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A Pugh Matrix framework for selecting effective CALL software in South African schools

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ABSTRACT

In recent years, digital technology integration in education, including language learning, has become widespread. South African schools are increasingly acknowledging the benefits of computer-assisted language learning (CALL) applications. Digital tools in educational materials offer advantages such as time efficiency, enhanced accessibility, flexible learning methods, and inclusivity for disabled individuals. However, there's a lack of appropriate guidelines for assessing and selecting CALL software due to the unique complexities it presents. To address this gap, the study developed a systematic framework, utilising a Pugh Matrix, tailored for South African educational contexts and beyond. This matrix was informed by guiding principles derived from iterative developmental research. A Likert scale survey validated these principles, influencing the weighting of assessment criteria. These criteria encompass curriculum alignment, feedback mechanisms, socio-cultural relevance, affordability, technical considerations, and pedagogical approaches. The developed Pugh Matrix serves as a comprehensive and objective tool for CALL software selection and evaluation. It empowers schools to make informed decisions aligned with their educational goals, instructional methods, technical needs, and budgetary constraints.

Keywords: digital technology integration; computer-assisted language learning; educational technology; selection; evaluation

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1. Introduction

In contemporary educational contexts, the integration of digital technology has become increasingly prevalent, ushering in transformative possibilities for teaching and learning. South African schools are progressively acknowledging the potential advantages of incorporating computer-assisted language learning (CALL) applications into their educational frameworks. This recognition is grounded in the anticipation of enhanced efficiency, improved accessibility to learning materials, adaptability in teaching approaches, and increased inclusivity, especially for learners with disabilities.

Despite the enthusiasm for integrating CALL software, a notable void exists in the educational landscape. This stems from the absence of suitable guidelines and resources for the systematic assessment and selection of CALL applications. Existing evaluation tools, originally designed for conventional educational materials, fall short in accommodating the distinctive attributes and intricacies associated with CALL software.

This study, therefore, seeks to address this critical gap by proposing the development of a structured framework embodied in a Pugh Matrix for the purposeful evaluation and selection of CALL software. The necessity for such a framework arises from the evolving nature of digital technology, requiring tailored assessment criteria that go beyond traditional educational materials. The unique characteristics of CALL software demand a nuanced evaluation approach to ensure its compatibility with educational objectives, instructional methodologies, technical prerequisites, and financial constraints.

The rationale for this study stems from the urgent need to equip educators and decision-makers in South Africa with a comprehensive tool for selecting effective CALL software. Given the rapidly evolving educational landscape and increasing reliance on technology, it is imperative for schools to make informed decisions that align with their specific needs and goals. To achieve this, the study aimed to address the following research questions:

- What are the key criteria that South African schools should consider when selecting CALL software for language learning?
- How can a Pugh Matrix be adapted and weighted to effectively evaluate CALL software in South African educational contexts?

The absence of appropriate evaluation mechanisms may inadvertently perpetuate disparities in digital technology adoption, especially in under-resourced schools. By developing a Pugh Matrix based on guiding principles derived from an iterative

developmental research approach, this study aims to contribute a valuable resource that transcends the limitations of existing evaluation tools.

In essence, the value of this lies in its potential to empower educational institutions, particularly in South Africa, with a systematic and objective tool for the purposeful evaluation of CALL software. By addressing the identified gap in current evaluation resources, the study aspires to facilitate a more equitable and effective integration of digital technology, ultimately enhancing the quality and inclusivity of language learning in educational settings.

2. Literature review

Integrating digital technology into education represents a transformative shift in disseminating and acquiring knowledge, reshaping educational practices across various levels. With the rapid advancements in digital technology over recent decades, educational ecosystems have witnessed significant evolution, embracing a plethora of tools ranging from computers and mobile devices to multimedia platforms and online learning management systems. Such integration has been propelled by the recognition of digital technology's potential to foster inclusive and equitable quality education, aligning with global initiatives such as the United Nations' sustainable development agenda for 2030. The following review explores the current landscape of digital technology integration in education, with a specific focus on CALL applications, while also examining the challenges associated with the assessment and selection of such software. Additionally, the review contextualizes the development of a novel framework, in the form of a Pugh Matrix, designed to provide schools with a systematic tool for selecting and evaluating CALL software in the South African context and beyond. Through an analysis of existing literature, this review aims to elucidate the rationale behind the development of the framework and provide insights into its potential implications for educational practice.

2.1 Introduction to digital technology in education

Integrating digital technology into education represents a paradigm shift in how knowledge is imparted and acquired. Over the past few decades, advancements in technology have revolutionised various aspects of modern society, and the field of education is no exception. Digital technologies encompass a wide array of tools, ranging from computers and mobile devices to multimedia platforms and online learning management systems. These technologies have permeated every level of the educational ecosystem, from early childhood education to higher education and lifelong learning.

Recognising digital technology's transformative potential has fuelled its adoption in education. As highlighted by Haleem, Javaid, Qadri, and Suman (2022), technology has emerged as a powerful tool for promoting inclusive and equitable quality education, aligning with global initiatives such as the United Nations' sustainable development agenda for 2030. By leveraging digital tools and platforms, educators can create dynamic and interactive learning environments that cater to the diverse needs and preferences of learners.

