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Development and validation of upper secondary students' attitudes towards digital competence instrument in Malaysia

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ABSTRACT

Digital competency is increasingly vital for students in today's technology-driven world. Despite efforts to enhance digital skills in education, measuring students' attitudes toward digital competency remains a challenge, especially in developing contexts like Malaysia. This paper develops and validates the upper secondary students' attitudes towards digital competency instrument (USSADCI) in Malaysia, providing a psychometrically reliable and valid tool specifically designed while addressing a gap in previous research. Using the Rasch measurement model (RMM), the USSADCI measures constructs such as digital technology application, problem-solving, interpersonal skills, data and information literacy, content creation, digital security, and digital citizenship. A survey method was employed, collecting 47 feedback from students in the urban secondary schools and 43 feedback from the rural secondary schools in the State of Perak. The analysis found that the reliability of the item was 0.96 with a separating index of 4.77. While the respondent's reliability was 0.92 with a separating index of 3.42. The 14 items were removed due to misfit, resulting in a final 42-item instrument. The study concludes that USSADCI is a robust tool for measuring digital competence attitudes in secondary education. Future research should expand its use to other regions and demographics, exploring the longitudinal impact of digital competence attitudes on students' academic performance and digital readiness.

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1. INTRODUCTION

Attitude towards digital competency refer to an individual's beliefs, perceptions, and tendencies about their digital skills. Attitudes are important for effectively applying digital competency [1], [2]. In education, attitudes towards digital competency can be assessed through multiple dimensions, including teaching and learning, critical thinking, and many more [3]. These dimensions not only highlight cognitive abilities but also emphasize the behavioral and emotional aspects of technology use. Hence, students' attitudes towards digital competency also influence their engagement, utilization, and development [4], [5]. Therefore, understanding and fostering positive attitudes is a crucial step in helping students effectively engage with and utilise digital technologies.

Understanding students' attitudes toward digital competency helps to create effective educational strategies [6], [7]. Factors such as motivation and self-confidence in utilising digital technology play a key role in shaping attitudes among students [8]–[10]. Meanwhile, emotional intelligence, which includes abilities such as self-awareness, empathy, and self-regulation also significantly influences an individual's

capacity to handle challenges in learning digital technology [11], [12]. Students with higher emotional intelligence tend to have more positive attitudes towards technology and greater resilience when facing difficulties [13]. Thus, integrating emotional intelligence development with strategies to enhance digital competency is essential for producing adaptive and confident learners.

Previous studies have explored the relationship between attitude and digital competency, but there is a need for research on improving students' attitudes towards digital competency [14]. A reliable instrument is important to assess students' attitudes towards digital competency and identify areas that require intervention. Hence, lack of standard and reliable tools to measure students' attitudes towards digital competency can pose a significant obstacle to digital progress. Without proper measurement tools, it is difficult to assess the effectiveness of educational initiatives and guide policy decisions [15], [16]. The Malaysian Ministry of Education (MOE), in collaboration with the Malaysia Digital Economy Corporation (MDEC), introduced digital competency standards (DCS) in 2015 in order to address this need [17]. DCS were developed based on international digital competency models focusing on assessing cognitive, technological, and global citizenship skills. However, DCS does not fully capture students' attitudes toward digital competency, especially in context with the new digital era. This is critical in contexts of Malaysia, where digital technology integration in education is prioritised, yet measurement tools remain limited. Therefore, the development of upper secondary students' attitudes towards digital competency instrument (USSADCI) is expected to complement existing DCS by providing a more comprehensive understanding of how students' attitudes influence their learning behaviour and readiness to adopt new technologies.

The development of USSADCI requires a systematic approach by applying the model proposed by DeVellis and Thorpe [18]. Meanwhile, the Rasch measurement model (RMM), will be used to validate USSADCI in order to validate items and provide detailed information about respondents [19], [20]. RMM were used across multi-disciplines, including education, psychology, and health research. It offers a more holistic instrument view and improves the quality of the verification process [21]–[23]. The integration of RMM analysis into educational assessment can provide an important overview of students' attitudes towards digital competency and learning outcomes in the context of upper secondary students in Malaysia. It helps to understand the impact of digital competency on student engagement, learning experiences, and the effectiveness of interventions. Therefore, this study aims to, develop and validate USSADCI as a reliable tool for assessing the attitudes of upper secondary school students in Malaysia.

