



PRACTITIONER RESEARCH

<https://e-journal.uum.edu.my/index.php/pr>

How to cite this article:

Yahaya, N. A. D., & Hussin, A. Z. (2024). Validity and reliability instrument of mathematics teachers' perception on 21st century learning. *Practitioner Research*, 6, July, 115-133. <https://doi.org/10.32890/pr2024.6.7>

VALIDITY AND RELIABILITY INSTRUMENT OF MATHEMATICS TEACHERS' PERCEPTION ON 21ST CENTURY LEARNING

¹Nur 'Aina Damia Yahaya & ²Ahmad Zaidi Hussin
School of Education, Universiti Utara Malaysia, Malaysia

¹Corresponding author: damiayahaya@gmail.com

Received: 2/2024

Revised: 5/2024

Accepted: 6/2024

Published: 12/2024

ABSTRACT

21st century learning (PAK21) is among the most well-known educational phenomena in Malaysia nowadays in the face of IR4.0. In order to enter the era of the 21st century learning, mathematics teachers required to discover advance methods, strategies and teaching techniques so that generation Z is able to navigate IR 4.0 while able to sustain national identity and possess high spiritual values. This study conducted a survey of 30 primary school mathematics teachers on 21st Century Learning in Jitra, Kedah. This study examines the validity and reliability of the instrument from the perspective of mathematics teachers on 21st century learning. The results found that the validity test, which is Bartlett's test of sphericity and Kaiser-Mayer-Olkin (KMO) of sampling adequacy, is significant. Next, the reliability test shows a significant value when Cronbach's Alpha value is 0.941.

Keywords: 21st century learning, Bartlett's sphericity, mathematics teacher, validity, reliability.

INTRODUCTION

The expansion of science and technology has changed the world. Without realizing it, the world is now in the era of the 4th Industrial Revolution (IR4.0). The term IR4.0 means the 4th phase of the expansion of capitalism's technology which is the appearance of cyber-physical technologies such as robotics and artificial intelligence. In line with the explosion of this industrial revolution transition wave, transformation in the national education system is an unavoidable necessity (Nor Atika Jalil & Siew, 2022a). The 21st century learning (PAK21) is educational phenomena that among the most well-known in Malaysia nowadays in the face of IR4.0. In order to enter the era of the 21st century learning, mathematics teachers required to discover advance methods, strategies and teaching techniques so that generation Z is able to navigate IR 4.0 while able to sustain national identity and possess high spiritual values.

The Malaysian Ministry of Education (2012) also suggested the needs of teachers in facing the transformation of education, especially from the aspect application of technology and communication based on the requirements of the 21st century education world. In accordance with Jalil and Siew (2022a), 21st century learning began to be implemented on a pilot basis in Malaysia starting in 2015 and has sprouted little by little. Studies related to the implementation of the 21st century PdP have also been vigorously carried out since 2015. The PAK21 process uses information technology-related resources as the primary source of knowledge and makes use of all facilities, including computers, multimedia, CDs, and the Internet, to aid students in their learning.

In order to identify significant economic achievement, government need a proactive workforce. A paradigm change is a required to enable the country's economy to grow more robust and more stable in accordance with industrialized nations given its increasingly difficult economic accomplishment level (Iberahim et al., 2019). Industry and the job market emphasize the aspect of competence and competent skills among employees. Employees not only act as human capital, but can also create expertise and knowledge abilities in assisting research and change in their workplace interventions. However, constraints and weaknesses in using knowledge and skills holistically often limit a person from expanding their abilities and competencies (Saleh & Rosli, 2019).

