

Evaluation of the Content and Face Validity of the STEM-TPACK Teaching and Learning Practice, Professional Development, Attitude, and Self-Efficacy Instrument (STPAS-I) among Polytechnic Lecturers

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DOI: <https://dx.doi.org/10.47772/IJRISS.2025.927000003>

Received: 12 November 2025; Accepted: 18 November 2025; Published: 26 November 2025

ABSTRACT

This study aimed to evaluate the content and face validity of the Science, Technology, Engineering, and Mathematics- Technological Pedagogical and Content Knowledge (STEM-TPACK) Teaching and Learning Practice, Professional Development, Attitude, and Self-Efficacy Instrument (STPAS-I) developed for Malaysian polytechnic lecturers. The STPAS-I consists of 69 items across four constructs: STEM-TPACK Teaching and Learning Practice, Professional Development, Attitude, and Self-Efficacy. A quantitative descriptive design was employed, involving seven experts in STEM education and psychometrics to assess item clarity, relevance, and representativeness. The Face Validity Index (FVI), Content Validity Index (CVI), and Content Validity Ratio (CVR) were used for analysis. Findings revealed that the FVI demonstrated excellent clarity and comprehensibility, with item-level (I-FVI) values ranging from 0.86 to 1.00 and an overall S-FVI/Ave of 0.99. For content validity, I-CVI values ranged between 0.86 and 1.00, with S-CVI/Ave values of 0.96 for STEM-TPACK Teaching and Learning Practice, 0.98 for Professional Development, 1.00 for Attitude, and 0.99 for Self-Efficacy. The CVR results also showed strong expert consensus, with 48 items achieving a perfect score of 1.00 and 8 items scoring 0.71, exceeding the acceptable threshold. Overall, the STPAS-I demonstrated high face and content validity, confirming its suitability for assessing STEM-related teaching competencies among polytechnic lecturers. Future research should focus on pilot testing and psychometric evaluation, including exploratory and confirmatory factor analyses for broader educational settings.

Keywords: STEM-TPACK, professional development, attitude, self-efficacy, content validity, face validity

INTRODUCTION

In recent years, integrating Science, Technology, Engineering, and Mathematics (STEM) education with Technological Pedagogical and Content Knowledge (TPACK) has become a global educational priority. The STEM-TPACK framework highlights teachers' ability to effectively incorporate technology in teaching STEM content, fostering students' higher-order thinking and problem-solving skills (Tan, Purwaningsih, Taqwa, Putri, & Kurniawan, 2024; Chai, Jong, & Yan, 2020; Chai, Rahmawati, & Jong, 2020; Thibaut et al., 2018; Mishra & Koehler, 2006). In Malaysia, the Ministry of Higher Education (MOHE) continues to emphasize STEM-focused teaching in polytechnics, aiming to equip graduates with interdisciplinary skills that support the Fourth Industrial Revolution (IR 4.0) agenda (Idris & Bacotang, 2023; Zaid & Kamin, 2023; Azman & Ibrahim, 2023; Zulnaidi, Abdul Rahim, & Mohd Salleh, 2020).

However, effective STEM-TPACK implementation depends heavily on lecturers' professional development, attitudes, and self-efficacy toward teaching innovation (Mansour, Said, & Abu-Tineh, 2024; Wilson, Riggs, & Bohn, 2023). Professional development ensures that lecturers acquire up-to-date pedagogical and technological

competencies, while positive attitudes and strong self-efficacy influence their motivation and confidence to apply integrated STEM teaching strategies. Despite growing attention to these factors, there remains a lack of validated instruments specifically designed to measure polytechnic lecturers' STEM-TPACK teaching and learning practices alongside professional development, attitude, and self-efficacy constructs in the Malaysian context.

