, Mróz and Ocetkiewicz (2024) also identified anticipatory thinking as a key "future readiness" competence. Using a self-assessment checklist with Polish teenagers, they found that nearly half of students believed they had a high level of anticipatory thinking (e.g. consistently considering future consequences of decisions). Interestingly, that study reported significant gender differences-girls tended to rate themselves lower in anticipatory skills than boys. Although our own sample was balanced in terms of demographics, we did not specifically examine gender effects; this could be a worthwhile avenue for follow-up research, given the cross-cultural evidence of such differences. Similarly, a recent evaluation by Suhendar et al. (2025) used a multidimensional framework (visioning, planning, predicting, etc.) to map Indonesian students' future-thinking skills, underscoring the international recognition that these competencies are multifaceted and vital for youth development. In line with their observation that rigorous measurement tools are "urgently needed" to support future-oriented education, our study contributes a validated model that can fill this need in the Malaysian context and beyond.

Overall, the convergence of findings across these studies reinforces the notion that anticipatory thinking is a distinct, measurable construct. Despite differing methods, ranging from performance-based tasks in Geden et al. (2019) to self-report surveys in our research and others, all point to the importance of cognitive skills like scenario planning, foresight, and adaptability in preparing for uncertain futures. Our eight-dimensional ATS model broadens the scope by incorporating elements such as opportunity recognition and skill development, which have received less emphasis in earlier instruments. The inclusion of these dimensions is supported by futures education scholars who argue that students should not only foresee risks but also "create and seize opportunities" for positive futures. This aligns with Wiek et al. (2011) concept of anticipatory competence in sustainability, which involves not just analyzing future

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problems but actively envisioning and working toward desirable outcomes. By validating a framework that spans both the protective (risk-focused) and proactive (opportunity-focused) aspects of thinking about the future, the present study offers a more comprehensive understanding of ATS in adolescents.

Conclusion

In conclusion, this study provides a validated measurement model for anticipatory thinking skills in Malaysian secondary school students, filling a critical gap in futures-oriented education research. The seven-dimensional ATS framework is grounded in theory and aligns with prior findings, yet offers a novel comprehensive tool for educators. By using this model, stakeholders in education can better assess and subsequently nurture the competencies that young people need to navigate an uncertain future. The work sets the stage for further scholarly exploration of how anticipatory thinking can be cultivated and how it benefits learners, ultimately contributing to educational practices that empower students as future-ready, cognitively agile individuals. As the challenges of the 21st century continue to evolve, such forward-looking competencies will be indispensable, and now we have a robust way to measure and track them in the leaders of tomorrow. The validated ATS measurement model has important implications for educational practice and curriculum design. First, it provides educators and policymakers with a reliable means to assess students' future-oriented cognitive skills. Given global calls to enhance "future-ready" education, having a standardized ATS instrument allows schools to benchmark and track these otherwise intangible skills over time. For instance, teachers could administer the ATS survey to diagnose areas of strength or weakness in their students' anticipatory thinking (e.g. perhaps some classes excel in engagement and awareness but are weaker in scenario planning). Such diagnostic insight enables targeted interventions – curricula might be adjusted to include more scenario-based learning, strategic foresight exercises, or debates about future risks and opportunities, depending on the areas that need improvement. Prior work has suggested that well-designed educational activities (like scenario simulations or future problem-solving tasks) can indeed bolster students' anticipatory thinking capacity (Suhendar et al., 2025; Mróz and Ocetkiewicz, 2024). With a validated tool, the effectiveness of these pedagogical innovations can be empirically evaluated.

Second, fostering anticipatory thinking aligns with broader educational goals, particularly in education for sustainable development (ESD) and 21st-century skills. Students equipped with strong ATS are arguably better prepared to navigate an increasingly complex, uncertain world. They may be more adept at envisioning alternative futures, weighing the long-term consequences of actions, and adapting to change, all of which are crucial for addressing challenges like climate change, technological disruption, and global pandemics. As noted in recent ESD literature, "a competence in anticipatory thinking should be one of the outcomes of formal education" to empower young people in the face of future challenges (Mróz and Ocetkiewicz, 2024; Wiek et al., 2011). Our research offers a practical framework to integrate that outcome: the seven ATS dimensions can be mapped to specific learning objectives or modules (for example, forecasting skills could be practiced in science classes via trend analysis projects, while Adaptability and Engagement might be nurtured through interdisciplinary projects that require students to respond to hypothetical future

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scenarios). Ultimately, using the ATS model in curriculum development could help cultivate students who are not only aware of global futures, but also feel capable of shaping those futures proactively. This is particularly relevant in the Malaysian context of rapid socioeconomic change, where today's students will become tomorrow's decision-makers facing novel problems. By strengthening anticipatory thinking in secondary education, we lay a foundation for a more forward-looking, resilient generation. While this study provides valuable insights into the structure of anticipatory thinking skills, several limitations should be acknowledged. First, the use of self-report questionnaires may introduce response biases, such as social desirability or overestimation of abilities. Second, the sample was limited to Malaysian secondary school students, which may restrict the generalizability of the findings to other cultural or educational contexts. Future research is encouraged to address these limitations by incorporating multiple assessment methods (e.g., interviews, behavioral tasks) and involving more diverse populations across regions and education systems.

