Integrating Culturally Responsive Teaching and TPACK Frameworks in the Design and Validation of Indonesian Language Learning Tools for Multicultural Schools

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Abstract. Although there is a rise in cultural diversity and the use of technology in education, numerous Indonesian educators struggle to successfully integrate cultural values and digital teaching approaches into language learning. Therefore, this study aims to design and validate Indonesian language teaching tools based on the Culturally Responsive Teaching (CRT) approach, integrated with the Technological Pedagogical Content Knowledge (TPACK) framework, for use in multicultural high schools. This study followed a simplified Borg and Gall model, focusing on three main phases: needs analysis, prototype development, and expert validation. The method focused on designing, improving, and evaluating educational tools that are culturally appropriate and integrate technology for learning the Indonesian language. Data were collected from Grade X teachers and students in ten multicultural schools in Asahan Regency, Indonesia. Results indicated a very high level of agreement among experts as measured using a Gregory Index score of 0.89; this represents a robust content validity of the educational resource materials. Thus, these materials have educational and culturally relevant validity and can be used in multicultural school settings. Testing the effectiveness of the teaching resources used with 60 students (30 in the experimental group and 30 in the control group) resulted in significantly improved learning outcomes for the experimental group (experimental mean posttest = 41.20) when compared to the control group (control mean posttest = 19.80). A Mann-Whitney U Test p-value of 0.000 also supported the results, indicating that incorporating culturally responsive education and

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technology-enhanced pedagogy increased students' engagement and understanding of Indonesian language learning. These results provide validation of the effectiveness of the developed teaching materials and demonstrate how applying the CRT and TPACK models can merge cultural relevance and technical pedagogy to support contextualized learning and inclusive learning practices. Local cultural stories are incorporated into the tool to enable students to express their identities while enhancing the TPACK model by including CRT principles. This study demonstrates a successful combination of culturally responsive education and technology-enhanced pedagogy — applications that have previously been underrepresented in research. This research has developed a design model that has been empirically tested and validated to combine the CRT and TPACK models to enhance the theoretical basis for culturally sustainable learning and establish a base for future research that explores inclusive and context-based language education in various educational settings.

1. Introduction

The rapid growth of technology and the increasing variety of backgrounds in classrooms lead to the need for updated teaching methodologies (Rahimi & Oh, 2024). This complexity reveals the need for constructs of technology and cultural awareness by illustrating TPACK (Technological Pedagogical Content Knowledge) (Mishra & Koehler, 2006) as the illustrative representation between technology, pedagogy, and content knowledge, while Culturally Responsive Teaching (CRT) (Gay, 2018) emphasizes the need for individualized instruction based on students' cultural backgrounds. This synthesis of two paradigms makes for educational, practical learning experiences appropriate for the cultural context of technology.

New generations of technology — including generative technologies such as artificial intelligence (AI) and digital platforms — have changed mass education through various means, but perhaps most notably with respect to distance and blended learning. The literature suggests that in addition to providing personalized learning options via customized materials, pacing, and student feedback (Collins et al., 2024; Valko & Osadchyi, 2020; Wang et al., 2020), there is a growing number of uses of AI to assist in all areas of education — including assessment and instruction (Gao et al., 2025; Ryabko et al., 2022). This creates a need for educators to develop and apply integrated models of teaching that include new technology while still reflecting pedagogical and cultural issues within multicultural classrooms.

Some recent studies indicate that TPACK integration can be a valuable tool for assisting with teachers' ability to respond to these new challenges of the 21st century, including responses to the effects of the pandemic and the SDGs by 2030 (Alotaibi, 2022; Méndez et al., 2022). The increasing diversity of student populations due to social and economic migrations creates a culture of students

from different racial and ethnic backgrounds, thus requiring a pedagogy that addresses their diversity through CRT (Gay, 2015). Unfortunately, many teachers have not been prepared to effectively integrate technology into their instruction on all levels and in various cultural and instructional environments (Shumeiko et al., 2024). Integrating TPACK into CRT has many advantages; these include increased diversity among students, increased involvement of students, better preparation for teachers in diverse settings, and better educational outcomes for students. Prior research emphasizes the ability to increase student engagement through TPACK-based methods, as shown by Zahroh et al. (2025), who created student engagement using a problem-based learning model grounded in TPACK.

Additionally, Lai et al. (2022) also showed that student engagement improved when a modified version of TPACK was used in a mobile interactive system with an on-screen writing feature. Furthermore, previous research on CRT has identified other complementary advantages, such as increasing the cultural competence and equity literacy of teachers (Ghaemi & Boroushaki, 2025); promoting inclusive teaching practices through dialogue and planning in diverse classrooms (Markey et al., 2021); and creating positive long-term inclusion in education and society (Ashrafova, 2024).

Regarding the complementary roles that CRT and TPACK play in teaching culturally relevant content, CRT defines the culturally relevant context of the instructional material, while CRT and TPACK together represent two distinct yet complementary aspects of culturally responsive teaching: the *what* defined by CRT and the *how* defined by TPACK. While CRT focuses on the cultural relevance of content, classroom interactions, and teacher-student relationships, TPACK outlines the instructional design process to ensure that appropriate instructional technology is utilized to achieve CRT's culturally relevant content delivery goals.

In a multicultural classroom setting, CRT provides the basis for ensuring that the curriculum content is relevant to the students' identities and their own cultural knowledge. In contrast, TPACK provides the method or process by which the digital technologies and educational strategies used in the classroom will give students access to that culturally relevant content. When CRT and TPACK are combined, CRT provides the culturally relevant foundation from which teachers select their pedagogy and content.

At the same time, TPACK mediates the implementation of those pedagogical and content selections using technology and results in teaching tools that are both culturally relevant and technologically adaptable. This research is grounded in the theoretical work of Shulman (1986), who identified the importance of Pedagogical Content Knowledge (PCK) in the effective delivery of instruction. Mishra & Koehler (2006) extended Shulman's PCK theory into the TPACK framework. CRT has its roots in the work of Ladson-Billings (1995) and further development by Gay (2002), who emphasized the need for student cultural experience to be included as an integral part of the instructional process. Integrating these frameworks aligns with socio-cultural learning theory, underscoring the role of culture and interaction in knowledge construction.

Although technology–pedagogy integration has been widely studied through the TPACK framework and cultural awareness developed through the CRT approach (Chuang et al., 2020), few studies have combined these approaches into a single, practical framework or produced ready-to-use teaching tools for teachers. Some studies, such as the development of a TPACK–Culturally Responsive Transformative Teaching (CRTT)-based module (Lestari et al., 2025), demonstrate early efforts in this direction, yet such work remains limited to specific subjects and lacks a broader instructional design model applicable across contexts.