One of the most significant advantages of digital technology in education is its ability to enhance accessibility and flexibility. With the proliferation of digital devices and internet connectivity, learners can access educational resources and participate in learning activities virtually anywhere and anytime (Haleem et al., 2022). This flexibility is particularly beneficial for learners with diverse backgrounds, abilities, and learning styles, as it allows for personalised and self-paced learning experiences.

Moreover, digital technology has revolutionised how educational content is delivered and consumed. Traditional textbooks and lecture-based instruction are being supplemented, if not replaced, by multimedia-rich resources, interactive simulations, and immersive learning experiences (Haleem et al., 2022). Digital classrooms, characterised by the integration of electronic devices and software, have become the new norm, enabling educators to engage learners through multimedia presentations, collaborative projects, and real-time feedback mechanisms.

However, the integration of digital technology in education is not without its challenges. One of the primary concerns is the digital divide, which refers to disparities in access to and utilisation of digital technologies among different socio-economic groups (Chetty et al., 2018). Despite efforts to bridge this gap, issues of limited infrastructure, high costs, and inadequate digital literacy persist, particularly in underserved communities. Addressing these challenges requires a multi-faceted approach that combines infrastructure development, digital skills training, and inclusive policy frameworks (Goncalves, Oliveira, & Cruz-Jesus, 2018).

While the integration of digital technology in education offers numerous benefits, it is important to acknowledge that the effectiveness of these technologies depends on their pedagogical design and implementation. Merely introducing technology into the classroom without considering its alignment with educational objectives and teaching strategies may not yield the desired outcomes. Therefore, it is crucial to adopt a critical and reflective approach to the integration of digital technology, ensuring that it enhances teaching and learning processes rather than simply replacing traditional methods.

2.2 Digital divide and educational inequality

The digital divide, characterised by discrepancies in access to and utilisation of information and communication technologies (ICT), constitutes a significant barrier to achieving educational equity and inclusivity (Chetty et al., 2018). This divide manifests in various forms, including limited infrastructure, high costs, and inadequate digital literacy, particularly prevalent in low and middle-income communities (Chetty et al., 2018). Despite advancements in ICT penetration, disparities persist, requiring continuous efforts to bridge this gap and ensure equal opportunities for all learners (Goncalves, Oliveira, & Cruz-Jesus, 2018).

Moreover, the digital divide is not solely confined to access issues but extends to disparities in digital skills and usage (Maceviciute & Wilson, 2018). In developing countries, understanding individual-level digital divide becomes imperative for advancing the living conditions of millions who lack access to essential digital resources and skills (Goncalves et al., 2018). The lack of digital literacy exacerbates educational inequalities, hindering marginalised communities' ability to fully engage in the digital age.

Recent global initiatives, such as the G20 communiques, have acknowledged the importance of addressing the digital divide, primarily focusing on infrastructure development and financial inclusion (Chetty et al., 2018). However, to achieve meaningful progress, a comprehensive approach encompassing digital skills training, policy reforms, and community engagement is essential (Goncalves et al., 2018). This requires collaboration among governments, educational institutions, and civil society to tackle the multifaceted nature of the digital divide and its implications for educational equity.

Furthermore, the COVID-19 pandemic has highlighted the urgency of addressing digital inequalities in education. School closures and the shift to online learning have widened existing disparities, particularly affecting learners from disadvantaged backgrounds (van de Werfhorst, Kessenich & Geven, 2020). Access to digital devices and internet connectivity has emerged as crucial determinants of educational outcomes, underscoring the need for targeted interventions to support vulnerable populations (Dube, 2020). Addressing digital disparities is imperative to ensure that all learners, including those from marginalised communities, can benefit from the opportunities offered by educational technology to thrive in inclusive learning environments. These groups are often less likely to have access to digital devices, internet connectivity, and digital literacy skills. This lack of access can exacerbate existing educational inequalities, limiting students' opportunities for learning and development. Educational institutions have a crucial role to play in addressing the digital divide by providing access to technology, digital literacy training, and support for students who are

struggling to keep up. Failing to address the digital divide can have long-term consequences, such as limited employment opportunities, social exclusion, and a widening gap between the haves and have-nots

2.3 Educational technology and inclusive education

Educational technology has emerged as a powerful tool for promoting inclusive education by addressing barriers to learning and providing tailored support to diverse learners (Haleem et al., 2022). As advocated by Dube (2020), inclusive education emphasises the provision of equitable educational opportunities for all learners, regardless of their backgrounds or abilities. Digital technologies offer innovative solutions to meet the diverse needs of learners, enabling personalised learning experiences and fostering greater engagement and participation in the educational process.

Educational technology integration in inclusive education has been facilitated by advancements in digital learning platforms, multimedia resources, and assistive technologies (Haleem et al., 2022). These technologies cater to a wide range of learning styles and preferences, allowing educators to differentiate instruction and provide individualised support to learners with disabilities or special educational needs (Dube, 2020). Additionally, digital tools such as screen readers, speech recognition software, and text-to-speech applications enhance accessibility and promote greater independence for learners with disabilities. Furthermore, educational technology facilitates collaboration and communication among learners, educators, and parents, fostering a supportive learning environment (Haleem et al., 2022). Online learning platforms enable remote access to educational resources and facilitate peer interaction and collaborative projects, breaking down geographical barriers and promoting inclusivity (Dube, 2020). By leveraging digital technologies, educators can create inclusive learning environments that celebrate diversity and empower all learners to reach their full potential.