Despite its contributions, this study has several limitations that open avenues for future research. One limitation is the sample scope: our data were drawn from 320 students in selected urban and rural schools, which, while diverse, may not capture the full cultural and regional variability within Malaysia. Replicating the ATS model validation with larger and more varied samples (including different states or ethnic groups, and even students in other countries) would enhance confidence in the model's generalizability. Cross-cultural comparisons could be particularly insightful – for example, would the eight dimensions hold equally well in other education systems, or might certain cultures emphasize additional facets of anticipatory thinking? Early evidence from Poland suggests some universality in the core of AT competence, but also points to contextual differences (such as gender norms affecting self-perception of futures thinking) (Mróz and Ocetkiewicz, 2024). Future studies could investigate whether similar patterns appear in Malaysian students or elsewhere, thereby enriching the normative understanding of ATS development across different populations. Another important direction is to examine the predictive validity and long-term impact of ATS. While we established structural validity (i.e. that the survey items indeed measure the intended latent constructs), it remains to be tested how these measured skills translate into real-world outcomes. Does a higher ATS score correlate with, say, better problem-solving performance, innovation, or academic/career planning success? Longitudinal research could track students with strong anticipatory thinking skills to see if they handle academic and life transitions more effectively than their peers. Conversely, intervention studies could be designed: for instance, implementing a specific "futures thinking" training program in a school and using the ATS instrument to gauge improvements pre- and post-intervention. Such research would inform whether improving ATS leads to measurable gains in student adaptability and strategic decision-making, a claim often theorized in futures education but needing empirical support. Additionally, exploring relationships between ATS and other psychological traits would be worthwhile. Geden et al. (2019) found anticipatory thinking was positively associated with traits like need for cognition and mindfulness; in adolescents, links with creativity, optimism, or even anxiety about the future would be interesting to assess. Identifying these relationships can help educators personalize approaches (for example, anxious students might need support to channel future-thinking in constructive ways, whereas more cognitively curious students might readily engage in foresight exercises).

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Finally, ongoing refinement of the ATS model itself should be considered. While the overall model fit was good, some fit indices (e.g., CFI just above 0.90) suggest there is room to improve item quality and reduce any redundancies between dimensions. Qualitative feedback from students on the survey items could reveal if any questions were confusing or if any important aspect of anticipatory thinking was not captured by the current seven domains. Future versions of the instrument might add or tweak items, especially for constructs like Engagement or Skill Development where theoretical definitions can be broad. Ensuring that each scale fully captures its intended meaning without overlap will tighten the model and potentially raise the model fit in subsequent validations. In addition, researchers could experiment with alternative modeling approaches, such as a second-order factor model (treating ATS as an overarching construct manifested through the seven first-order factors) or even bifactor models, to verify that the seven sub-dimensions all meaningfully contribute to a single underlying "anticipatory thinking" competency. Such advanced analyses were beyond the scope of our initial validation but would deepen the psychometric understanding of the ATS construct (Hair et al., 2022; Brown, 2015).

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Conflict of interest

The authors declare no potential conflict of interests with respect to research, authorship, and/or publication of this article.

REFERENCES

[1] Amos-Binks, A., Dannenhauer, D. (2019): Anticipatory thinking: A metacognitive capability. – ArXiv Preprint arXiv:1906.12249 13p.

[2] Amos-Binks, A., Dannenhauer, D., Gilpin, L.H. (2023): The anticipatory paradigm. – AI Magazine 44(2): 133-143.

[3] Brown, T.A. (2015): Confirmatory factor analysis for applied research. – The Guilford Press 462p.

[4] Geden, M., Smith, A., Campbell, J., Spain, R., Amos-Binks, A., Mott, B., Feng, J., Lester, J. (2019): Construction and validation of an anticipatory thinking assessment. – Frontiers in Psychology 10: 10p.

[5] Hair, J.F., Jr., Black, W.C., Babin, B.J., Anderson, R.E. (2014): Multivariate data analysis. – Pearson Education 734p.

[6] Hair, J.F., Jr., Hult, G.T.M., Ringle, C.M., Sarstedt, M. (2022): A primer on partial least squares structural equation modeling (PLS-SEM). – SAGE Publications 384p.

[7] Mróz, A., Ocetkiewicz, I. (2024): Anticipatory thinking as a key competence in management for sustainability: The results of research among Polish teenagers. – Sustainability 16(22): 17p.

[8] National Academies of Sciences, Engineering, and Medicine (NASEM) (2018): Learning from the science of cognition and perception for decision making: Proceedings of a workshop. – The National Academies Press 78p.

[9] Suhendar, S., Widodo, A., Solihat, R., Riandi, R. (2025): Students' future thinking skills: Implications for school education programs. – Journal of Pedagogical Research 9(1): 254-273.

[10] Wiek, A., Withycombe, L., Redman, C. (2011): Key competencies in sustainability: A reference framework for academic program development. – Sustainability Science 6(2): 203-218.

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https://doi.org/10.55197/qjssh.v7i4.1301