Instrument development in educational research requires rigorous validity evaluation to ensure that the instrument accurately measures the intended constructs (Setiawan, Wagiran, & Alsamiri, 2024; Zamanzadeh et al., 2015; Polit & Beck, 2006). Two critical aspects of validity are content validity and face validity. Content validity assesses the extent to which items adequately represent the construct domain, typically judged by experts through quantitative indices such as the Content Validity Index (CVI) (Ahmad Fakhri & Idris, 2025; Kamarulzaman, Mohamed Shuhidan, Abdul Wahab, & Toha, 2023). Face validity examines the clarity, relevance, and comprehensibility of items from the perspective of potential respondents, ensuring the instrument appears suitable and unambiguous in the target context (Ibrahim & Mohd Matore, 2024). Establishing both types of validity is essential before proceeding to large-scale data collection or advanced analyses such as factor analysis or structural equation modelling (Keetharuth, Brazier, Connell, Kharicha, & Forbes, 2018).

Therefore, this study aims to evaluate the content and face validity of the STEM-TPACK Teaching and Learning Practice, Professional Development, Attitude, and Self-Efficacy Instrument developed for polytechnic lecturers. The validation process involved a panel of experts assessing item relevance, representativeness, and clarity, as well as a group of respondents reviewing the instrument for comprehensibility and appearance. The findings provide empirical evidence on the suitability and quality of the developed instrument, ensuring it meets psychometric standards for future use in evaluating STEM-TPACK teaching and learning practices in Malaysian polytechnics.

LITERATURE REVIEW

The integration of STEM education and the TPACK framework has become increasingly essential in preparing educators to teach effectively in the 21st-century learning environment. The TPACK model, proposed by Mishra and Koehler (2006), emphasizes the dynamic interaction between teachers' knowledge of technology, pedagogy, and content, forming a foundation for effective technology integration in teaching. In the context of STEM education, TPACK provides a comprehensive framework that supports educators in designing and implementing multidisciplinary lessons that foster critical thinking, creativity, and innovation (Abdullah & Mahmud, 2024; Thibaut et al., 2018). Studies have shown that educators with a high level of TPACK competency are more capable of integrating technology to enhance student engagement and learning outcomes (Sonsupap, Cojorn, & Sitti, 2024; Scott, 2021; Usman, Auliya, Susita, & Marsofiyati, 2022).

Within Malaysian polytechnics, the implementation of STEM-TPACK-oriented teaching is aligned with national education policies that promote Science, Technology, Engineering, and Mathematics as key areas for industrial growth and innovation (Ministry of Higher Education Malaysia, 2024). Polytechnic lecturers play a vital role in equipping students with STEM-related skills relevant to Industry 4.0 demands. However, research indicates that many lecturers face challenges in integrating technology effectively into STEM teaching due to limited pedagogical training, inconsistent professional development programs, and varying attitudes toward instructional technology (Yunus & Joblie, 2022; Omar, 2021). These challenges underline the importance of assessing lecturers' STEM-TPACK teaching and learning practices together with their professional development experiences, attitudes, and self-efficacy levels to strengthen STEM education quality in higher learning institutions.

Professional development is widely recognized as a key driver of teaching competency and innovation. Continuous training allows educators to update their pedagogical and technological skills and apply new strategies in the classroom (Napitupulu et al., 2025). In STEM contexts, effective professional development programs should promote hands-on, inquiry-based learning experiences that foster integrated STEM teaching (Capraro et al., 2021). Moreover, lecturers' attitudes toward STEM teaching influence their willingness to adopt new instructional technologies and cross-disciplinary teaching methods (Mohamad Hasim et al., 2022; Cribbs, Duffin, & Day, 2022). A positive attitude correlates with higher engagement and creativity in lesson design,

while negative attitudes can hinder technology adoption and innovative practice. Equally important, self-efficacy, the belief in one's own capability to perform specific teaching tasks, strongly predicts how effectively lecturers implement STEM-TPACK strategies (Bandura, 1997; Palmer et al., 2015; Kim & Park, 2023). High self-efficacy encourages risk-taking and perseverance in integrating technology into complex STEM lessons, whereas low self-efficacy often results in resistance or minimal adoption.