Several early studies have attempted to adapt the TPACK model to be more culturally contextual (e.g., TPACCK) (Haga, 2024), but have not been systematically developed in instructional design and validation of applicable teaching tools. On the other hand, CRT research still focuses mainly on affective aspects and teacher–student relationships, with limited use of technology to convey cultural values in learning, particularly in language education (Nguyen & Huynh, 2023).

However, unlike prior studies that only adapted parts of TPACK to cultural contexts or focused on affective aspects of CRT, this study advances the integration by embedding both frameworks within a complete instructional design cycle—from needs analysis to prototype validation. The proposed design bridges technological and cultural pedagogies conceptually and translates them into validated, field-ready teaching tools for Indonesian language learning. This approach extends previous CRT- or TPACK-based research by providing a systematic model for culturally sustainable and technologically grounded instruction.

In addition, other local factors, for example, in multicultural schools in Indonesia, most research on the integration of CRT and TPACK has little to do with the local context (Mariyono, 2024). Many previous studies were conducted in countries with more homogenous educational systems or dealt with foreign language instruction (Onishchuk et al., 2020), making generalizations to Indonesia's diverse cultural environment and its students' local languages, a different experience in school (Sumartana et al., 2025).

This context calls for an instructional design approach that incorporates technological and pedagogical knowledge while considering learners' cultural background and identity. Thus, further development and testing of locally applicable teaching tools for Indonesian teachers to teach CRT and TPACK in multicultural schools is needed. These should focus on design theory, validity, and applicability to the local context (Vonti et al., 2025).

Based on the identified gaps, this research seeks to develop and test Indonesian teaching materials that use the CRT in a TPACK framework. It is achieved through 4 key focus: 1) the identification of the conceptual and pedagogical and cultural features of the teaching materials (Boon & Lewthwaite, 2015); 2) the development of materials appropriate to students' cultural background and the effective use of technology (Ajani, 2024); 3) the validation of the materials assessed

by experts in terms of content, pedagogy, and technology (Cavanagh & Koehler, 2013); and 4) the trial of materials in multicultural schools (Gabdulchakov et al., 2016).

It is anticipated that this study will contribute to advancing both the theoretical and practical knowledge of education by combining two previously researched theories (TPACK and CRT). This study was the first to establish a multi-disciplinary framework for developing instructional tools that integrate technology, pedagogy, subject matter, and culture into Indonesian instruction. Practically, this study's findings are intended to assist educators in developing culturally responsive and contextually relevant instructional materials, specifically for educators in diverse school settings. Other studies conducted in Indonesia emphasize the need to create culturally contextualized instructional media and curricula that reflect the diversity of language and identity of the region (Efendi & Lien, 2021; Mandarani et al., 2024; Safitri & Efianingrum, 2020).

2. Literature Review

Mishra & Koehler's (2006) TPACK framework, a model of teacher knowledge that includes pedagogical knowledge (PK) and content knowledge (CK) in addition to technological knowledge (TK), expands on Shulman's (1987) concept of PCK. Including technology knowledge (TK) further emphasizes that teachers must utilize their technological knowledge to assist them in making the most effective use of technology to support and improve their instructional practices (Cheung et al., 2018; Koehler et al., 2013).

Although TPACK builds upon our prior understanding of how to successfully incorporate technology into instructional practices, TPACK has been criticized for not including a cultural perspective regarding the increasing diversity in today's classroom. CRT addresses the lack of a cultural perspective by emphasizing the importance of students' cultural backgrounds as assets to their own learning. Ladson-Billings (2014) and Gay (2002) argue that culturally responsive or relevant teaching requires educators to interact with students' cultural histories and perspectives. Approaches to education based on assets have been shown to create a more inclusive and effective learning environment (Bressoud et al., 2025; White et al., 2023).

In fact, Dietrich (2022) has found that improved teacher-learner discourse and teaching practices are achievable by reframing cultural differences as assets instead of barriers. Similarly, Jia and Nasri (2019) conclude that teacher competence in culturally responsive practice is necessary in establishing classroom equity. In addition, it has been shown that the teachers' knowledge of the student population's cultural and linguistic diversities directly impacts their use of CRT in the classroom (Gul et al., 2022). It was further emphasized that it is preeminently important that the students' cultural and linguistic identities be included in the curriculum in a meaningful way to enhance the inclusion of all members of the learning community and the overall learning experience. The benefits of this approach will be that they greatly enhance academic success

frequency and facilitate students' feeling a greater sense of belonging to their learning community (Rogelberg et al., 2020).

Current research has identified the value of integrating the TPACK model and CRT for developing learning environments using technology that are fair, relevant to a specific culture, and educationally significant. The authors also note that TPACK should be "culturally mediated" to ensure an authentic educational experience (C. Lai et al., 2022; Marosi et al., 2021; Ning et al., 2022). Research by Haga (2024), in Japan, and Fadlilah et al. (2025), in Indonesia, demonstrates that various cultural factors — including local norms and religious values — can significantly affect how teachers implement TPACK within their instructional practices.

Building on this, Indonesian studies by Devi & Ikhsanudin (2023) and Lestari et al. (2025) developed teaching modules that merge CRT's transformative aims with TPACK design principles, showing how culturally responsive content and digital media can reinforce learners' engagement and contextual relevance. Simultaneously, work on professional development (Armistead et al., 2024; C. Lai et al., 2022) finds that teacher collaboration, autonomy, and reflection—key elements of CRT—help strengthen TPACK when applied in culturally responsive learning communities. These findings suggest that adding culturally relevant perspectives to TPACK will broaden its pedagogical scope and help address sociocultural inequities in digital learning environments.

The TPACK model is an all-encompassing method to direct the implementation of technology into foreign language instruction with emphasis on how pedagogy, content, and technology work together dynamically (Belda-Medina & Calvo-Ferrer, 2022; Subrata et al., 2024). Within communicative language teaching, TPACK provides teachers with the means to develop instructional activities where the digital tools directly enable students to interact, enhance their vocabulary, and engage in authentic language usage (Mulyadi et al., 2020). However, many scholars have found a lack of longitudinal and cross-cultural studies that specifically utilize CRT-informed TPACK models, indicating the necessity of research that will simultaneously evaluate both technological competence and cultural responsiveness (Ogodo, 2024; Thyssen et al., 2023).

3. Materials and Methods
3.1 Research Design
The current study represents a Research and Development (R&D) project. The goal of this R&D project is to develop and validate an Indonesian teaching tool that integrates the CRT and the TPACK framework. CRT and TPACK are appropriately integrated as an R&D methodology because they emphasize an iterative design process based on context-specific needs. A modified version of the development model developed by Gall et al. (2003) was utilized for this R&D project.