A country's strength and development are primarily relying on the knowledge and skills of its citizens. Therefore, education system needs to be given a large mandate as a vehicle for imparting knowledge and skills to its people. The world community believes that knowledge and skills are vital for learners to face specific challenges in the 21st century. Even though there are dissimilarity in terms of the meaning of the terminology of 21st century skills between countries in the world, they all emphasize knowledge, skills and values (Mohamad Zaid Mustafa et al., 2018). In relation to that, Malaysia has experienced a transformation in the field of education where the Malaysian Education Development Plan 2013-2025 emphasizes four elements, namely communication, critical thinking, collaboration and creativity to produce students who can be competitive and quality by the 21st century.

According to Mustafa et al. (2018), education in the early 20th century focused more on obtaining fundamental abilities, namely reading, writing and counting. Majority of schools do not teach the skills to read and think critically or to solve complex problems. However, in the 21st century, teaching and assessment do not focus on basic skills alone but rather on thinking skills, life and career skills and values. By 2020, Malaysia aims to become a developed country according to its own standards, which is to achieve balanced progress in terms of economy, politics, social, spirituality and culture. Therefore, the field of education still needs improvement and special attention in order to be able to make the final leap to be recognized as a developed country which is portrayed in Vision 2020. In an effort to compete with the most advanced countries in the world, an educated youth generation that is capable of thinking critically and creatively and being able to communicate effectively at a national scale must be produced by the educational system,

The government must thus create a generation that fosters innovation and competitiveness in a wide range of fields, particularly in those related to education, the economy, technology, and other areas (Iberahim et al., 2019). In relation to that, today's society is urgent in improving knowledge, skills and abilities as early as in the early education stage of life. In fact, in line with the drastic paradigm and time shift, education based on the concept of the 21st century is increasingly highlighted and realized in the context of teaching and learning consistently and systematically (Saleh & Rosli, 2019).

PROBLEM STATEMENT

In this era of globalization, 21st century learning is an educational phenomenon that is given much attention in going through IR4.0 (Jalil & Siew, 2022). Current changes cause having knowledge alone is not enough. Students need to have the ability to think at a high level, have a high level of innovation and the ability to solve every problem (Sahari & Mahamod, 2018). Teachers should explore new methods, strategies and approaches to keep pace with 21st century learning. Teachers' willingness to change the education system must be emphasized by superiors. It is because teachers are the main leaders in the field of education who will apply the learning characteristics of the 21st century to students (Jalil & Siew, 2022).

The Malaysian Ministry of Education has emphasized the national education system by implementing the Primary School Standard Curriculum (KSSR) and Secondary School Standard Curriculum (KSSM) in 2014 to meet the needs and wants of the current generation of students. Teachers who act as effective transformation agents to hone 21st century learning skills in students. Learning activities that are relevant, interesting and student-centred can encourage students to have high-level thinking abilities, innovation and problem-solving abilities. This makes the main focus of the National Education Development Plan (2013-2025) in line with the 4K features of 21st century learning explicitly explained by UNESCO; Communication, Critical Thinking, Collaboration and Creativity. Therefore, 21st century learning is seen as a critical need to encourage learners to deal with the current challenges of globalization (Nor Atika Jalil & Siew, 2022b).

The execution of 21st century learning in Malaysia is a new topic, and research on it is still ongoing. Various research in the education field related to the implementation of 21st century learning with certain variables have been studied. Among the studies related to 21st century learning are related to work craft (Hashimah Yusoff et al., 2019), school psychosocial environment and teacher self-efficacy (Amatan & Han, 2019) as well as PAK21 practices and challenges (Mohd Rusdin & Ali, 2019). Despite this, research that really presents theories and models related to 21st century learning within the framework of the 21st century is still limited, especially in Malaysia. Therefore,

this study adapted the 21st Century Teaching and Learning Survey (21CTLs) instrument by Jalil and Siew (2022) to suit the context of primary school mathematics teachers and determine the validity and reliability to ensure that this instrument is able to be used in the actual field.