Given the multidimensional nature of these constructs, the development of a valid and reliable instrument is crucial to measure STEM-TPACK teaching and learning practice, professional development, attitude, and self-efficacy among polytechnic lecturers. Previous studies have highlighted the importance of validating such instruments to ensure that they accurately reflect the intended constructs (Akbar et al., 2023; Syariff, Fuad, Musa, & Yusof, 2022; Zamanzadeh et al., 2015; Polit & Beck, 2006). Content validity focuses on the relevance, representativeness, and clarity of instrument items as evaluated by experts, while face validity ensures that the items appear appropriate and understandable to respondents (Yusoff, 2019; Abdullah et al., 2024). Lawshe's (1975) Content Validity Ratio (CVR) and Polit and Beck's CVI are commonly applied to quantify expert agreement on item relevance. These validation procedures are foundational to ensuring psychometric soundness before conducting large-scale reliability and construct validity assessments.

Despite the growing research on TPACK and STEM education, limited empirical evidence exists on the validation of instruments that simultaneously assess STEM-TPACK teaching and learning practice es, professional development, attitude, and self-efficacy, particularly within the Malaysian polytechnic context. Most prior studies have adapted TPACK scales designed for school teachers or general education settings without proper contextual validation for tertiary-level STEM teaching (Li & Nugraha, 2025; Abdullah et al., 2024; Shafie, Abd Majid, & Ismail, 2024; Li & Noori, 2023). Therefore, establishing both content and face validity of the proposed instrument is a critical step to ensure it accurately captures the unique teaching context of polytechnic lecturers. This study addresses that gap by systematically evaluating the content and face validity of the developed instrument, contributing to the body of knowledge on STEM-TPACK measurement and providing a foundation for future empirical investigations into factors influencing effective STEM teaching in higher education.

Research Objectives

The following objectives guide this research:

1. Evaluating the face validity of the STPAS-I instrument using FVI analysis
2. Evaluating the content validity of the STPAS-I instrument using CVR analysis
3. Evaluating the content validity of the STPAS-I instrument using CVI analysis

RESEARCH METHODS

Research Design and Instrument

This study employed a quantitative descriptive design focused on expert evaluation to establish the content validity and face validity of the developed instrument, the STPAS-I instrument (STEM-TPACK Teaching and Learning Practice, Professional Development, Attitude, and Self-Efficacy Instrument). The validation process aimed to ensure that the instrument items were relevant, representative, and clearly formulated to measure the intended constructs among polytechnic lecturers. The STPAS-I instrument was designed to measure four primary constructs: (i) STEM-TPACK Teaching and Learning Practice, (ii) Professional Development, (iii) Attitude, and (iv) Self-Efficacy. Each construct was developed based on an extensive literature review of existing models, including the TPACK framework (Mishra & Koehler, 2006), Bandura's Self-Efficacy Theory (1997), and established scales regarding professional development, teacher attitudes toward STEM education, and self-efficacy.

The initial instrument comprised a total of 69 items categorized into four constructs: STEM-TPACK Teaching and Learning Practice (26 items), Professional Development (16 items), Attitude (11 items), and Self-Efficacy (16 items). All items were rated on a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly

Agree). The draft instrument was reviewed by experts for validation prior to pilot testing. A total of seven experts were purposively selected to evaluate the instrument. The panel comprised subject-matter experts in STEM education, educational measurement, and curriculum design from polytechnics. Each expert had more than ten years of experience in higher education or research related to STEM teaching and psychometric evaluation.

Face and Content Validity Procedure

The validation process involved two main stages: content validity and face validity, conducted with the participation of seven expert reviewers. The primary objective was to ensure that all items in the STPAS-I instrument were relevant, clear, and capable of accurately representing the intended constructs of STEM-TPACK Teaching and Learning Practice, Professional Development, Attitude, and Self-Efficacy among polytechnic lecturers.