This development model was reduced to three primary stages (needs analysis, design/prototype development, and expert validation) to support a systematic

and quantifiable developmental focus (see Figure 1). The reduction in stages from five to three was made to be consistent with the goals of this study, which include needs assessment, design/prototype development, and validation. Additionally, a small-scale effectiveness test was performed instead of a large-scale field implementation.
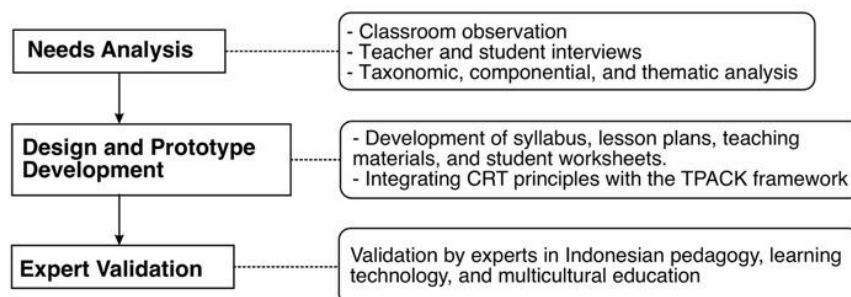

Figure 1: Research and development stages

3.2 Development Stages

The needs analysis incorporated observations of classroom practice (10 sessions), interviews with a semi-structured format with 10 teachers and 30 students, and document analysis of lesson plans. The qualitative data were thematically analyzed for patterns of cultural representations and technology use, which directly influenced the content of the prototypes and the activities. The qualitative exploration encompassed some themes as it investigated the student profile, the multicultural nature of the school environment, and the cultural value of the locality that could be integrated.

Taxonomic and thematic analyses resulted in discovering cultural patterns that formed as prominent features, whilst the componential analysis was employed to compare intercultural values and practices and explore comparisons to group similarities and differences. This combination of analyses has a qualitative dimension, which is the basis of the logic of the study model espoused by Aris et al. (2024), who used taxonomic procedures to classify the conceptual categories in their sample study belonging to the area of educational research. The findings of that stage provided the conceptual basis for the design of the teaching instruments.

Next came the design and prototyping phase, which resulted in the development of the initial instructional tools, including a course syllabus, lesson plans, teacher materials, and student worksheets (Melindawati, 2021; Sudipa et al., 2020). The integration of CRT into the content, methodology, and learning activities also followed the TPACK model, which is designed to ensure the effective use of educational technology, Indonesian content, and appropriate pedagogical approaches.

Finally, three expert validators were consulted in Indonesian pedagogy, learning technology, and multicultural education to validate expertise with a minimum of five years of professional experience in their respective areas of specialization and

holding at least a doctoral degree. The data were collected through the use of an adapted version of a structural evaluation form developed by Gall et al. (2003), which contained multiple evaluation indicators of five categories: 1) appropriateness of content and purpose, 2) clarity of instruction and language, 3) incorporation of CRT (local culture), 4) TPACK (technology integration), and 5) visual design and interactivity. Each indicator's relevance level was assessed on a four-point scale (1 = Not Relevant to 4 = Very Relevant) to assess the overall validity of the created instructional materials (Shahidayanti et al., 2024). After the expert validation, the prototype was revisited iteratively based on feedback before being tested in a small pilot study (Aris et al., 2024).

3.3 Data Analysis
The qualitative and quantitative methods utilized for this study include interviewing both students and teachers in the needs analysis, which provided a qualitative data set, and assessing all open-ended comments received from experts as part of the needs analysis using descriptive analysis in order to identify and provide substantive revisions to the teaching tools.

The quantitative methodology involved several phases, including preparation of validation grids and instruments, obtaining expert validation of the content, data collection for validation results, and statistical analysis of the effectiveness of the teaching tools in their use within classrooms. The degree of agreement among experts was measured using the Gregory formula (Gregory, 2007) to evaluate the effectiveness of the teaching tools. Statistical analysis of student learning outcomes in both experimental and control classes was made to determine if the two groups had statistically significant differences at an alpha level of 0.05.

3.4 Research Site and Participants
The study was conducted in ten multicultural senior high schools in Asahan Regency, North Sumatra, Indonesia. Participants included ten Indonesian language teachers. Schools were purposively selected to represent diverse ethnic, linguistic, and cultural backgrounds. Purposive sampling is a widely used nonprobability sampling strategy in studies of multicultural education because it allows researchers to intentionally select participants who are most informative about the research questions, contexts, and phenomena of interest (Mashuri, 2020; Saranza, 2020).

The participants' ethnic backgrounds are as follows. Among the teachers were three Javanese, two Batak Toba, two Mandailing, two Malay, and one Minangkabau. The control class consisted of 30 students: ten Javanese, six Batak Toba, five Mandailing, four Malay, three Minangkabau, and two Nias students. The experimental class also included 30 students: nine Javanese, seven Batak Toba, six Mandailing, five Malay, two Minangkabau, and one Simalungun student.

3.5 Research Instrument
The research instrument was a multiple-choice test designed to assess student achievement after learning with the CRT–TPACK–based materials, focusing on observation report texts. In order to assess whether the teaching materials are

effective, the study assessed the performance of 30 students in an experimental group compared to 30 students in a control group using this assessment tool. Items on the tool were constructed based on competency indicators that incorporated regional culture into Asahan Regency and addressed cognitive levels ranging from C1 to C4. Before its use in the study, the assessment tool was empirically tested to ensure it functioned appropriately. An item-total correlation analysis was performed to determine the validity of each item; the discrimination index was determined by comparing the top 27% and bottom 27% of the students' performances; the difficulty index was established as the proportion of correct responses; and the internal consistency or reliability of the assessment tool was evaluated via Cronbach's Alpha.

Classical Test Theory (CTT) was utilized because it is a relatively simple theory regarding item-level diagnostics. It is best used in studies involving small to medium-sized student populations and/or during early exploratory validation stages of educational research (Boateng et al., 2018). The results indicated that 16 items met all of the requirements for validity, discrimination, and appropriate difficulty and thus were used for both the pre-test and post-test assessments.

3.6 Ethical Approval and Informed Consent
Ethics approval was received from the Research Ethics Committee of Asahan University for this study. Participants' identities were protected (per ethics guidelines) by obtaining informed consent.

4. Results and Findings
4.1 Needs Analysis Results
The initial phase of creating the educational materials involved a field-based assessment to determine learning needs in culturally diverse classrooms. Data collection methods included classroom observation, in-depth interviews with students and teachers, and ethnopedagogical analyses based on taxonomic, componential, and thematic analysis techniques. The use of ethnopedagogical analysis was particularly relevant to the study as it represents a key aspect of CRT. Ethnopedagogical analysis focuses on examining local knowledge, cultural values, and community practice as important aspects of designing instruction.