However, the successful implementation of educational technology in inclusive education requires careful consideration of accessibility and usability issues (Lu et al., 2022). Designing digital learning materials and platforms accessible to learners with diverse needs is essential for ensuring equal opportunities for all students (Valverde-Berrocoso, Acevedo-Borrega, & Cerezo-Pizarro, 2022). Moreover, ongoing professional development and training are crucial for educators to effectively integrate educational technology into their teaching practices and accommodate the needs of diverse learners (Qureshi et al., 2021).

Educational technology has the potential to be a powerful tool for promoting inclusive education by addressing barriers to learning and providing personalised support for

diverse learners. However, it is important to recognize that the successful implementation of educational technology in inclusive settings requires careful consideration of accessibility, usability, and equity. By adopting universal design for learning principles and providing professional development for educators, we can ensure that educational technology is used to break down barriers to learning and create inclusive and equitable learning environments for all students. While educational technology can be a powerful tool for inclusion, it is also important to be aware of the potential for it to exacerbate existing inequalities if not implemented carefully. For example, if educational technology is not accessible to all students, it can create a digital divide that further marginalizes disadvantaged groups.

2.4 Empowering educators and decision-makers

Empowering educators and decision-makers is crucial for effectively integrating educational technology and promoting inclusive education (Haleem et al., 2022). Educators play a central role in leveraging digital tools and platforms to create inclusive learning environments that cater to the diverse needs of learners (Dube, 2020). Therefore, providing educators with the necessary support, resources, and professional development opportunities is essential for enhancing their capacity to harness the potential of educational technology.

Professional development programs tailored to the needs of educators are vital for building their digital literacy skills and confidence in using educational technology (Qureshi et al., 2021). These programs should focus on enhancing educators' understanding of inclusive pedagogies, accessibility guidelines, and best practices for integrating digital tools into teaching and learning (Haleem et al., 2022). By equipping educators with the knowledge and skills to effectively utilise educational technology, decision-makers can empower them to create engaging and inclusive learning experiences for all students.

Moreover, decision-makers at the institutional and policy levels play a critical role in shaping the educational landscape and promoting the adoption of inclusive practices (Dube, 2020). By developing inclusive policies, allocating resources, and fostering collaboration among stakeholders, decision-makers can create an enabling environment for effective educational technology integration (Haleem et al., 2022). Additionally, decision-makers should prioritise investments in infrastructure, connectivity, and digital resources to ensure equitable access to educational technology for all learners (Dube, 2020).

Furthermore, partnerships between educational institutions, government agencies, and industry stakeholders are essential for driving innovation and scaling successful initiatives involving educational technology (Qureshi et al., 2021). Collaborative efforts

can facilitate knowledge sharing, resource mobilisation, and capacity building, thereby enhancing the impact of educational technology on teaching and learning outcomes (Haleem et al., 2022). By fostering a culture of collaboration and continuous improvement, decision-makers can create an ecosystem that supports innovation and promotes the sustainable integration of educational technology in education.

Empowering educators and decision-makers is essential for the successful integration of educational technology in promoting inclusive education. Educators may face challenges such as lack of training, lack of resources, or resistance to change. School leaders can play a crucial role in creating a supportive environment for educators to use technology effectively by providing professional development opportunities, access to resources, and a culture of innovation. Policymakers can also contribute by developing supportive policies and allocating resources to facilitate the use of educational technology. By addressing these challenges and providing the necessary support, empower educators and decision-makers are empowered to leverage educational technology to create inclusive and engaging learning environments for all students.

2.5 Computer-assisted language learning

Computer-assisted language learning (CALL) has emerged as a dynamic and interdisciplinary field, propelled by the advancements in educational technologies and digital devices (Chen, Zou, Xie & Su, 2021). Egbert (2005) provides a comprehensive definition of CALL, emphasising its broad scope, which encompasses language learning facilitated by any computer technology within various contexts. The proliferation of mobile and broadband technologies has facilitated ubiquitous learning, allowing access to diverse online resources anytime and anywhere (Chen, et al., 2021). Moreover, a wide range of technologies, including interactive whiteboards, automatic speech recognition (ASR), and digital games, are increasingly being integrated into language education to enhance learning experiences (Chen, et al., 2021). This integration reflects CALL's international recognition as a discipline leveraging digital technology for language education (Chen, et al., 2021).

The effectiveness of CALL in facilitating interactions among students and teachers is particularly noteworthy in the current language learning era, characterised by a focus on social interactions (Chen, et al., 2021). While previous research often focused on students' perceptions or affective status, recent studies within the CALL community have explored various aspects, such as the effectiveness of virtual-related technologies, authentic communication, and task-based learning (Chen, et al., 2021). The development of mobile-assisted language learning (MALL) is diversifying, thanks to advances in digital technology that enrich language learning experiences on mobile devices (Chen, et al., 2021).