The Face Validity Index (FVI) was used to assess the clarity and comprehensibility of the questionnaire items. The criteria for face validity are based on Oluwatayo (2012), which include the acceptability of the instrument format, clarity of instructions, appropriateness of wording, suitability of font, correctness of spelling, proper grammar, and the use of relevant terminology. Each was rated on a 4-point Likert scale (strongly disagree=1, disagree=2, agree=3, strongly agree=4), which was dichotomized for analysis: ratings of 3 or 4 were recoded as "1," and ratings of 1 or 2 as "0." Four indices were computed: Item-Level Face Validity Index (I-FVI), Scale-Level Face Validity Index (S-FVI), Scale-Level Face Validity Index with Universal Agreement (S-FVI/UA), and Scale-Level Face Validity Index Averaging method (S-FVI/Ave). The I-FVI was calculated as the proportion of raters who rated an item as clear divided by the total number of raters. The S-FVI/Ave was derived by averaging I-FVI scores across all items and by averaging clarity ratings across raters, adapted from the CVI calculation method. The S-FVI/UA represented the proportion of items with 100% agreement among raters on clarity. Interpretation of FVI values followed the CVI benchmark; an acceptable level is ≥ 0.80 , and for panels exceeding five raters, a value of ≥ 0.83 is considered satisfactory.

To establish content validity, the expert panel evaluated each questionnaire item for its relevance on a 4-point Likert scale (Not relevant=1, Less relevant=2, Relevant=3, highly relevant=4), which was dichotomized for analysis: ratings of 3 or 4 were recoded as "1" and ratings 1 or 2 as "0." The analysis applied both the CVI and the CVR. The I-CVI was calculated as the number of experts rating an item relevant divided by the total number of experts. The S-CVI/Ave was obtained by averaging the I-CVI values across all items, and the S-CVI/UA represented the proportion of items with universal expert agreement. According to Polit and Beck (2006), an I-CVI value of 0.83 or higher is acceptable when seven or more experts are involved. The CVR was calculated using Lawshe's (1975) formula, which reflects the extent of agreement among experts on whether each item is essential.

$$CVR = \frac{ne - \frac{N}{2}}{N/2},$$

where

ne = number of experts who rated the item 3 or 4

N = total number of experts

RESULTS

Objective 1 - Evaluating the face validity of the STPAS-I Instrument using FVI

The results of the face validity analysis are presented in Table 1. Seven experts assessed the clarity and comprehensibility of seven questionnaire items. Six items achieved full agreement, each with an I-FVI of 1.00. One item, "The terminology used is appropriate," had a consensus from six of seven experts, resulting in an I-FVI of 0.86. The S-FVI/UA was 0.86, while the S-FVI/Ave was 0.98, both exceeding the acceptable threshold of 0.83 (Polit & Beck, 2006). These results demonstrate the instrument's strong clarity and comprehensibility. Minor wording refinements were incorporated based on expert feedback, with no major revisions necessary.

Table I Face Validity Analysis Findings

Item	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	I-FVI
The format of the instrument is acceptable	1	1	1	1	1	1	1	1.00
The instructions provided are clear	1	1	1	1	1	1	1	1.00
Commonly used words are applied	1	1	1	1	1	1	1	1.00
The font used is appropriate	1	1	1	1	1	1	1	1.00
Spelling is accurate	1	1	1	1	1	1	1	1.00
Grammar is correct	1	1	1	1	1	1	1	1.00
The terminology used is appropriate	1	0	1	1	1	1	1	0.86
S-FVI/UA								0.86
S-FVI/Ave								0.98

Objective 2 - Evaluating the content validity of the STPAS-I Instrument using Content Validity Ratio (CVR)

Using Lawshe's (1975) formula, seven experts rated the essentiality of all 69 items across the four constructs: STEM-TPACK Teaching and Learning Practice (ST), Professional Development (P), Attitude(A), and Self-Efficacy(S). Most items had CVR values between 0.71 and 1.00, with 48 items receiving a perfect agreement (CVR = 1.00), and 8 items at 0.71. Although Lawshe's critical value is 0.99 for seven experts, literature supports retention of items with $CVR \geq 0.71$ (Wilson et al., 2012; Ayre & Scally, 2014). No items fell below this threshold, affirming satisfactory content validity across constructs. Table 2 summarizes the CVR results and item decisions.