LITERATURE REVIEW

The literature review showed that the implementation of 21st century learning obtained different findings across research areas and years. Past studies involving the implementation of 21st century learning included various subject areas and study sample types. Rouhani et al. (2019) and Raja Abdullah and Daud (2018) show that PAK21 is being implemented at a good level. It proves teachers can implement government policies as a result of teachers' awareness of their accountability. Rouhani et al. (2019) found that the level of 4C practice applied by Basic Vocational Education (BAV) teachers was at a high level. Overall, the domains of creativity, critical thinking, and collaboration are at a moderate level, while communication and value aspects are at a good level. Raja Abdullah and Daud's study (2018) found that knowledge and 4C concepts applied by trainee teachers were at a high level.

However, the literature also shows that the implementation of PAK21 is practiced at a moderate and low level. This situation proves that the level of execution of PAK21 actually depends on the teacher as the main individual in the classroom (Jalil & Siew, 2022a). Mashira et al. (2019), for example, although their study found that the practice of PAK21 in the *PdPc* of teachers in primary schools can be implemented successfully, but the situation is still in the unsatisfactory category. Improvements need to be made because there are teachers who still do not understand what PAK21 is and do not master current technology. The study by Ahmad et al. (2019) which was conducted on lecturers of Malaysian Institutions of Higher Education, showed that the lecturers adopted the PAK21 approach during learning sessions. Among the skills applied are communication, collaboration, critical thinking, creativity and innovation, as well as integrating technology in *PdPc*.

Figure 1

Framework of 21st Century Learning



Figure 1 shows the Framework of 21st century learning that introduced by the organization Partnership for 21st Century Skills. The 21st century learning framework, which drafted in 2002 has 18 different skills. There are four components of core knowledge and skills that learners required to master within the framework of PAK21 including 'Basic Subjects and 21st Century Themes', 'Learning and Innovation Skills', 'Information, Media and Technology Skills' and 'Life and Career Skills'. At first, the framework was seen as perfect, but in 2010 they discovered that this framework was too long and complicated. After analyzing this framework, the National Education Association (NEA) of the United States came to the consensus conclusion that the four most crucial skills, which are critical thinking skills, communication, collaboration and creativity are sufficient (NEA, 2010). These four specific skills are also known as the 4C Concept.

According to (Mustafa et al., 2018), critical thinking which includes the ability to analyze information and offer solutions to problems, is an essential skill in 21st century education. This critical thinking skill can be fostered when the teacher changes the teaching method from giving information towards students to asking students in order to find out the information themselves. Teaching activities that promote

critical thinking can help students apply it in the outside world. The second skill is communication, where students must be able to filter, differentiate and identify true and false information and how that information can be used. In addition, communication in the 21st century is not limited to sharing information in a clear, concise and concise manner, but also includes the choice of appropriate forms of communication and the ability to manage conflicts and establish effective interactions with people from various backgrounds, cultures and countries (NEA, 2010).

Collaboration or cooperation between students is one of the skills in order to achieve their goals. NEO (2010) states that students in the 21st century need to have some collaborative skills. Among them, the ability to work effectively and respect others, show flexibility to compromise in achieving goals as well as accept shared responsibility for collaborative task and appreciate the accomplishments of group members. Creativity is often associated with innovation and 'thinking outside the box'. Creativity is an important issue in the field of education and has become one of the main agendas of the country (Yusoff et al., 2018). Cultivating creativity in the classroom is a key requirement in the education system and among the agendas that are given attention in the development of education in Malaysia. The implementation of this creative practice is able to create a conducive learning atmosphere, build students' cognitive development, predict academic achievement and success and make learning more meaningful (Jalil & Siew, 2022a).

METHODOLOGY

Research Design and Sample

The design of this study is a quantitative study. A quantitative research method involves quantifying and analyzing variables to obtain results (Apuke, 2017). They defined quantitative research methods as the process of elucidating an issue or phenomenon by collecting numerical data and analyzing it using mathematical techniques, especially statistics. This study was conducted by survey method. A survey study was conducted on 30 Mathematics teachers selected in the Jitra district, Kedah, who teach the subject of Mathematics in primary schools.