Observations of classrooms in ten multicultural high schools in Asahan Regency found that learning Indonesian as a language is centered on students' academic achievements, with little focus on students' cultural diversity. These results are similar to those from prior research studies, which indicate that the teaching of Indonesian has historically emphasized student academic achievement and formalized language usage over the cultural aspects of the students' knowledge (Permatasari & Rahardi, 2022).

Most teacher-student interactions were unidirectional; teachers controlled them and had limited use of technology. None of the instructional activities included a method for students to reflect upon their cultural identities through texts or class discussions. One observer noted that "the teacher used only one example of a

narrative text from the textbook without mentioning the cultural context of the students in a very diverse classroom."

The interviews with teachers indicated that the teachers lack awareness of how to approach cultural differences in learning. In particular, one teacher stated:

> *"I know the children in the class come from different ethnicities, but I am confused about how to relate Indonesian subject matter to their culture without seeming to favoritism." (Teacher A, School A)*

Further, this finding indicates that the challenges teachers face are not simply individual issues; however, they also reflect a larger professional development issue. Teachers' inability to link the curriculum to students' cultural backgrounds reflects that most of the current teacher training has emphasized pedagogy and technology and neglected to focus on culturally responsive teaching practices.

In addition, students indicated they were less invested in the content. One student noted:

> *"Sometimes we read stories about other regions, but never discuss stories from our own culture. Even though I want my friends to know about our traditions in the village." (Student A, School B)*

The results from ethnopedagogical analysis are shown in Table 1. A taxonomic analysis was conducted on the data to measure the diversity of ethnicity found in each school. It showed an abundance of Batak (Toba and Mandailing), Malay, Javanese, and Nias cultures at all schools. The componential analysis indicated that the culturally based values of the students' parents influenced the way the students learned and participated during class activities. Some students were passive participants in class discussions because they were raised under social norms of politeness and respect for authority.

Three urgent needs for multicultural Indonesian language learning as identified by the thematic analysis include: (1) the lack of representation of students' local cultures in the curriculum materials, resulting in low emotional connection to the subject matter; (2) the lack of technology utilization to support students' cultural expression and exploration of their identity; and (3) teachers have limited knowledge and skills to manage diverse classrooms because of the lack of training and professional development in CRT.

Table 1: Ethnopedagogical Analysis Results for Designing Teaching Tools

Types of Analysis	Key Findings	Design Implications
Taxonomy	Dominance of Batak, Javanese, Malay, Nias, and Mandailing ethnicities in each school	Teaching tools must accommodate all local cultures represented in the classroom
Components	Cultural values influence learning styles and participation (e.g., passive behavior linked to politeness norms)	Learning activities should be varied and sensitive to different learning styles
Theme	Lack of cultural representation; limited technology use for cultural exploration	Materials and media should integrate local culture and employ technology for identity expression

The implications of this analysis provide a strong theoretical basis for developing CRT-based educational tool development. These educational tools are designed to culturally contextualize local cultural narratives in writing assignments and other classroom activities; they also allow students to express their cultural identities through both print and digital forms of media. By implementing CRT-based methods, teachers will have specific support with using these tools in managing classrooms that reflect diversity. The tools utilize technology as an instrument of cultural expression and the TPACK framework to ensure that curriculum content, teaching methods, and technology are used together to support student learning.

4.2 Prototype Development of Learning Materials

In developing the prototype for learning materials, this study built on the principles of CRT and the TPACK framework. These two theories were integrated by incorporating culturally responsive content into the technological and pedagogical aspects of lessons. From the CRT aspect, the learning materials are constructed to include cultural context from students' local communities, examples of multiple languages, and community-based themes to validate students' identities and experiences. The TPACK aspect includes selecting digital platforms, multimedia tools, and assessments to facilitate collaborative and culturally relevant learning tasks.

The primary product developed at this stage is an interactive digital module in the form of a flipbook and numerous complementary components that work in conjunction (Table 2).

Table 2: Components of the Interactive Digital Module and Their Functions

Component	Description
Learning Module	Serves as the conceptual foundation aligning pedagogical knowledge (PK) and content knowledge (CK) with CRT's emphasis on cultural relevance. It guides teachers to design lessons that balance linguistic objectives with cultural validation and inclusivity.
Cultural Teaching Materials	Integrates content knowledge (CK) and cultural knowledge (from CRT) by embedding local folklore, proverbs, and narratives, enabling learners to connect linguistic forms with their lived cultural contexts.
Instructional Videos	Combines technological knowledge (TK) and pedagogical knowledge (PK) through multimedia explanations that link abstract linguistic concepts with authentic cultural practices, promoting culturally contextualized comprehension.
Online Quizzes	Reflects technological and assessment pedagogical knowledge (TPK) while reinforcing CRT's principle of equitable evaluation by providing accessible, interactive feedback that accommodates diverse learning backgrounds.
Digital Worksheets	Foster pedagogical content knowledge (PCK) within a CRT framework by encouraging critical reflection, cultural comparison, and collaborative exploration of identity through digital tools.
Teacher's Guide	Synthesizes all TPACK dimensions—TK, PK, and CK—while operationalizing CRT principles through explicit guidance on inclusive instruction, culturally responsive assessment, and adaptive technology use in multicultural settings.

This course's "Explore Digital Culture" project segment is one of its primary components, as it enables students to utilize digital media to represent their cultural identities. Examples of student projects include a video showcasing family tradition, an infographic highlighting local celebrations, an interactive map detailing cultural events, etc. Tools like *Padlet*, *CapCut*, and *Canva* enable students to create these digital artifacts, which are then distributed on class forums to promote cross-cultural dialogue and mutual understanding.

This rationale for designing this project component represents how CRT and TPACK connect TK with culturally responsive pedagogical practices in the classroom: When students employ digital technologies in creating digital artifacts, it does not provide students with a creative outlet; instead, it validates students' cultural backgrounds as legitimate and valuable sources for learning. The project components in the teaching materials embody CRT's principles of affirming culture and promoting student voice. At the same time, the TPACK dimension demonstrates how technology can support collaborative and multimodal communications and authentic assessment processes that relate to students' real-life experiences. The overall component structure of the CRT–TPACK-based teaching materials is presented in Table 3.