2. METHOD

The process of developing and validating the USSADCI in this study was implemented by applying the model proposed by Devellis. The process involved eight steps, as shown in Figure 1. These steps are divided into two phases, namely the instrument development phase and the instrument validation phase.

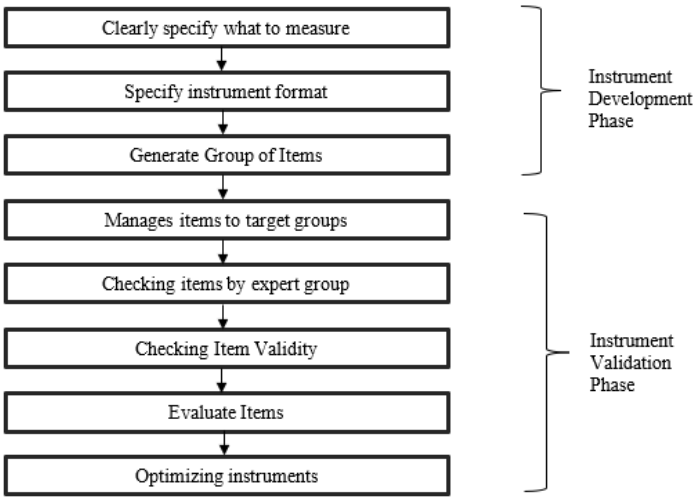

Figure 1. Instrument development and validation process

2.1. Instrument development phase

The instrument development phase involves essential steps to ensure the creation of a reliable and valid measurement tool. Phase one of the USSADCI development focuses on conceptualisation and item

generation. This begins with a systematic literature review (SLR) of articles published between 2000 and 2022. The SLR approach enhances decision-making, aids in analysis, and provides a structured methodology for assessing research quality [24], [25]. From the SLR, 14 articles met the criteria for designing upper secondary students' digital competency structures. Seven key constructs: digital technology application, problem-solving, interpersonal skills, data and information literacy, content creation, digital security, and digital citizenship were identified. The emotional fitness model [26] is integrated into the USSADCI, focusing on self-awareness, self-regulation, motivation, empathy, and social skills. The instrument is developed using a 3-point scale: "never", "sometimes", and "always", with items shown in Table 1.