Research Objective

The research objective was addressed:

1. To test the validity and reliability instrument of Mathematics Teachers' Perceptions on 21st Century Learning.

Research Question

The research question was addressed:

1. What are the values of validity and reliability instrument of Mathematics Teachers' Perceptions on 21st Century Learning?

Research Instrument

The main instrument used in this study is questionnaire. The use of questionnaire instrument is suitable for obtaining data, especially for quantitative research that requires a sample size that is adequate and comprehensive (Nor Atika Jalil & Siew, 2022a). This study has adopted an instrument of Jalil & Siew (2022a) that conducted a study on teachers' perceptions regarding 21st century learning in Sabah. Table 1 shows the questionnaire that has been used in this study. This study retains the questions in Malay for distribution to respondents. However, the questionnaire in English is provided in Appendix 1 for the reference of other researchers.

The questionnaire in this study consists of 20 items representing the four constructs of PAK21 implementation, namely five items of Communication, five items of Collaboration, five items of Critical Thinking Skills and five items of Creativity and Innovation Skills. The measurement scale used in this section is five-point Likert scale, from 1 (Very rarely) to 5 (Very Often). Therefore, all item statements in this section are positive. The distribution of items according to the construct for the PAK21 implementation variable is shown in Table 1.

Table 1*Instrument of the Study*

Construct	Construct Definition	Item	Statement
Kemahiran pemikiran kritikal	Menggalakkan murid berfikir secara kritikal dalam menyelesaikan masalah Matematik.	1	<i>Saya menggalakkan murid saya...</i> Membandingkan maklumat daripada pelbagai sumber sebelum menyelesaikan tugas. (contoh: rujukan perpustakaan, internet)
		2	Membuat kesimpulan berdasarkan analisis maklumat yang relevan.
		3	Membuat ringkasan sendiri berdasarkan apa yang telah dibaca/ diajar. Menganalisis
		4	Menganalisis penyelesaian terhadap sesuatu masalah melalui perbincangan.
		5	Membina hujah yang meyakinkan melalui pencarian pelbagai sumber (contoh: rujukan perpustakaan, internet)
Kemahiran Kolaborasi	Menggalakkan murid berkerja dalam kumpulan dalam menyelesaikan tugas matematik yang diberi.	6	Bekerja secara berpasangan/ kumpulan kecil untuk menyelesaikan tugas bersama-sama.
		7	Berbincang melalui aplikasi digital untuk menyelesaikan tugas kumpulan. (contoh: whatsapp, facebook, telegram dll)
		8	Mencipta produk bersama menggunakan sumbangan daripada setiap pelajar.
		9	Bekerja sebagai satu kumpulan untuk memberikan maklum balas mengenai kerja kumpulan atau produk.
		10	Memberi maklum balas terhadap idea murid lain secara rasional.

(continued)

Construct	Construct Definition	Item	Statement
Kemahiran Komunikasi	Menggalakkan murid menyampaikan idea secara berani dan berfikiran terbuka dalam berkongsi pendapat. Kemahiran	11	Merangka data untuk digunakan dalam hasil kerja bertulis (contoh: membuat carta, jadual atau graf).
		12	Memindahkan idea menggunakan medium yang berbeza (cth: poster, video, ppt dll.)
		13	Membentangkan hasil kerja melalui pelbagai platform. (contoh: kertas mahjong, power point presentation dll)
		14	Menjawab soalan yang diajukan dengan yakin.
		15	Memilih cara tersendiri untuk membentangkan hasil kerja mereka.
		16	Menggunakan teknik penjanaan idea seperti sumbangsaran/ peta konsep dalam merancang sesuatu tugasan.
Kemahiran Kreativiti dan Inovasi	murid menggunakan pengetahuan sedia ada untuk mencipta pengetahuan baru sesuai dengan konteks matematik.	17	Menjana idea mereka sendiri untuk menyelesaikan soalan.
		18	Menggunakan kaedah penyoalan yang bersesuaian dengan situasi bagi mencungkil idea.
		19	Mencipta penyelesaian daripada masalah bukan rutin.
		20	Mengemukakan idea tanpa membataskan dari sudut betul atau salah.