TABLE 2 Average Cvr Values For Constructs Stem-Tpack Teaching Practice (St), Professional Development(P), Attitudes (A), And Self-Efficacy (S)

CVR	Item	Total	Decision
1.00	ST1, ST2, ST3, ST4, ST6, ST8, ST9, ST10, ST11, ST12, ST13, ST14, ST15, ST17, ST20, ST21, ST24, ST25, ST26, P1, P2, P3, A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, S1, S2, S3, S4, S5, S6, S8, S9, S10, S11, S12, S13, S14, S15, S16	48	Retained
0.71	ST5, ST7, ST16, ST18, ST19, P5, P9, S7	8	Retained

Objective 3 - Evaluating the content validity of the STPAS-I Instrument using Content Validity Index (CVI) analysis

The results of the CVI analysis, as summarized in Table 3, indicate that all I-CVI values ranged from 0.86 to 1.00, which exceeded the acceptable threshold of 0.83 recommended by Polit and Beck (2006) for seven or more experts. This suggests a strong level of agreement among the expert panel regarding the relevance of all items. Specifically, within the STEM-TPACK Teaching and Learning Practice construct, I-CVI values ranged from 0.86 to 1.00, with an S-CVI/Ave of 0.96. The Professional Development construct achieved I-CVI values between 0.86 and 1.00, yielding an S-CVI/Ave of 0.98. All items under the Attitude construct demonstrated perfect agreement among experts, with an I-CVI of 1.00 and an S-CVI/Ave of 1.00. Similarly, the Self-Efficacy construct recorded I-CVI values from 0.86 to 1.00, resulting in an S-CVI/Ave of 0.99. Overall, the findings confirm that all items demonstrated satisfactory content validity, exceeding the recommended cut-off values. Therefore, no items were eliminated from the STPAS-I instrument based on CVI analysis. These results indicate that the instrument possesses a high level of content representativeness and relevance across all constructs.

TABLE 3 I-Cvi And S-Cvi Values For Constructs For All Constructs

STEM-TPACK Teaching & Learning Practice		Professional Development		Attitude		Self-efficacy	
ITEM	i-CVI	ITEM	I-CVI	ITEM	I-CVI	ITEM	I-CVI
ST1	1.00	P1	1.00	A1	1.00	S1	1.00
ST2	1.00	P2	1.00	A2	1.00	S2	1.00
ST3	1.00	P3	1.00	A3	1.00	S3	1.00
ST4	1.00	P4	1.00	A4	1.00	S4	1.00
ST5	0.86	P5	0.86	A5	1.00	S5	1.00
ST6	1.00	P6	1.00	A6	1.00	S6	1.00
ST7	0.86	P7	1.00	A7	1.00	S7	0.86
ST8	1.00	P8	1.00	A8	1.00	S8	1.00
ST9	1.00	P9	0.86	A9	1.00	S9	1.00
ST10	1.00	P10	1.00	A10	1.00	S10	1.00
ST11	1.00	P11	1.00	A11	1.00	S11	1.00
ST12	1.00	P12	1.00			S12	1.00
ST13	1.00	P13	1.00			S13	1.00
ST14	1.00	P14	1.00			S14	1.00
ST15	1.00	P15	1.00			S15	1.00
ST16	0.86	P16	1.00			S16	1.00
ST17	1.00						
ST18	0.86						
ST19	0.86						
ST20	1.00						
ST21	1.00						
ST22	0.86						
ST23	0.86						
ST24	1.00						
ST25	1.00						
ST26	1.00						
S-CVI	0.96	S-CVI	0.98	S-CVI	1	S-CVI	0.99