Table 3: Structure and Components of CRT–TPACK-Based Teaching Modules

Module Components	Description	Technology Used
Introduction	Mapping of competencies, topic overview, and preliminary tests	Google Form, Wordwall
Contextual Cultural Materials	Texts derived from students' local culture (folklore, rhymes, proverbs)	Flipbook Maker, Canva
Reflective and Interactive Activities	Discussions on cultural meaning, comparison of interethnic values, and self-expression	Google Docs, Jamboard
Project "Explore Digital Culture"	Creation of cultural videos, posters, or interactive maps	CapCut, Padlet, Canva
Final Test	Online quizzes to measure cultural understanding and appreciation	Wordwall, Google Form
Teacher's Guide	CRT-based implementation steps, TPACK integration, assessment alternatives, and responsive strategies	Interactive PDF, Infographics

4.3 Expert Validation Feedback
Open notes provided qualitative input from the experts. This information is invaluable in synergizing the iterative revision process of the teaching tools. Overall, the experts supported the combination of CRT's components and TPACK, while encouraging the revision of several elements to improve clarity and utility in multicultural classrooms.

For example, the input of the Indonesian education specialist guided language and pedagogical changes so that the materials would be appropriate to the students' literacy levels about the PK and CK aspects of TPACK. The multicultural education specialist recommended broadening the cultural components and making the materials multimodal. This would increase the cultural relevance and critical consciousness, which are elements central to CRT. Finally, the input of the

digital technology specialist guided interface revision and improvement in the multimedia aspects, thus impacting the TK and pedagogical-technical fit aspects of TPACK. Table 4 summarizes the experts' feedback on the developed teaching materials.

Table 4: Expert Validation Feedback on the Developed Teaching Materials

Expert	Area of Expertise	Feedback and Recommendations
Expert 1	Indonesian Education Specialist	• Simplify the language in flipbooks without reducing academic depth. • Revise worksheet instructions by adding concrete examples for grade X literacy levels. • Link the module's opening narrative more directly to students' local cultural experiences.
Expert 2	Multicultural Education and CRT Specialist	• Broaden representation of diverse local cultures. • Balance inclusion of Batak, Malay, and Javanese cultural texts instead of focusing on one. • Add exploratory assignments allowing students to present their culture through multimedia projects.
Expert 3	Digital Learning and TPACK Specialist	• Improve visual and interactive aspects of flipbooks. • Adjust navigation icon placement for more intuitive use. • Add audio narration to support auditory learners. • Expand online quiz formats beyond multiple choice to include reflective, culturally contextualized open-ended questions.

In order to help with the revision process, Table 5 outlines the experts' comments and the corresponding potential follow-up actions. Revisions centered on student diversity, field implementation problems, and integrating academic content with digital learning technology. The revisions simultaneously reinforced the theoretical coherence of the CRT-TPACK integration by ensuring that cultural responsiveness (CRT) was consistently built into technological pedagogical strategies (TPACK).

Thus, for example, changes in cultural representation, clarity of instructional material, and digital interactivity improved the coherence of teachers' technological, pedagogical, and content competencies and sensitivity to the diverse cultural contexts of students. Hence, the revised teaching tools display much improved pedagogical validity and actual applicability as they can provide more extensive, inclusive, culturally relevant, and technology-supported learning trajectories in diverse classrooms.

Table 5: Summary of Expert Comments and Follow-up on Revision of Teaching Tools

Commented Aspects	Expert Commentary	Follow-up/Revision
Language in Digital Worksheets	Instruction sentences are too abstract	Simplified and added concrete examples
Representation of Local Culture	Too focused on the majority culture (Malay)	Added Batak and Javanese cultural texts
Module Narrative	Lack of contextuality to the student experience	Reinforced with local stories or events
Flipbook Navigation	Less intuitive button placement	Redesigned user interface
Multimedia Features	Need additional audio to support auditory students	Added voice narration to material explanation
Online Quiz Format	Multiple choice only	Expanded with reflective open-ended questions

4.4 Revisions Based on Expert Feedback

Based on the outcome of the experts' feedback, several alterations were made in the teaching materials to enhance their feasibility and effectiveness in actual classroom practice. In fact, the changes made were in respect of four aspects, namely, content, presentation, language, and technology, all of which have to be balanced with enough academic rationale to ensure things are sure, with the practical necessities (Table 6).

These comprehensive alterations give evidence of a desire to produce academically valid teaching materials, pedagogically sound, and congruent with the milieu from which they come. The end-products have arrived at a point where they are productive of productive learning by encouraging students to correlate their linguistic knowledge with their settled experiences in the culture from which they spring, for example, by means of tasks of reflection which correlate local customs with linguistic use and with multimedia projects which emphasize the cultural identity.

Table 6: Revisions in Teaching Tools Development

Aspect	Before Revision	After Revision	Alignment with Theory/Principle
Student Worksheet Instructions	Instructions were abstract and general.	Language simplified, sentences made explicit and contextual; concrete activity examples added for each assignment.	Scaffolding in constructivist learning.
Cultural Content in Flipbook Module	Focused mainly on Malay culture.	Added Batak and Javanese cultural content and activities to reflect Asahan Regency's diversity.	Culturally Responsive Teaching (CRT).
Technology Interface Design	Navigation buttons were unclear and confusing.	Enlarged icons, added text labels; included narrative audio to support auditory learners and enhance engagement.	Universal Design for Learning (UDL) – principle of multiple representations.
Evaluative Quiz Format	Quiz relied only on multiple-choice questions.	Added open-ended reflective questions to connect materials with students' cultural experiences.	Culturally responsive assessment.

4.5 Results of Expert Validation of Teaching Tools

The validity of the developed teaching tools was evaluated by three expert validators, focusing on aspects of content, design, and usability (Table 7). Gregory's formula was applied to ensure the consistency of the experts' assessments. A coefficient of 0.89 was found to be extremely high concerning the degree of agreement among the experts. That being said, it provides evidence that the reliability and consistency of the judgments made by the experts are pretty reliable. The average of the experts' ratings was used to find a general measure of validity.

The mean rating of 3.66 (out of 4) was identified as "highly valid." As such, the teaching tools met the expectations concerning content relevance, the incorporation of culture, and the accessibility of technology. Therefore, the teaching tools have been demonstrated to have a high degree of validity, both from an expert evaluation perspective and through the strength of the inter-rater agreement. These results form a strong basis for the subsequent use of the flipbook in classroom-based learning activities.

Table 7: Results of Expert Validation of Teaching Tools (n=3)

Aspect	Mean Score (Scale 1–4)	Validity Categories
Content and Purpose Suitability	3.70	Highly Valid
Clarity of Instructions and Language	3.30	Valid
Integration of Local Culture (CRT)	3.90	Highly Valid
Technology Integration (TPACK)	3.80	Highly Valid
Visual Design and Interactivity	3.60	Highly Valid
Overall Average	3.66	Highly Valid

Note: Gregory's coefficient of inter-rater agreement = 0.89 (Very High Agreement).