DATA COLLECTION AND ANALYSIS METHODS

Due to constraints to fill in the questionnaire face-to-face, the questionnaire is distributed online in the form of a google form through a special link to the heads of the mathematics committee of the schools involved to be distributed to other mathematics teachers. This study uses a simple random sampling method because each element in the population has the same chance to be chosen as a study sample (Mohamad Zaid Salleh et al., 2018). According to Cooper and Schindler (2011), 30 respondents is sufficient because between 25 and 100 people is the appropriate number of respondents in a study. Yusoff et al. (2018) also stated that the minimum amount of respondents for a pilot study that aims to conduct an initial study or scale development is 30 people.

This study analyzes the validity and reliability using Exploratory Factor Analysis (EFA) and Cronbach's Alpha for the instrument. Factor analysis known as a vital procedure in order to identify, reduce and rearrange questionnaire items depending on the strength of the correlation between items in certain constructs under the study variable (Wahab, 2022). the validity of this research instrument was analyzed using the data collected for th purpose of conduct Exploratory Factor Analysis (EFA). According to Hair (2018), there are two tests, namely Bartlett's test of sphericity and Kaiser-Mayer-Olkin (KMO) of sampling adequacy that need to be carried out to confirm that the data is suitable for factor analysis. EFA was carried out utilising the Promax Rotation technique and Principal Components Analysis (PCA) as a way to find out the scale's construct validity once the data is appropriate for factor analysis was confirmed (Ruştioğlu et al., 2021). SPSS 29.0 program package was used in analyzing validity and reliability. Through Factor Analysis, the indices will be identified and should have the values recommended by (Hair, 2018) as in Table 2.

Table 2

Suggested Values for Exploratory Factor Analysis (EFA) Model Indexes

Exploratory Factor Analysis (EFA) Model Indexes	Suggested Values
Bartlett's test of sphericity	< 0.05
Kaiser-Mayer-Olkin (KMO) of sampling adequacy	> 0.50

The findings of the factor analysis are referenced by the findings of the Keiser-Meyer-Olkin (KMO) test as well as the Bartlett Test of Sphericity to determine the appropriateness of the factors as a whole. The KMO test express multicollinearity while Bartlett's Test of Sphericity is used for the purpose of identifying whether the correlation between items is adequate for factor analysis. If two or more items exist same correlation value, thus it means that same aspect was evaluated by the items. This test helps researchers recognize whether the item is suitable or not for factor analysis (Wahab, 2022). This is necessary to make sure that inappropriate questionnaire items are removed and that the items are organized under one construct. In EFA, factor loading values less than 0.6 will be discarded. As reported by Wahab (2022) and Hair et al. (2018), a loading factor of less than 0.6 is not good. Items can be deleted if their factor loading value is less than 0.6 because they are deemed irrelevant to the assessment of the construct.

Table 3

Cronbach's Alpha Score Classification

Justification	Cronbach's Alpha value
Very High	> 0.90
High	0.70 – 0.89
Moderate	0.30 – 0.69
Low	< 0.30

With a view to acquire the reliability index of each construct in the questionnaire, Cronbach's Alpha value was utilized. The stability and internal consistency of the questionnaire are considered the research tool of reliability (Othman & Kassim, 2018). For the purpose of measuring the internal consistency of a construct, the Cronbach's Alpha value should be used as a reference (Cronbach, 1946). As a result, the Cronbach's Alpha Statistical Test was measured using Statistical Packages for Social Science (SPSS) software version 29 to examine the level of reliability of the data gathered and retrieved. Table 3 shows the classification of Cronbach's Alpha scores. Yusoff et al. (2018) said that the reliability index of a research instrument could be calculated using a Cronbach's Alpha value exceeding 0.60. Cronbach's Alpha scores between 0.70 and 0.80 are excellent and acceptable, whereas values below 0.60 are unacceptable. Next, a value that exceeds 0.90 is excellent, effective and at a high level

of consistency. Therefore, this study chose Cronbach's Alpha to determine the reliability of the research instrument.