Table 1. USSADCI items based on construct

Item code		Construct/item
Digital technology applications	B1	I find it easy to perform variety of tasks using digital technology
	B2	I use technology applications to solve variety of tasks
	B3	I am confident to collaborate with others using digital tools
	B4	I am open to learning and exploring new digital tools and technologies
	B5	I am critical when solving problems using digital technology
	B6	I frequently use online resources to improve troubleshooting
	B7	I can adapt well to new technology
	B8	I have always been patient with the challenges of using technology applications
Digital problem solving	C1	I identify the device's basic features first when I use it to solve the problem
	C2	I am motivated to use technology devices to solve problems in daily activities
	C3	I use a variety of alternatives in solving problems using computer digital technology
	C4	I can collaborate well to solve the problem using digital technology
	C5	I am looking for creative solutions using digital technology responsibly
	C6	I am looking for opportunities to keep learning and improve my digital skills in troubleshooting
	C7	I know the limitations of the use of technology in solving problems digitally
	C8	I am trying to tackle the challenge positively in solving problems using digital technology
Interpersonal skills	D1	I appreciate the work published by other people shared on the Internet
	D2	I am comfortable giving and receiving feedback from others during online interactions
	D3	I will think carefully about the information I'm going to share on social media
	D4	I maintain appropriate behaviour while interacting on social media networks
	D5	I reject a friend's request from a stranger through social media networks
	D6	I am prepared to report any cyber-terrorism against me or anyone who has experienced it
	D7	I always control what I broadcast because I'm aware of the impact if it becomes viral
	D8	I show empathy for the feelings of my peers in online discussions
Data and information literacy	E1	I organise information I save on my computer into a different folder
	E2	I always ask for permission from a friend before sharing their information on the Internet
	E3	I analyze information I obtained on the Internet before using it
	E4	I use internet confidently when I am looking about any information
	E5	I compare information obtained on the Internet before using it for any task
	E6	I am committing to ensure data privacy and confidentiality, as well as sensitive information
	E7	I am worry if classmates think all the information found on the Internet is true
	E8	I prioritize transparency in communicating data and information to others
Creating digital content	F1	I show positive qualities when communicating using digital tools
	F2	I enjoy discovering new ways to prepare for my assignment
	F3	I take a stance to discern any abuse on the Internet
	F4	I use programming and coding in my learning activities
	F5	I took the time to review my communications with others on social media
	F6	I prioritize user experience in creating digital content
	F7	I am always learning to improve my digital content creation skills
	F8	I am open to feedback or criticism to develop my content creation
Digital security	G1	I am trying to use an environmentally friendly technology device
	G2	I maintain responsibility in my online conversation
	G3	I browse the website, even though I know it's a phishing attempt or a fake website
	G4	I use Wi-Fi in public places, when I'm sure it's safe
	G5	I share the digital application password with my parents
	G6	I upload photos to the Internet and share personal and family information
	G7	I share content I obtained from online with caution
	G8	I keep accessing banking information online using a public Wi-Fi network
Digital citizenship	H1	I show honesty in digital interaction
	H2	I respect other people's views during online community discussions
	H3	I am trying to improve my digital literacy skills
	H4	I accept well the differences of opinion in the online community
	H5	I am always willing to work with people who don't know about the digital environment to achieve a common goal
	H6	I prioritize the safety of others over myself in an online environment
	H7	I make choices that have a positive impact on the digital community
	H8	I protect my and others' privacy in digital space

2.2. Instrument validation phase

The second phase is the validation phase of USSADCI that has been developed. The validation of USSADCI includes both content and construct validity. The validity of content was determined using the content validity ratio (CVR). It is a method for assessing items based on expert judgement. The 5 experts contributed to CVR: two university professors, one MOE officer, and two teachers teaching computer science basic subjects. The experts were selected through purposive sampling based on their expertise and relevance to the field. They evaluated each item using a 3-point scale: i) important; ii) useful but not important; and iii) not important. The 5 experts are adequate for conducting CVR analysis, provided that higher CVR thresholds are applied when panel size is small [27], [28]. Feedback was given by the expert team after evaluating the entire item [29], [30]. Numbers indicating "important" for each item were counted, and the critical value of the CVR is determined using the (1):

$$CVR=[ne–(N/2)]/(N/2) \quad (1)$$

where, ne is the number of experts indicating "important" and N is the sum of experts. The results of the CVR carried out show all the experts agreed all the items were accepted for continuation in this study.

Meanwhile, construct validity was tested through field studies. It aims to ensure that USSADCI developed can accurately measure what is intended to be measured. The RMM is used to assess the effectiveness of the USSADCI structure because it can provide more information about items and respondents studied [31], [32]. It predicts variables measurement using several indicators, i.e., items and respondents reliability, items and respondents separation index, item fit, item polarity, unidimensionality, and local independent analysis [33]. The survey participants consisted of form four students from two urban secondary schools and two rural secondary schools located in Kuala Kangsar District, as well as Larut Matang and Selama, Perak. Authorisation from the Ministry of Education and the Department of Education of Perak has been secured to conduct the field study. School authorities were also contacted, and a parent's consent form was distributed to authorise students' involvement in the field study. Once parental permission was obtained, the instrument link was notified to the coordinating teachers and students involved for the purpose of obtaining feedback on the study. This method is used because data retrieval is fast and accurate [34], [35]. Students were given a week to respond to USSADCI.