4.6 Learning Materials Effectiveness

Pre- and posttest scores from the experimental and control groups were used to evaluate the success of the developed CRT-TPACK-based instructional material. As shown in Table 8, there are the results of the normality test (Kolmogorov-Smirnov/Shapiro-Wilk) as follows: For the pretest scores, both the experimental and control groups failed the tests with p-values less than 0.05 for at least one of the two tests, which indicated that the data were not normally distributed. However, the posttest scores were normally distributed, as the Shapiro-Wilk tests indicated a p-value greater than 0.05 for each group, although the Kolmogorov-Smirnov values were marginally significant. Because the normality test results were mixed, non-parametric tests were utilized for the subsequent analysis.

Table 8: Normality Testing

Group		Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Pretest	Exp	0.159	30	0.050	0.928	30	0.044
	Con	0.173	30	0.023	0.922	30	0.029
Posttest	Exp	0.153	30	0.069	0.953	30	0.201
	Con	0.156	30	0.061	0.935	30	0.067

The Wilcoxon Signed-Rank test (Table 9) examined learning gains within each group. In the experimental group, all students showed positive ranks, indicating an improvement from pretest to posttest, with a significant Z-value of -4.901 ($p < 0.05$). This demonstrates a substantial increase in student achievement after using the CRT–TPACK-based teaching materials. In the control group, only 50% of students improved, while the other 50% showed no change (ties), with a significant Z-value of -3.578 ($p < 0.05$). This suggests that traditional teaching methods produced smaller gains than the experimental intervention.

Table 9: Wilcoxon Signed-Rank Test

Comparison	N	Negative Ranks	Positive Ranks	Ties	Z	p-value
Posttest vs. Pretest (Control)	30	0 (0.0%)	15 (50%)	15 (50%)	-3.578	0.000
Posttest vs. Pretest (Experimental)	30	0 (0.0%)	30 (100%)	0%	-4.901	0.000

The Mann–Whitney U test (Table 10) was used to compare posttest scores between the experimental and control groups. The experimental group had a higher mean rank (41.20) than the control group (19.80), and the difference was statistically significant (U = 129.0, Z = -4.798, $p < 0.05$). This result confirms that students who received instruction using the CRT–TPACK-based materials achieved significantly higher learning outcomes than those in the control group.

Table 10: Mann–Whitney U Test for Posttest Scores Between Experimental and Control Groups

Group	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Exp	30	41.20	1236.00	129.000	594.000	-4.798	0.000
Con	30	19.80	594.00				

4.7 Teaching Materials Overview

The teaching materials produced in this research project are delivered through a digital flipbook created using the *Heyzine* platform. It provides a medium that is both interactive and easily accessible for both teachers and students. It combines various media (text, images, video, etc.) as well as hyperlinks to other educational resources. The primary focus of the teaching materials is the "Observation Report Text," which is one of the four key areas in Indonesian language learning.

As seen in Figure 2, the teaching materials have been structured into logical steps, starting with a brief overview of an observation report and followed by definitions, examples, and activity-based instructions.
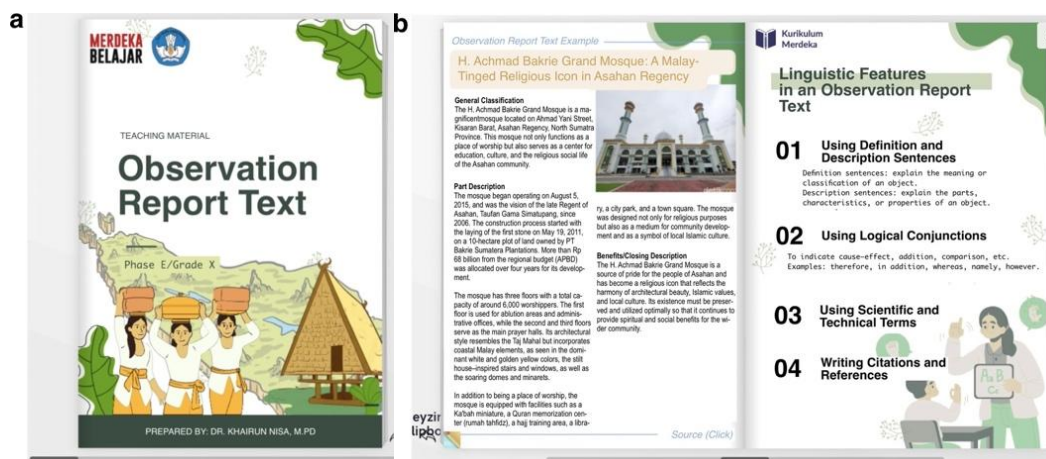
Figure 2: (a) Cover of the teaching material book and (b) content of the teaching material

Multimedia has also been incorporated to assist students with their understanding of the subject matter. Figure 3 shows example content from the teaching materials that includes video clips embedded in the content and linkable to *YouTube* to provide students with visual demonstrations of how observation reports can be used when providing observation results. These video clips were designed to help connect theoretical aspects of reporting observation results with practical applications to support students who learn differently.
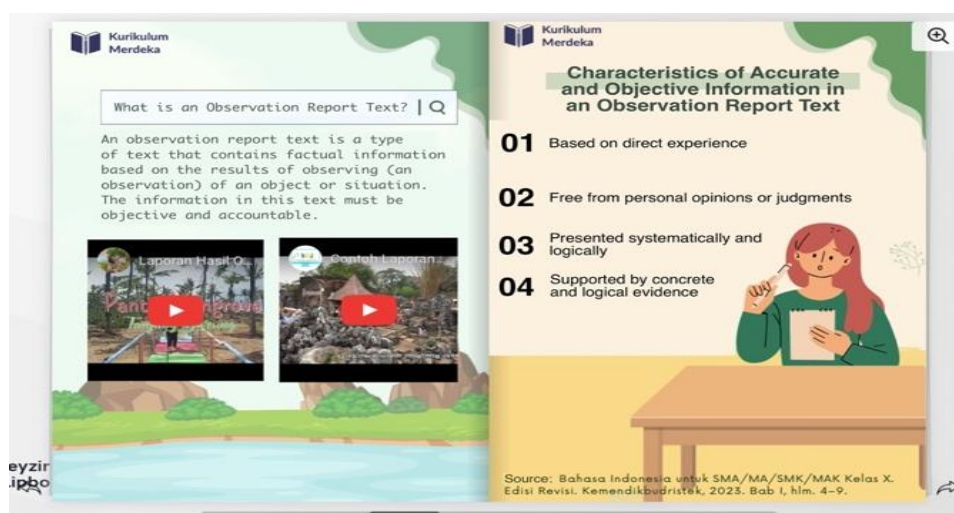