DISCUSSION

This study aimed to examine the validity evidence of the STPAS-I instrument, focusing on both face validity and content validity as part of the preliminary validation phase. The findings demonstrated strong expert agreement, indicating that the items were clear, relevant, and representative of their respective constructs. The FVI results confirmed that the items were perceived as clear and comprehensible by the panel of experts. The I-FVI values ranged from 0.86 to 1.00, while the S-FVI/Ave achieved 0.99, exceeding the acceptable threshold of 0.83 for seven or more experts (Polit & Beck, 2006). These findings suggest that the experts found the questionnaire's structure, language, and layout appropriate and user-friendly. The high level of clarity across items indicates that respondents are likely to interpret the statements consistently, minimizing the risk of ambiguity or misinterpretation during data collection. This result aligns with previous studies and recent research highlighting the importance of face validity in ensuring item clarity and functional readability for respondents (Ibrahim & Mohd Matore, 2024; Karami, Parra-Martinez, Ghahremani, & Gentry, 2024; Zamanzadeh et al., 2015)

Similarly, the CVI and CVR analyses provided robust evidence of item relevance and essentiality (Ahmad Fakhrin & Idris, 2025). The I-CVI values ranged from 0.86 to 1.00, surpassing the minimum acceptable standard of 0.83 (Polit & Beck, 2006). Scale-level indices also demonstrated strong consistency, with S-CVI/Ave values of 0.96 for STEM-TPACK Teaching and Learning Practice, 0.98 for Professional Development, 1.00 for Attitude, and 0.99 for Self-Efficacy. These values exceed the commonly accepted benchmark of 0.90 (Lynn, 1986), indicating a high degree of expert agreement on item relevance (Polit & Beck, 2006).

The CVR analysis supported these results, showing that most items achieved the maximum value of 1.00, reflecting unanimous expert agreement on their essentiality. A few items had slightly lower CVR values (0.71), yet remained above the critical cut-off based on Lawshe's (1975) formula for seven experts, justifying their retention. This outcome is consistent with prior research in STEM-TPACK validation studies (Amatan, Han, & Pang, 2021; Suryadi, 2022), where similar high CVI and CVR scores indicated strong construct alignment and theoretical soundness.

CONCLUSION

This study assessed the face and content validity of the STPAS-I instrument, developed to measure STEM-TPACK Teaching and Learning Practice, Professional Development, Attitude, and Self-Efficacy among polytechnic lecturers. Findings revealed that the instrument possesses strong validity evidence. The FVI indicated excellent clarity and comprehensibility, with I-FVI values ranging from 0.86 to 1.00 and an overall S-FVI/Ave of 0.99, confirming that all items were clear and appropriate for the target respondents. Similarly, the CVI and CVR values were high, with S-CVI/Ave ranging from 0.96 to 1.00, reflecting strong expert consensus on item relevance and representativeness. These results demonstrate that the STPAS-I items effectively capture the intended constructs within the STEM-TPACK framework. Overall, the STPAS-I shows excellent face and content validity, establishing it as a reliable instrument for evaluating lecturers' STEM-related competencies. Further research is recommended to perform pilot testing and psychometric validation, including exploratory and confirmatory factor analyses to establish the instrument's construct validity and reliability for broader application.

RECOMMENDATION

Based on the findings, it is recommended that the STPAS-I instrument be adopted for assessing polytechnic lecturers' competencies in STEM-TPACK teaching and learning practices, professional development, attitude, and self-efficacy. Future studies should involve a larger and more diverse sample to further validate the construct through exploratory and confirmatory factor analyses. In addition, reliability testing using Cronbach's alpha or composite reliability is suggested to strengthen the instrument's psychometric properties. Continuous refinement and adaptation of the instrument are also encouraged to ensure its applicability across different educational contexts and disciplines.

ACKNOWLEDGMENT

The authors would like to express sincere appreciation to all expert panels for their valuable contributions in evaluating the content and face validity of the STPAS-I instrument. Special thanks are also extended to the polytechnic lecturers who participated in the study and to the institution for the continuous support throughout this research.

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