3. RESULTS AND DISCUSSION

The USSADCI was distributed to 50 respondents from each category of schools selected through random sampling within the chosen schools. However, the researcher only received a total of 47 feedback from students in the urban secondary school and 43 feedback from the rural secondary school, as in Table 2. The amount of feedback obtained is sufficient to be analysed using the RMM [36], which emphasizes the quality of data fit over sample size alone. A sample size of at least 30 to 50 respondents is adequate to achieve stable item calibration within ±0.5 logits at a 95% confidence level, provided the data fit the model requirements. In RMM, moderate sample sizes are acceptable as long as the data meet model fit criteria, allowing for valid item calibration and respondent measurement.

Table 2. Respondents' participation

Nos.	Secondary school category	School name	Number of respondents selected	Number of replies from respondents
1.	Urban	Sekolah Sains Raja Tun Azlan Shah, Taiping	25	22
		SMK Datuk Haji Abdul Wahab, Sungai Siput	25	25
2.	Rural	SMK Redang Panjang, Batu Kurau	25	20
		SMK Sultan Tajul Ariffin, Manong	25	23

3.1. Results

The advancement of digital technology implies how previous tools could not measure effectively. As a result, USSADCI was carried out to improve the existing instrument by assessing students' attitudes towards a broader construct of digital competency and keeping up with current technological advancements. The importance of USSADCI lies in its ability to assist educators in comprehending and enhancing the integration of digital competency into the curriculum. USSADCI is a psychometric tool that covers the statistical analysis of respondents' quality, instruments quality, and interaction between people and items [36], [37]. This is because students' attitudes towards digital competency can influence the way they interact with digital tools and technologies in learning. Therefore, the development of this specialised instrument to

measure attitudes towards digital competency can help to ensure that the data collected is relevant and accurate for the context of upper secondary education [38].

There were 56 items out of seven constructs that have been tested in this study. These items go through a process of content validity and construct validity to ensure they have high reliability and validity. Data obtained from field study were analysed using Winstep software version 4.4.7. Information on validity, reliability, item/respondent separation index, misfit items, polarity items, unidimensional items, and local independence items was obtained from the analysis. Based on the analysis of the RMM carried out, as in Table 3, it was found that the reliability of this instrument is at an excellent stage where the reliability value of the item is 0.96 and the respondent's reliability value is 0.92. Therefore, USSADCI is an excellent instrument [39]. While the separation index for the instrument developed is also at a good stage where the value of the item separation index is 4.77 and the respondent's separation index is 3.42 [31].

Table 3. Analysis based on RMM analysis

RMM analysis	Purpose	RMM analysis result	Quality/action indicator	References
Reliability	Shows to what extent the items in the instrument yield consistent results in a variety of circumstances	Item reliability: 0.96	Good	[39]
		Respondent reliability: 0.92	Good	[39]
Separation index	Shows the instrument's ability to distinguish between respondents by level	Item separation index: 4.77	Good	[39]
		Respondent separation index: 3.42	Good	[39]
Item fit	Shows the extent to which the respondent's answer to the item matches the RMM	Infit MNSQ: 0.52–2.47 Infit ZSTD: -4.15–7.40 Outfit MNSQ: 0.50–2.56 Outfit ZSTD: -4.11–7.67	A good item is an item that has an infit and outfit MNSQ value between 0.6-1.4 and ZSTD -2.0-+2.0. Items to pay attention: B5, B8, C4, D5, D7, E5, F7, H1, H3, H7, G3, G4, G5, G6, and G8.	[31], [36], [40]
Item polarity	Determines whether the item is positive or negative in relation to the measured construction	0.06–0.73	Items with polarity values above 0.30 are retained while below 0.30 and negative is given attention. Items given attention D5, G2, G3, G5, G6, G8, and H8.	[31], [36], [40]
Unidimensionality of items	Determines that the items in the instrument all measure the same aspect of the intended construction	Principal components analysis (PCA): 42.6%	Good	[31], [36], [41]
		Unexplained variance in 1st contrast: 5.1%	Good	
		Eigenvalue: 4.5958	Good	
Local independence item	Ensure that there is no relationship between residual items after considering the primary dimensions	-0.32–0.45	Locally independent	[31]