Figure 3: Content of the teaching material showing linkable video examples

In addition, the flipbook has a link to step-by-step writing assistance for developing an observation report (see Figure 4). Links to student worksheets, online quizzes, and reflection tasks are also included in each stage of developing an observation report. By including these links in the development of an observation report, students have a method to apply their understanding of the theory of CRT and other educational concepts, while at the same time practicing what they learned using interactive learning tools.
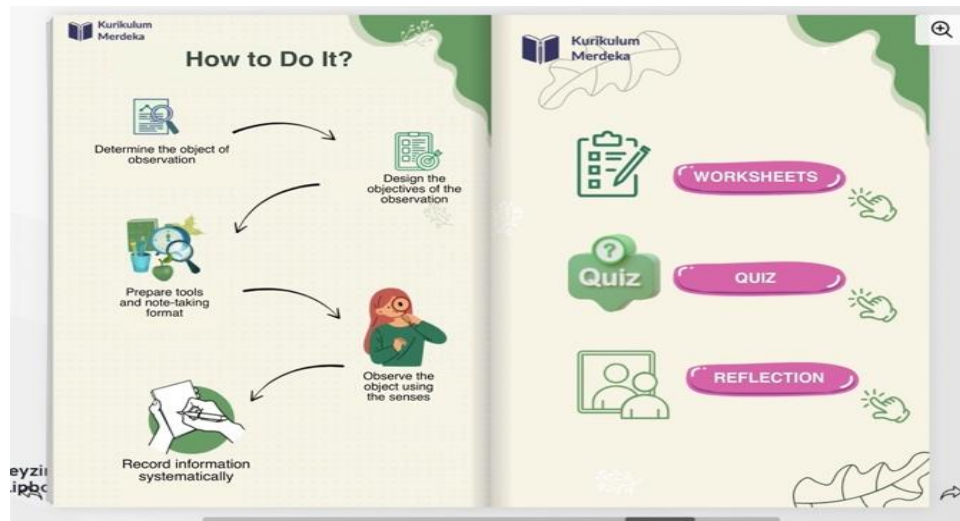
Figure 4: Content of the teaching material showing the stages of writing observation report and links to student worksheets, quizzes, and reflection

Supporting materials are also included to strengthen student engagement. Figure 5 shows the student worksheets, which were developed to provide students with opportunities to explore cultures, think critically, and write reflectively, all of which are part of the foundation of CRT.
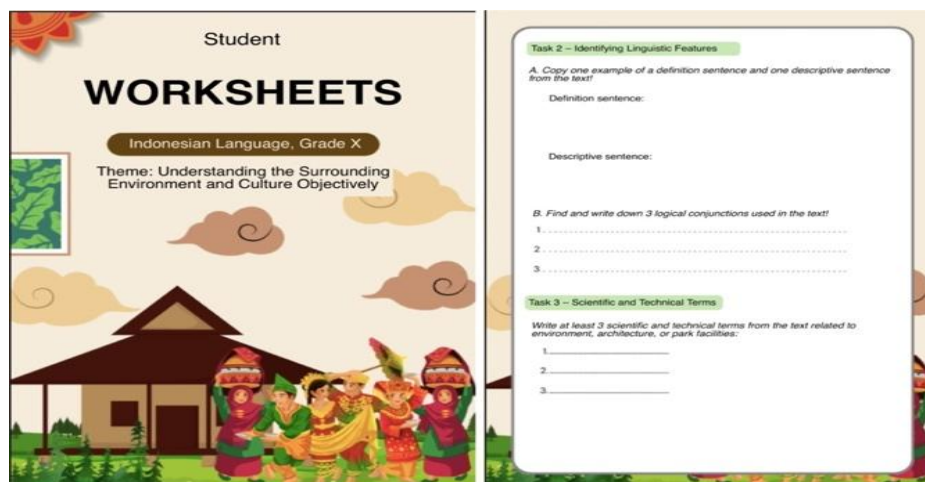

Figure 5: Left: cover of student worksheets; Right: student tasks

When assessing student engagement in the experimental group's classroom activities, it was evident that students displayed very high levels of interest and enthusiasm for using the CRT-TPACK-based flipbook. The flipbook contained culturally diverse visuals, short video clips, and examples of local culture (traditions, various ceremonial events, and unique regional foods) that sparked curiosity and pride in students' understanding of cultural diversity. Students demonstrated active reading throughout the activity by reading through all the flipbook pages on the classroom display device and their individual devices.

At the start of the activities, approximately four to five students had difficulty navigating the flipbook pages and completing the integrated digital worksheets.

These students needed a brief period of assistance from the teacher to access links and record their answers. Once these students received the support, they were able to complete the activity successfully.

Approximately two-thirds of the students indicated enjoyment and active participation in the learning process. Evidence of positive responses to the activities included smiles and occasional laughter when viewing examples; peer-to-peer discussions when viewing cultural content related to their life experiences; and several students providing examples of their personal experiences that were relevant to the cultural content presented in the flip book.

Approximately thirty percent of the students asked questions or provided suggestions for the discussion sessions; nearly all of the questions related to how learning Indonesian relates to the students' local cultural values or how they can describe their regional culture as part of writing a descriptive paragraph. It was apparent that numerous students had engaged cognitively and affectively in the lessons and worksheets at a very high level.

Generally, the students responded very favorably to the culturally diverse nature of the content contained within the flipbook. They expressed gratitude for the culturally diverse content used in the teaching process. Additionally, the students represented various ethnicities and appreciated each other's respective regional cultures. Furthermore, students of multiple ethnicities indicated a sense of pride and happiness in having their respective regional cultures included in the teaching materials. In conclusion, using the CRT-TPACK flipbook in the classroom resulted in a positive and inclusive interactive learning environment promoting multiculturalism and diversity awareness among the students.

5. Discussion

The findings suggest that a CRT-oriented educational tool (utilizing the TPACK framework) could be developed for application within multicultural schooling environments in Indonesia; that experts were very positive with respect to the quality of the educational tool; and to what extent it was culturally and technologically aligned. Further, the results indicated that using CRT and TPACK as complementary frameworks when creating educational tools resulted in positive outcomes. CRT provides teachers with a theoretical base that enables them to develop an understanding of and support the diversity of their student population.

At the same time, TPACK adds another layer of credibility to the tool so that technology appears to be integrated into meaningful instructional design and content decisions as much as possible. This interrelationship between CRT and TPACK was evident during the implementation of the classroom process. High student enthusiasm occurred, mainly because the CRT-TPACK-based flipbook used in class featured local illustrations, short video clips, and various interactive activities. Students actively engaged with the material, discussed cultural themes, and shared personal experiences about their regional traditions. As Mishra and Koehler (2006) suggested, all three aspects, content, pedagogy, and technology,

must be balanced in designing meaningful learning experiences. In this context, interactive flipbooks that present materials in multimodal formats (text, audio, visual, and interactive) and online application-based quizzes are concrete evidence of implementing TPACK principles that support CRT strategies.