Digital game-based language learning (DGBLL) has gained attention for its immersive exposure to the target language context, reduction of affective barriers, and promotion of target language use for interaction (Chen, et al., 2021). The implementation of various digital games in language education has facilitated situated learning, anchored instruction, and discovery-centred learning (Chen, et al., 2021). Furthermore, the integration of advanced technologies, such as deep learning algorithms, sensor and networking technologies, and Web 2.0 tools, has contributed to the enhancement of language learning experiences (Chen, et al., 2021).

In language assessment, CALL offers access to various assessment types, providing opportunities to assess language proficiency comprehensively (Bahari, 2021). Bahari (2021) highlights the need to address integrated language skills for learning and assessment purposes to enhance authenticity, engagement, competence, and performance in the CALL context. By leveraging CALL's interactive, dynamic, and adaptive affordances, educators can enhance pedagogical practices and promote more effective language learning outcomes (Bahari, 2021). Curriculum alignment, affordability, technical compatibility, and pedagogical approaches are among the key variables that influence the selection of CALL software in schools (Hubbard, 2006; Lee, 2001; Bailey & Lee, 2020).

The dynamic field of computer-assisted language learning (CALL), driven by advancements in educational technology, underscores the necessity for a comprehensive approach in selecting and evaluating educational resources for schools, particularly in under-resourced settings, where considerations such as infrastructure limitations, curriculum alignment, and resource usability are paramount for promoting effective language education and supporting diverse learner needs.

2.6 The selection and evaluation of educational resources

The selection of educational resources for schools, particularly in under-resourced settings, necessitates a comprehensive and objective approach that considers various factors such as infrastructure limitations, curriculum alignment, and resource usability. In such contexts, where access to technology and educational materials may be limited, selecting appropriate resources is essential. Haleem et al., (2022) emphasise the significance of incorporating suitable technology into classroom instruction to cater to individual learner needs and monitor their progress, a principle that holds particular relevance for under-resourced schools. Previous research has shown that CALL software must align with the national curriculum and be compatible with existing infrastructure to be effective Hubbard (2006). However, the selection of educational software must consider the infrastructure limitations of schools, ensuring compatibility with available technology and resources.

Aguilar (2020) discusses the utility of rubrics as a framework for evaluating course designs, which can assist schools in aligning educational resources with curriculum objectives. In schools, where curriculum alignment is crucial for optimising resources, adopting objective evaluation criteria becomes even more imperative. By adhering to such criteria, schools can ensure that educational resources effectively support the curriculum and instructional goals.

Moreover, the challenges Allen and Seaman (2014) highlighted regarding faculty adoption of open educational resources (OER) underscore the importance of objective evaluation mechanisms, particularly in under-resourced schools. These schools often face more significant barriers in accessing and evaluating educational resources, making impartial evaluation criteria essential for informed decision-making. The need for objectivity in resource selection and evaluation extends to considerations of usability, particularly where technical support may be limited. Lu, et al. (2022) advocate for usability studies to evaluate educational software, emphasising the importance of usability assessments in ensuring that resources are accessible and user-friendly for both teachers and learners.

The selection of educational resources is a critical process for schools, especially in under-resourced settings. By using objective evaluation criteria, such as rubrics and usability studies, schools can ensure that they select resources that are aligned with their curriculum objectives and support student learning. Teachers play a crucial role in the selection and evaluation process and should be provided with training and support in using evaluation tools. The quality and appropriateness of educational resources can have a significant impact on student outcomes, so it is important for schools to continuously evaluate and update their resources to ensure they remain relevant and effective.

2.7 Pugh Matrix

Decision-making processes within projects often involve numerous factors and perspectives, making it challenging to arrive at a consensus. Pugh Matrix Analysis (PMA) emerges as a valuable tool within the domain of multiple criteria decision analysis (MCDA) techniques, facilitating the understanding of complex relationships among various project issues and perspectives (Cervone, 2009).

The Pugh Matrix (PM) is a Matrix Diagram utilised for comparing and evaluating multiple design candidates against predefined criteria. It enables the selection of the most suitable option based on a set of criteria and allows for qualitative optimisation by generating hybrid alternatives (Burge, 2011). Unlike other decision-making tools, the Pugh Matrix is particularly adept at handling numerous decision criteria, making it a preferred choice for complex decision-making scenarios (Cervone, 2009).

The construction of a Pugh Matrix typically involves several sequential steps. First, the criteria for selection must be clearly identified and defined, reflecting the stakeholders' perspectives. Rushing through this step may result in non-robust outcomes (Burge, 2011). Next, one candidate design option serves as the baseline against which other options are compared criterion by criterion. Pairwise comparisons are made, assigning scores indicating whether each alternative is better, worse, or the same as the baseline (Burge, 2011). These scores are then totalled for each option, with the highest-ranked option deemed the "winner." However, it is cautioned not to solely rely on the highest-ranked concept without careful consideration (Burge, 2011). Additionally, the Pugh Matrix allows for the creation of hybrid alternatives by combining the best elements from different options, further enhancing decision-making flexibility (Burge, 2011).

The complexity of decision-making processes often involves interwoven factors and criteria, leading to inconsistent and irrational decisions. The Pugh Matrix offers a simple yet effective approach to considering multiple factors, thereby enhancing the objectivity of decision-making processes (Burge, 2011). Moreover, it enables sensitivity analysis, providing insights into the robustness of decisions made (Burge, 2011).