RESULT

Validity

Kaiser-Meyer Olkin (KMO) and Bartlett Sphericity values were measured to assess the adequacy of the data for factor analysis. It is pointed that the value of KMO which above 0.8 is deemed good. While KMO value of less than 0.5 occurs when most of the zero-order correlations are negative, and the item is required to remove from the instrument (IBM, 2022).

Table 4 shows the findings of the Kaiser-Meyer-Olkin test and Bartlett's test of sphericity. This finding has been obtained from the calculation results of the SPSS 29.0 program package. This study found that the value of the Kaiser-Meyer-Olkin test is 0.639. According to Ruştioğlu et al. (2021), the KMO value obtained indicates the sample size for factor analysis was "marvelous". This is because the KMO value is higher than the desired KMO value, which is 0.5. The Bartlett Sphericity test's statistical result found that the instrument is significant ($\chi^2 = 549.737$, df: 190, $p < 0.01$). The significant results point out that the data came from a multivariate normal distribution. It clearly shows that the data acquired from the scale are acceptable for factor analysis. However, this study could not reach the pattern matrix because of the small number of samples, which were only 30 people. A small number of items can also affect the inaccessibility of the pattern matrix.

Table 4

Kaiser-Meyer-Olkin (KMO) Test and Bartlett's Test of Sphericity Results

Kaiser-Mayer-Olkin (KMO) Measure of Sampling Adequacy	0.639	
Bartlett's Test Of Sphericity	Approx. Chi-Square	549.737
	df	190
	Sig.	<.001

($p < 0.001$)

Reliability

Table 5 indicates the reliability test's results. This study measures the reliability of the instrument using Cronbach's Alpha coefficient test also by using SPSS 29.0 program package. Reliability analysis was conducted on all items of the questionnaire of this study. The researcher found an alpha value of 0.941 through analysis using SPSS. The value of this reliability index clearly shows that this instrument can be used very well for real research. Data analysis involves the process of analyzing the data that has been obtained through the questionnaire. The researcher used the score analysis method according to a five-point Likert scale to analyze the results of the data obtained during the study. The data obtained through the questionnaire will be measured descriptively by utilizing a simple count based on the number of respondents' answers answered according to the set Likert Scale.

Table 5

Cronbach's Alpha Result

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.941	0.946	20

DISCUSSION

This study has discussed the validity and reliability of the PAK21 instrument based on the perception of primary school mathematics teachers. The determination of validity and reliability is a method used in the pilot study to improve the quality of the questionnaire items that allow to be used in the actual study. The PAK21 instrument was found to have high validity in evaluating the implementation of 21st century learning of secondary school mathematics teachers. The type of validity used in this study is Exploratory Factor Analysis (EFA). The value of the Kaiser-Mayer-Olkin (KMO) test which is 0.639, was higher than the recommended value. Construct validity shows that the items measure the construct intended to be measured. This shows that all these items can be used in the actual study later.

Next, the reliability value which was Cronbach's Alpha has been implemented for this instrument is also high quality and practical with a high consistency level of 0.941. Therefore, the PAK21 Instrument

is suitable for measuring the implementation of 21st century learning among primary school mathematics teachers. The validity and reliability analysis results can help the researcher ensure that the administered questionnaire can answer the research questions and be implemented effectively in the actual study. In conclusion, this study prove that the PAK21 Instrument can be used for secondary school mathematics teachers to assess the level of implementation of 21st century learning in classroom.