An analysis of item fit was performed to determine whether all items fit in the measured dimensions. Any item that has an infit or outfit mean square (MNSQ) value outside the range of 0.6 to 1.4 and a z-standardised (ZSTD) value outside of the range -2.0 to 2.0 is considered not fit [31], [36], [40]. The analysis revealed that items B5, B8, C4, D5, D7, E5, F7, H1, H3, H7, G3, G4, G5, G6, and G8 are outside the MNSQ and ZSTD infit and outfit range specified. These items require attention and reconsideration, as the inappropriate item will interfere with the measurement performed. Meanwhile, the polarity item analysis was performed to determine whether all items measuring students' attitudes towards digital competency and move in the same direction. The point-measure correlation (PTMEA CORR) values obtained were between 0.06–0.73. There were no negative values. However, PTMEA CORR values less than 0.30 are given attention for re-examination [31], [40], [41]. These items are D5, G2, G3, G5, G6, G8, and H8. Unidimensionality analysis of USSADCI was performed to identify correlation patterns between items based on residual [41]. This instrument has an empirical value of raw variance explained by measures of 42.6%, which indicates a good measurement dimension [40] and passes the minimum measuring dimension [31], [36]. The empirical value of unexplained variance in 1st contrast is 5.1%, which is good [39]. Standardised residual correlation analysis is also performed to ensure that no items intersect or correlate with each other. None of the items were found to have a correlation between each other since the resulting standardized residual correlation value is between -0.32–0.45 and not exceeding 0.70 [31].

3.2. Discussion

This study aimed to develop and validate USSADCI to fill the gap in existing literature regarding the quantitative measurement of students' attitudes toward digital competence. Previous studies have explored the relationship between digital competence and attitudes, yet none have offered a comprehensive psychometric tool like USSADCI with a broader construct of digital competency and keeping up with current technological advancements. This research specifically addresses the need for a validated instrument that includes key constructs such as digital security, digital citizenship, and problem-solving skills, which are vital for secondary education in Malaysia. In doing so, the study provides educators and policymakers with a valuable tool to measure and enhance students' digital competence [4], [6]. The RMM analysis confirmed the reliability and validity of USSADCI for measuring digital competence attitudes among secondary students. The reliability and validity of USSADCI are considered critically through a systematic approach to assessing the conformity of items with the measured basic structure [21]. The instrument showed excellent item reliability at 0.96 and respondent reliability at 0.92 [39], [40]. The separation index further indicated that the instrument could effectively distinguish between various levels of digital competence. Following expert review, 14 items were excluded due to misfit indices, and 3 were improved based on feedback [29]. Improvement of the item with expert approval is as shown in Table 4.

Table 4. Improving items with expert approval

Item	Original items	Improved items
G2	I maintain responsibility in my online conversation.	I ensured my online conversations are secure.
G4	I use Wi-Fi in public places when I am sure it's safe.	I make sure the public Wi-Fi is safe first before connecting to the device.
H8	I protect my and others' privacy in the digital space.	I try to protect the privacy of myself and others when interacting on social media.

The final version of the USSADCI consisted of 42 items, providing a robust and reliable measure of students' attitudes toward digital competence. By adhering to the standards set by the RMM, researchers can enhance the quality and accuracy of the measuring instruments. Our findings align with previous studies, such as those by studies [4], [6], which highlight the importance of self-confidence and problem-solving skills in shaping students' attitudes toward digital competency. Students with higher confidence in digital problem-solving tend to have more positive attitudes toward digital tools. While prior research often emphasises general digital literacy, the USSADCI uniquely focuses on specific constructs, offering a more detailed understanding of attitudes within. This is particularly crucial in the Malaysian educational context, where digital security and responsible digital citizenship are growing concerns.