Despite its utility, the Pugh Matrix is not without limitations. The quality of decisions heavily depends on the selection criteria employed. Incorrect, incomplete, or inadequately defined criteria can lead to flawed decisions (Burge, 2011). Additionally, the granularity of the pairwise scale used in the Pugh Matrix poses a challenge. While the simplicity of the scale allows for rapid evaluations, it may lack the granularity required for robust decision-making, potentially resulting in varying rankings of options (Burge, 2011).

The Pugh Matrix serves as a valuable tool for facilitating decision-making processes within projects, especially in scenarios involving multiple criteria and perspectives. However, careful attention must be paid to the selection criteria and the pairwise scale's granularity to ensure the decisions' robustness and validity.

2.7.1 Why is a Pugh Matrix suitable as a tool for the selection process?

The utilisation of a Pugh Matrix in the selection process of Computer-assisted language learning (CALL) software is justified due to its structured and systematic approach, providing a comprehensive framework for evaluating multiple criteria simultaneously. The matrix allows for the objective comparison of different software options against pre-defined assessment criteria, including curriculum alignment, assessment and formative feedback, socio-cultural relevance, affordability, technical considerations, and pedagogical approaches. Its inherent flexibility allows educators and decision-makers to assign weighted scores to each criterion, reflecting their relative importance. This structured evaluation ensures a nuanced and transparent decision-making process,

enabling schools to align their selection with specific educational objectives, instructional approaches, technical requirements, and budget constraints. The Pugh Matrix, as a versatile and user-friendly tool, empowers stakeholders to make informed and objective decisions, addressing the challenges associated with the unique characteristics of CALL software and contributing to effective technology integration in language learning environments. This aligns to the primary objective of this study which is to develop a comprehensive framework for selecting effective CALL software in South African schools. Specific objectives include:

- Identifying key criteria for evaluating CALL software in South African contexts.
- Developing a weighted Pugh Matrix based on stakeholder input.

3. Methodology

The study employed a mixed-methods approach, combining quantitative and qualitative data analysis techniques. This triangulation of data helped to enhance the validity and reliability of the findings.

Data collection for this study involved a two-phase approach. In the first phase, a purposive sampling strategy was employed to recruit participants from South African schools. This phase involved a cyclic developmental research approach with seven (7) cycles to formulate guiding principles for selecting and appraising CALL software for South African Grade 7-9 EFAL classes. Empirical observations and stakeholder feedback informed the iterative process. The development team comprised eight learners, four ESL teachers, and six curriculum experts with expertise in curriculum studies, educational management, and e-education. Participants were selected based on their experience and knowledge of CALL software in South African educational settings.

Subsequently, a Likert-scale survey was designed and administered to 81 stakeholders, including learners, teachers, administrators, and curriculum designers, to measure the perceived utility of the formulated guiding principles. The survey consisted of twenty-five (25) items designed to measure participants' perceptions of the guiding principles for CALL software selection. The survey included items related to curriculum alignment, assessment, socio-cultural relevance, affordability, technical considerations, and pedagogical approaches.

For this phase of the study, a mixed sampling approach was used to select participants. Education officials from the Tshwane North and Tshwane South Districts, as well as

those based at the DBE, were selected using simple random sampling based on their expertise in language and LTSM. Due to the large, geographically dispersed population of learners and teachers, cluster sampling was employed. Three schools within the Tshwane North district were chosen based on the availability of CALL programs to form the clusters. A total of 43 Grade 7-9 learners, 16 teachers, and 22 education officials participated in the study, ensuring a diverse and representative sample of stakeholders involved in CALL implementation in South African schools. The survey assessed stakeholders' opinions on the relevance and effectiveness of the principles formulated during the developmental phase of the study. The data collection procedure was designed to gather comprehensive and relevant information from stakeholders involved in CALL implementation in South African schools and was chosen for its efficiency and ability to measure attitudes and perceptions. Descriptive statistics were used to analyze the Likert-scale survey data, including calculating mean scores and standard deviations for each item. These statistics provided insights into the overall distribution of responses and the perceived importance of the guiding principles. To ensure the trustworthiness of the data, inter-rater reliability checks were conducted for the qualitative data collected during the survey. While the Likert scale survey provided a structured and efficient way to collect data from a large number of participants, it is important to note that it is subject to limitations such as social desirability bias and the potential for participants to provide inaccurate or misleading responses.

These guiding principles formed the basis for the selection and evaluation criteria of a Pugh Matrix, a decision-making tool for objectively assessing CALL software options. Data from the Likert scale survey informed the weighting of individual criteria in the Pugh Matrix. Criteria were clustered based on relevance, and the mean scores of Likert scale items within each cluster were used to determine weights. A weighted scaling process was undertaken, calculating initial criterion weights based on mean scores, summing them, and then proportionally adjusting each weight using a scaling factor derived from a desired total weight of 100. This ensured all weights contribute meaningfully to the final evaluation and facilitated the establishment of possible decision-making thresholds. The Pugh Matrix was selected as it provided a structured approach for evaluating CALL software and aligns with the principles of evidence-based decision-making, which advocate for using data and research to inform decision-making processes. By incorporating stakeholder input and empirical data, the Pugh Matrix provides a data-driven approach to CALL software selection. Figure 1 illustrates the development process of a Pugh Matrix, including the inductive formulation of

guiding principles, the design of a Likert scale survey based on these principles, and their incorporation into a weighted Pugh Matrix.