Some suggestions are presented to help future researchers to conduct research better. Since this study did not achieve a pattern matrix, this study suggests that future researchers use a larger sample. The suggestion is to use a larger number of respondents because Othman & Kassim (2018) state that EFA requires a large number of respondents which is 100. This allows the results to be more accurate. In addition, future researchers can increase the number of items to produce better findings. Besides, future researchers also can further expand the scope of study, for example, not only for mathematics teacher but also other subjects' teacher.

REFERENCES

- Ahmad, Syahrul Ahmar & Yoke, Soo & Yunos, Rahimah & Mohd Amin, Juyati. (2019). Exploring Lecturers' Readiness for 21st Century Education in Malaysian Higher Learning Institutions. *European Journal of Teaching and Education*. 1.15-29. 10.33422/EJTE.2019.10.27.
- Amatan, M. A. & Han, C. G. K. (2019). Pengaruh Persekitaran Psikososial Sekolah dan Efikasi Kendiri Guru Terhadap Amalan Pengajaran dan Pembelajaran Abad Ke-21. *International Journal of Education, Psychology and Counseling, Counseling*, 4(32), 301-331
- Cronbach, L. J. (1946). Response Sets and Test Validity. *Educational and Psychological Measurement*, 672-683.
- Hair, J. F., Babin, B. J., Anderson, R. E., & Black, W. C. (2018). *Multivariate data analysis*. 8th Ed. United Kingdom: Cengage Learning.
- Apuke, O. D. (2017). Quantitative research methods : A synopsis approach. *Kuwait Chapter of Arabian Journal of Business and Management Review*, 6(11), 40–47. <https://doi.org/10.12816/0040336>

- Hashimah Yusoff, Mohd Isa Hamzah, & Shahlan Surat. (2019). Kesahan dan kebolehpercayaan instrumen kraf kerja. *Jurnal Pendidikan Malaysia*, 44(2), 61–71.
- Iberahim, A. R., Mahamod, Z., & Wan Mohamad, W. M. R. (2019). Pembelajaran Abad Ke-21 Dan Pengaruhnya Terhadap Sikap, Motivasi Dan Pencapaian Bahasa Melayu Pelajar Sekolah Menengah. *Jurnal Pendidikan Bahasa Melayu - JPBM (Malay Language Education Journal-My LEJ)*, Vol.7, 77–88. <http://spaj.ukm.my/jpbm/index.php/jpbm/article/view/152>
- Mohamad Zaid Mustafa, Mohd Sa'ari Mohd Salleh, Rosnee Ahad, & Abdul Rasid bin Abdul Razzaq. (2018). Kemahiran berfikir aras tinggi (KBAT) dalam kalangan guru Pendidikan Islam Sekolah Menengah Kebangsaan Daerah Batu Pahat , Johor. *Human Sustainability Procedia*, 21, 18–28.
- Mohamad Zaid Salleh, Mohd Sa'ari Mohd Salleh, Ahad, R., & Razzaq, A. R. bin A. (2018). Kemahiran berfikir aras tinggi (KBAT) dalam kalangan Guru Pendidikan Islam Sekolah Menengah Kebangsaan Daerah Batu Pahat , Johor. *Human Sustainability Procedia*, 21, 18–28.
- Nor Atika Jalil, & Siew, N. M. (2022a). Kesahan dan kebolehpercayaan instrumen pembelajaran abad ke- 21 guru matematik sekolah menengah menggunakan model pengukuran rasch. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 7(3), e001319. <https://doi.org/10.47405/mjssh.v7i3.1319>
- Nor Atika Jalil, & Siew, N. M. (2022b). Kesahan dan kebolehpercayaan instrumen pembelajaran abad ke- 21 guru matematik sekolah menengah menggunakan model pengukuran rasch. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, 7(3), 15. <https://doi.org/10.47405/mjssh.v7i3.1319>
- Nor Shela Saleh, & Mohd Shafie Rosli. (2019). Kepentingan pembelajaran abad ke 21 terhadap potensi kebolehpasaran modal insan. *Innovative Teaching and Learning Journal*, 2(2), 71–81.
- Othman, M. S., & Kassim, A. Y. (2018). Kesahan dan Kebolehpercayaan Instrumen Komposisi Pengajaran Guru Pendidikan Islam Sekolah Rendah yang Mengintegrasikan Kemahiran Berfikir Aras Tinggi (KBAT) Menerusi Pengajaran Akidah. *Sains Humanika*, 10(3). <https://doi.org/10.11113/sh.v10n3.1297>
- Ruştiođlu, O., Avciođlu, H., Karanfiller, T., & Adalier, A. (2021). Assistive Technologies Usage Skills Assessment Scale:

- Validity and Reliability Study. *TOJET: The Turkish Online Journal of Educational Technology*, 20(1), 10–18. <https://www.researchgate.net/publication/348607172>
- Sahari, S., & Mahamod, Z. (2018). Persepsi guru Bahasa Melayu sekolah menengah terhadap Kemahiran Berfikir Aras Tinggi dalam pengajaran dan pembelajaran. *Seminar Pascasiswazah Pendidikan Bahasa Melayu & Pendidikan Kesusasteraan Melayu*, 4(1), 25–44.
- Wahab, N. J. A. (2022). Penggunaan Analisis Faktor Penerokaan (Efa) Bagi Pengujian Kesahan Instrumen Perkongsian Pengetahuan. *Jurnal Ilmi*, 12, 127–133.
- Yusoff, H., Hamzah, M. I., & Surat, S. (2018). Kesahan dan Kebolehpercayaan Instrumen Indeks Pemupukan Kreativiti dalam Pengajaran Guru dengan Elemen Islam (I-CFTI) Berdasarkan Pendekatan Model Rasch. *Jurnal Pendidikan Malaysia SI*, 1(1), 77–88. <http://dx.doi.org/10.17576/JPEN-2018-43.03-09>

Appendix 1

Instrument of the study in English Language

Construct	Construct Definition	Item	Statement
Critical Thinking Skills	Encourage students to think critically in solving mathematical problems.	1	Compare information from various sources before completing the assignment. (example: library reference, internet)
		2	Draw conclusions based on analysis of relevant information.
		3	Make their own summary based on what has been read/taught.
		4	Analyse the solution to a problem through discussion
		5	Build a persuasive argument through the search of various sources (eg: library references, internet)
Collaboration Skills	Encourage students to work in groups to complete the math tasks given	6	Work in pairs/small groups to complete assignments together.
		7	Discuss through digital applications to complete group assignments. (example: whatsapp, facebook, telegram etc)
		8	Create a joint product using contributions from each student.
		9	Work as a group to provide feedback on group work or products.
		10	Give feedback to other students' ideas rationally.

(continued)

Construct	Construct Definition	Item	Statement
			I encourage my students to...
Communication Skills	Encourage students to present ideas boldly and be open-minded in sharing opinions.	11	Formulate data for use in written work (example: create charts, tables or graphs).
		12	Communicate ideas using different mediums (eg: posters, videos, ppt etc.)
		13	Present work through various platforms. (example: mahjong paper, power point presentation etc.)
		14	Answer the questions asked confidently.
		15	Choose their own way to present their work.
Creativity and Innovation Skills	Encouraging students to use existing knowledge to create new knowledge under the mathematical context.	16	Use idea generation techniques such as brainstorming/concept maps in planning an assignment.
		17	Generate their own ideas to solve the question.
		18	Use questioning methods appropriate to the situation to elicit ideas.
		19	Create solutions from non-routine problems.
		20	Present ideas without limiting from a right or wrong angle.