The USSADCI offers new insights by breaking down digital competence into measurable constructs, contributing to a clearer understanding of how attitudes shape students' digital competency. Despite the promising findings, this study has limitations that could affect the generalisation of the results. First, the sample size, though adequate for RMM analysis, may not represent the full diversity of Malaysia's secondary school population, particularly in remote or under-represented areas. Additionally, reliance on self-reported data introduces potential bias, as students may respond in a socially desirable manner, thereby affecting the result. Future studies should address these limitations by including a broader demographic sample and incorporating performance-based measures or observational data. Expanding the participant pool and exploring alternative data collection methods could lead to more nuanced insights into students' digital attitudes.

The findings from this study offer several avenues for future research. As USSADCI is a newly validated tool, future studies could explore its application across other regions and educational contexts. Longitudinal studies would be particularly valuable in examining how students' attitudes toward digital competency evolve over time, especially as they encounter new technologies and digital learning environments. Further research could investigate the relationship between students' attitudes and their actual performance in digital tasks, thereby providing more concrete evidence of how attitudes affect learning outcomes. Additionally, the impact of targeted interventions aimed at improving digital competence should be explored, particularly in terms of how these interventions influence students' academic and personal development in a digitalised world. Overall, the discussion of this study shows a recurring process to carefully evaluate each item based on the established criteria. This process increases the instrument's reliability, thereby strengthening its credibility as a tool for measuring high school students' attitudes toward digital competence. The considerations of items analysis based on the RMM are presented in Table 5.

Table 5. Item consideration based on RMM analysis

Construct	Number of items	Improved items	Number of improved items	Drop item	Number of items dropped	Number of items keep
Digital technology applications	8	-	-	B5, B8	2	6
Digital problem solving	8	-	-	C4	1	7
Interpersonal skills	8	-	-	D5, D7	2	6
Data and information literacy	8	-	-	E5	1	7
Creating digital content	8	-	-	F7	1	7
Digital security skills	8	G2, G4	2	G3, G5, G6, G8	4	4
Digital citizenship	8	H8	1	H1, H3, H7	3	5

4. CONCLUSION

In conclusion, this study successfully developed and validated the USSADCI, offering a reliable and valid instrument for measuring secondary students' attitudes toward digital competency in Malaysia. The instrument addresses key constructs that provide educators and policymakers with critical insights for fostering digital competency in students. This instrument also can assist educators and policymakers in designing curricula that are relevant to digital competence, identifying strengths and weaknesses in technology teaching, and adapting teaching approaches based on student attitudes. While this makes USSADCI valid and reliable, attention should be paid to two constructs, namely digital security skills mastering and digital citizenship, since items in the construct show instability. Thus, future research can build on these findings by expanding the use of USSADCI and investigating its broader implications for digital competence across different contexts and demographics. As a result, a more thorough investigation can provide a clearer picture of the structure's measurements. As a conclusion, USSADCI is a tool capable of evaluating the digital competence attitude of upper secondary school students to detect and design more effective educational interventions to enhance the digital competences of upper secondary students in Malaysia.

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AUTHOR CONTRIBUTIONS STATEMENT

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors state that there was state no conflict of interest in the conduct or publication of this research. Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals who participated in this study. All participants were informed of the purpose, procedures, and voluntary nature of their involvement, and consent was obtained prior to data collection. The authors affirm that participants' privacy and confidentiality were strictly protected throughout the research process, in accordance with established ethical guidelines.

ETHICAL APPROVAL

The research involving human participants was conducted in compliance with all relevant national regulations and institutional policies, and in accordance with the tenets of the Helsinki Declaration. Ethical approval for this study was obtained from the Ethical Review Committee of Universiti Putra Malaysia (Reference No.: JKEUPM-2022-979). All procedures were reviewed and approved prior to the commencement of data collection to ensure the protection of participants' rights, safety, and confidentiality.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [NFAG], upon reasonable request. Due to privacy and confidentiality agreements with participating schools and respondents, the data are not publicly available. Any requests for access to the dataset should be directed to the corresponding author, who may provide anonymized data for academic and non-commercial research purposes.

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