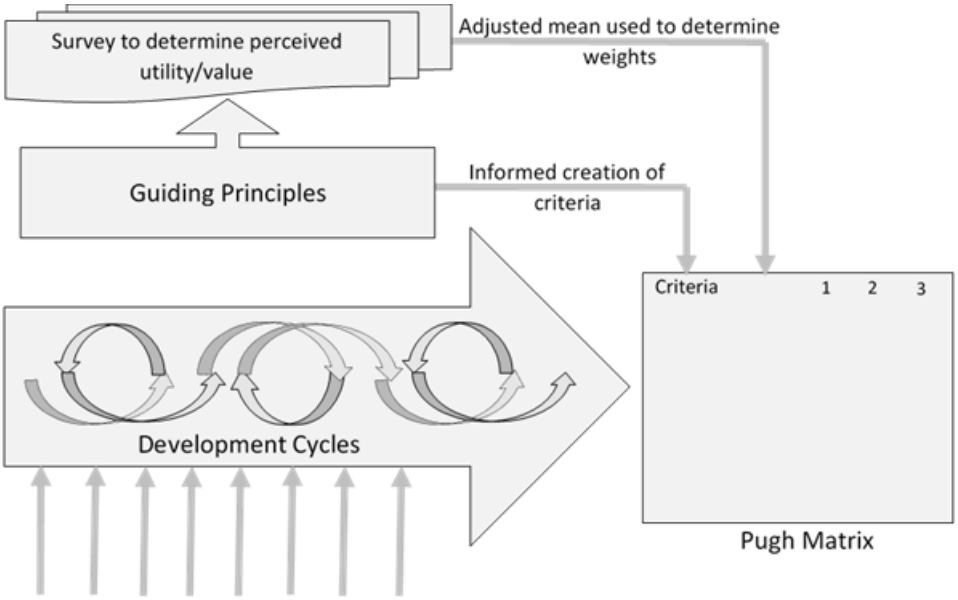

Figure 1: The process involved in getting from guiding principles to a weighted Pugh Matrix

Ethical considerations were a paramount concern throughout this study. To ensure the protection of participant rights, the research obtained ethical approval from the Faculty Committee for Research Ethics – Humanities (FCRE/APL/STD/2018/06), which is subsumed under the TUT Research Ethics Committee. The TUT Research Ethics Committee is a registered Institutional Review Board (IRB 00005968) with the US Office for Human Research Protections (IORG# 0004997) and has Federal Wide Assurance for the Protection of Human Subjects for International Institutions (FWA 00011501). In South Africa, it is registered with the National Health Research Ethics

Council (REC-160509-21). This approval process ensured adherence to ethical guidelines and the protection of participant rights, including informed consent, confidentiality, and data privacy.

4. Results

A developmental research approach was used to formulate a comprehensive set of guiding principles for evaluating English First Additional Language (EFAL) Computer-assisted language learning (CALL) applications in South African classrooms. These principles address critical aspects that include curriculum alignment, assessment methods, and teacher training support.

The inductively developed guiding principles provide a comprehensive foundation for developing the Pugh Matrix, outlining key considerations in assessing and selecting EFAL CALL applications. Each principle addresses specific facets crucial to effective evaluation, encompassing accessibility, curriculum alignment, assessment methods, teaching approaches, socio-cultural diversity, affordability, learner-centric features, and teacher training. These principles serve as evaluative criteria within the Pugh Matrix, guiding the structured comparison of different EFAL CALL applications. To determine their weighting in the matrix, results from the Likert scale survey could be analysed, assigning higher weights to principles with higher mean scores, indicative of their greater perceived importance and consensus among educators and stakeholders. By incorporating these guiding principles into the Pugh Matrix, the evaluation process becomes systematic and tailored to the unique characteristics and priorities of EFAL CALL applications, ensuring a nuanced and well-informed selection process.

The guiding principles offer specific assessment criteria that can be translated into the Pugh Matrix for the evaluation of EFAL CALL applications. Table 1 presents a summary of the guiding principles which informed the criteria used in the Pugh Matrix, these principles are reported on more fully in Ditaunyane and Collins (2023).

Table 1: Summary of guiding principles and the assessment criteria identified for inclusion in the Pugh Matrix

Trial version and appraisal (Guiding principle 1)		
Summary	**Assessment criteria**	**Justification**
This principle emphasises the importance of having a trial version available for evaluators to thoroughly assess compatibility with hardware, software capabilities, and connectivity.	Availability of trial version, compatibility with hardware/software/connectivity.	These criteria ensure that the EFAL CALL application can be effectively evaluated based on its technical feasibility and compatibility.
Curriculum alignment (Guiding principle 2)		
Summary	**Assessment criteria**	**Justification**
This principle focuses on evaluating how well the EFAL CALL application aligns with the intended curriculum, including language and development skills and policy imperatives.	Alignment with curriculum objectives and policy imperatives.	Ensuring alignment with the curriculum objectives guarantees that the EFAL CALL application contributes effectively to language learning goals.