Findings from the initial analysis stage, such as the lack of representation of local cultures, limitations of multicultural teacher training, and the lack of optimal use of technology in the classroom, became a strong conceptual basis in preparing the design of teaching tools. The design strategy that emphasizes exploring students' cultural identity through projects, regional cultural texts, and digital media proves that teaching tools can combine academic cognition with students' social contexts. This aligns with the asset-based pedagogy theory (Paris & Alim, 2017), which transforms cultural diversity from an obstacle to a strength in the learning process.

From a practical perspective, the teaching tools developed also answer the needs of teachers in managing cross-cultural learning. The teaching guidelines in the modules give concrete guidance on implementing a culturally responsive approach in the classroom, which is still missing in the current national curriculum. Amendments based on expert suggestions show that teacher training and structured support of teaching tools are needed to ensure efficient target implementation of CRT in the classroom. Specifically, teachers require capacity-building workshops on integrating cultural matters with digital pedagogy, mentoring seminars on designing inclusive learning activities, and continuing technical support on the operation and adaptation of CRT-TPACK-based materials. According to the findings of Ampo et al. (2025), the teachers' experiences with technology integration revealed both the creative tendencies and the challenges of ensuring accuracy, contextual relevance, and pedagogical control.

The results show that CRT–TPACK–based instructional materials are far superior to conventional instruction because they relate better to student learning outcomes. The Mann–Whitney U Test confirmed the null hypothesis could be rejected because there was a statistically significant difference between groups, with the experimental group getting a mean rank of 41.20 as compared to the control group's mean rank of 19.80 (U = 129.0, Z = -4.798, p < 0.05). This results from the potency of combining sure responsive teaching and pedagogical practices supported by technology, in that they facilitate conceptual understanding and equitable engagement on the part of all students, irrespective of their backgrounds.

These results are in agreement with Tetteh et al. (2025), who demonstrated that multimodal approaches to instruction, which combine printed materials, video, and interactive tasks, produce better knowledge acquisition and retention. These are consistent with the notion that culturally responsive approaches to instruction otherwise promote better engagement with the materials, due mainly to the technology interactivity, whereby the student is allowed to interact with the learning materials in depth and will end up obtaining substantial academic

benefits (Caingcoy, 2023; Li et al., 2024; Sawita et al., 2024). Nonetheless, these outcomes should be considered encouraging but preliminary, given the limited sample size of 60 participants.

6. Conclusion
The Indonesian teaching tools created using the CRT-TPACK framework for multicultural schools are highly valid concerning content relevance, instructional design clarity, cultural representation, technological compatibility, and visual interaction. Teaching materials (modules, interactive flipbooks, and worksheets) were developed after conducting fieldwork (observations, interviews), taxonomic and thematic analysis showing the lack of cultural representation, limited multicultural training for teachers, and little too no technology being utilized in classrooms.

The results of the expert validation indicated an extremely high level of agreement (Gregory value = 0.89) among the panel of experts concerning the degree of cultural inclusiveness, the degree of technology utilization, and the degree of pedagogical relevance; this level of agreement lends significant credibility to the tools developed, and lends credence to the notion that they will help enhance inclusive and technologically integrated learning in multicultural classrooms.

Revision based upon expert feedback added clarity to the instruction, enhanced the diversity of cultural representation, and improved the accessibility of the digital component of the tools; therefore, the teaching tools are both academically appropriate and practically viable. The comparison of the learning outcomes of students in the experimental group versus those in the control group further substantiated the efficacy of the instruments. The Mann-Whitney U test showed, specifically, that the posttest scores of the experimental group were statistically different ($p = 0.000$) than the posttest scores of the control group.

Therefore, the data continued to support the proposition that the instruments which have been developed not only comported with the academic and cultural validity criteria, but that they were efficacious in increasing the academic achievement of students in multicultural classrooms. Teachers are encouraged to utilize the tools developed by adapting them to include local cultural values, traditions, and linguistic diversity via examples, texts, and learning activities. Teachers are also encouraged to adapt the digital components of the tools to include digital aspects that are compatible with the levels of technological access and the specific learning needs of their students. In addition, curriculum developers are encouraged to utilize the CRT-TPACK model to assist in developing contextually relevant instructional materials that promote inclusion and engagement within various school settings.

7. Limitations and Future Directions
The results of this study have several significant limitations. The first is the small scale upon which the CRT-TPACK-based tools for teaching were implemented (only two multicultural school settings), limiting the findings' external validity. Secondly, the study measured only short-term learning gains (immediately post-

intervention) and did not consider whether the learning gained would persist in the longer term (retention/transfer). Thirdly, there is a lack of full student feedback regarding applying CRT-TPACK-based tools for teaching; this provides only a partial insight into the students' views, attitudes, and learning experiences using these tools. Fourthly, the analysis of the effectiveness of the intervention was primarily concerned with measuring the cognitive learning outcomes through the pretest and posttest measures of student learning.

Affective engagement, intercultural sensitivity, and the long-term retention of learning by the students were other important aspects of the potential impact of the CRT-TPACK-based tools that were not assessed. Fifthly, although an expert panel validated the tools as valid and feasible to develop, the study did not investigate the practicalities and challenges faced by teachers when applying the CRT-TPACK-based materials in real classrooms.

It is essential to gather data from teachers in relation to the practicalities and challenges of implementing CRT-TPACK-based materials within real classrooms, as teachers will ultimately determine how the CRT-TPACK-based materials are used, adapted, maintained, and applied in real classrooms, subject to various institutional and technological constraints. Finally, it was assumed in the study that all students had relative equality of access to technology and that teachers had a reasonable level of readiness, which may not reflect the diversity of real classroom conditions.

For future research to take place, several suggestions can be made. First, it is recommended that larger-scale studies be conducted that include a variety of school settings and geographic locations to support the generalizability of the results and assess how well the results apply to a variety of cultural environments. Second, it would be beneficial to conduct longitudinal research to assess the long-term effects of CRT-TPACK-based teaching materials on student performance, engagement, and cultural competence.

Finally, further research could include qualitative and quantitative methods (mixed methods) to determine the quantitative improvement of student performance and assess the qualitative aspects of student engagement, the development of their cultural identity, and the dynamics within the classroom. Additionally, there may be opportunities for future research to explore the potential of using adaptive digital technology to increase the integration of CRT-TPACK and to assess teachers' professional development requirements to ensure successful use of culturally responsive teaching tools.

8. Conflict of Interest
The authors declare no conflict of interest.

9. Author Contributions
Khairun Nisa conducted the research, collected the data, and wrote the initial draft of the paper; Ely Syafitri developed the research methodology, supervised the research process, and reviewed the manuscript; Amelia Simanungkalit

interpreted the findings, provided academic guidance, and critically revised the manuscript; all authors have read and approved the final version.

10. Acknowledgment

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