Assessment of learner performance (Guiding principle 3)		
Summary	**Assessment criteria**	**Justification**
This principle highlights the importance of assessing learner performance through summative assessment, formative assessment, and comprehensive feedback and reporting.	Inclusion of assessment features aligned with the national curriculum, covering summative and formative assessment.	Ensuring that the EFAL CALL application supports effective assessment practices, essential for monitoring learner progress and providing feedback.
Support for teaching approaches (Guiding principle 4)		
Summary	**Assessment criteria**	**Justification**
This principle evaluates whether the EFAL CALL application supports teaching approaches and methods to enhance learner proficiency.	Support for EFAL teaching approaches and methods.	This criterion ensures that the EFAL CALL application complements teaching strategies, promoting effective language learning outcomes.
Socio-cultural diversity (Guiding principle 5)		
Summary	**Assessment criteria**	**Justification**
This principle considers socio-cultural diversity, including multilingualism and relevance of content.	Consideration of socio-cultural diversity and relevance of content.	This criterion ensures that the EFAL CALL application addresses learners' diverse cultural and linguistic backgrounds, enhancing engagement and relevance.
Affordability (Guiding Principle 6)		
Summary	**Assessment criteria**	**Justification**
This principle assesses affordability based on factors such as school quintile classification, software price, and connectivity costs.	Affordability encompassing various costs.	Ensuring affordability is crucial for the widespread adoption of the EFAL CALL application, especially in resource-constrained settings.

Learner-centred features (Guiding principle 7)		
Summary	**Assessment criteria**	**Justification**
This principle evaluates the degree to which the application is learner-centred, considering features such as multimedia usage and learner interest.	The extent to which the application considers individual learning needs, including multimedia usage and learner engagement.	This criterion ensures that the EFAL CALL application effectively promotes active learner engagement and addresses individual learning needs.
Teacher training (Guiding principle 8)		
Summary	**Assessment criteria**	**Justification**
This principle includes teacher training as an evaluation criterion to ensure the effective implementation of the EFAL CALL application in schools.	Inclusion of teacher training support.	Providing adequate teacher training support is essential for maximising the benefits of the EFAL CALL application in classroom settings.

By incorporating these assessment criteria directly linked to the guiding principles, the Pugh Matrix offers a structured and comprehensive framework for evaluating EFAL CALL applications. As shown in Table 1, each principle translates into specific criteria that address essential factors for the software's effectiveness and appropriateness in educational settings. These factors include technical feasibility (Trial Version and Appraisal), curriculum alignment, assessment practices, support for teaching methods, consideration of socio-cultural diversity, affordability, fostering learner engagement, and ensuring effective implementation through teacher training.

Table 2 presents the Pugh Matrix criteria for CALL software selection in South African EFAL classes, along with the corresponding Likert scale items used to assess stakeholder perceptions of their importance, their mean scores, standard deviations, and the resulting adjusted weights.

Table 2: Drawing on Likert scale results to determine Pugh Matrix weights

Pugh criteria	Survey item indicating perceived importance	Mean	Standard deviation	Adjusted weight
Software includes provision of Trial Version: Ensures availability of a trial version for comprehensive evaluation before procurement. Software is Compatible: Ensures compatibility with existing hardware, software, and connectivity infrastructure to facilitate seamless integration.	It is important to obtain a trial version of the English teaching software before purchasing the software. (7)	4.519	0.739	12.8
Software demonstrates Curriculum Alignment: Indicates the extent to which the software aligns with curriculum objectives and policy imperatives for effective educational delivery.	The learning material included in English teaching software must be exactly in line with the national curriculum to be of value to Grade 7 – 9 learners. (8)	4.346	0.819	
	English teaching software needs to include activities that enable learners to improve their writing skills. (9)	4.593	0.562	
	English teaching software needs to include activities that enable learners to improve their reading skills.(10)	4.679	0.563	
	English teaching software needs to include activities that enable learners to improve their listening skills.(11)	4.556	0.720	
	English teaching software needs to include activities that enable learners to improve their speaking skills. (12)	4.575	0.738	
	English teaching software needs to include activities that allow learners to improve their English vocabulary.(13)	4.679	0.493	

Pugh criteria	**Survey item indicating perceived importance**	**Mean**	**Standard deviation**	**Adjusted weight**
Average		**4.571**		**12.95**
Software incorporates Assessment Features: Encompasses assessment tools aligned with national curriculum standards, covering both summative and formative assessment methods.	English teaching software needs to include tests after each section to determine whether learners have mastered the section.(14)	4.506	0.722	
	English teaching software needs to include tests after each term to determine whether learners have mastered the work for that term.(15)	4.383	0.840	
Average		**4.444**		**12.59**
Software supports EFAL Teaching Approaches: Supports English First Additional Language (EFAL) teaching methodologies and strategies for enhanced language learning outcomes.	The learning material included in English teaching software must be exactly in line with the national curriculum to be of value to Grade 7 – 9 learners. (8)	4.346	0.819	
	English teaching software needs to include activities that enable learners to improve their writing skills. (9)	4.593	0.562	
	English teaching software needs to include activities that enable learners to improve their reading skills.(10)	4.679	0.563	
	English teaching software needs to include activities that enable learners to improve their listening skills.(11)	4.556	0.720	
	English teaching software needs to include activities that enable learners to improve their speaking skills (12).	4.575	0.738	
	English teaching software needs to include activities that allow learners to improve their English vocabulary.(13)	4.679	0.493	
Average		**4.571**		**12.94**

Pugh criteria	**Survey item indicating perceived importance**	**Mean**	**Standard deviation**	**Adjusted weight**
Software considers Socio-cultural Relevance: Incorporates content that respects and reflects socio-cultural diversity, ensuring relevance to the target audience.	A translation tool should be included in English teaching software for learners who are struggling to understand concepts in English.(16)	4.296	0.761	
	Learners need to be able to relate closely to the examples used if the learning tool is to be of value to grade 7 – 9 learners.(17)	4.370	0.693	
Average		**4.333**		**12.27**
Software ensures Affordability: Considers various costs associated with procurement, implementation, and maintenance, ensuring financial sustainability.	The price of English teaching software should be a fundamental consideration before a school decides to purchase the software.(18)	4.235	0.850	12.00
Software promotes a Learner-centered Approach: Fosters learner engagement through multimedia usage and interactive learning experiences, prioritising individual learning needs.	It is important for learners to be involved in the assessment and selection of English teaching software.	3.963	1.082	
	It is important for English teaching software to include sound.(19)	4.506	0.593	
	It is important for English teaching software to include pictures.(20)	4.500	0.547	
	It is important for English teaching software to include animations.(21)	4.171	0.894	
	It is important for English teaching software to include videos.(22)	4.383	0.825	
	It is important for English teaching software to include games.(23)	3.901	1.140	
Average		**4.237**		**12.00**

Pugh criteria	Survey item indicating perceived importance	Mean	Standard deviation	Adjusted weight
Software includes Teacher Training Support: Provides resources and support mechanisms for teacher training and professional development to enhance instructional effectiveness.	Teachers need to be computer literate if they are going to use English teaching software effectively.(24)	4.463	0.757	12.63

Table 3 presents the Pugh Matrix for selecting and evaluating EFAL CALL software. It outlines the guiding principles, their corresponding weights, and a baseline comparison for various criteria across different software options.

Table 3: Pugh Matrix for selecting and evaluating EFAL CALL software

Principle	Criteria	Weight	Baseline	Option 1	Option 2	Option 3
Trial version and appraisal	Software includes provision of Trial Version: Ensures availability of a trial version for comprehensive evaluation before procurement. Software is Compatible: Ensures compatibility with existing hardware, software, and connectivity infrastructure to facilitate seamless integration.	**12.8**	0			
Curriculum alignment	Software demonstrates Curriculum Alignment: Indicates the extent to which the software aligns with curriculum objectives and policy imperatives for effective educational delivery.	**12.95**	0			
Assessment of learner performance	Software incorporates Assessment Features: Encompasses assessment tools aligned with national curriculum standards, covering both summative and formative assessment methods.	**12.59**	0			

Support for teaching approaches	Software supports EFAL Teaching Approaches: Supports English First Additional Language (EFAL) teaching methodologies and strategies for enhanced language learning outcomes.	**12.94**	0
Socio-cultural diversity	Software considers Socio-cultural Relevance: Incorporates content that respects and reflects socio-cultural diversity, ensuring relevance to the target audience.	**12.27**	0
Affordability	Software ensures Affordability: Considers various costs associated with procurement, implementation, and maintenance, ensuring financial sustainability.	**12.00**	0
Learner-centered features	Software promotes a Learner-centered Approach: Fosters learner engagement through multimedia usage and interactive learning experiences, prioritising individual learning needs.	**12.00**	0
Teacher training	Software includes Teacher Training Support: Provides resources and support mechanisms for teacher training and professional development to enhance instructional effectiveness.	**12.63**	0

5. Discussion

Existing methods for CALL software selection often lack a structured approach or rely solely on subjective criteria. The Pugh Matrix overcomes these limitations by:

- **Integrating inductively formulated guiding principles:** The matrix is grounded in eight core principles derived from stakeholder feedback, ensuring

the criteria address key aspects of effective CALL software for EFAL contexts.

- **Systematic weighting of criteria:** Stakeholder input through the Likert scale survey informs the weighting of criteria within the matrix. This prioritizes factors deemed most important for successful CALL software implementation.
- **Structured comparison of options:** The matrix facilitates a side-by-side comparison of various CALL software options against the established criteria. This enables a clear and objective evaluation process.

By employing these elements, the Pugh Matrix offers a unique value proposition compared to existing methods. It provides a data-driven, yet context-specific approach that considers both the essential features of CALL software and the specific needs of South African EFAL education. Through this structured approach, stakeholders can make informed decisions regarding the procurement and utilisation of CALL software, ensuring alignment with the specific needs and objectives of EFAL instruction within the South African schooling system.

The Pugh Matrix could be utilised as follows: Initially, stakeholders would populate the matrix with potential CALL software options across the rows and the predetermined evaluation criteria along the columns. Subsequently, each software option would be systematically compared against the criteria, with a rating of either -1, 0 or 1 assigned based on whether the option does not meet the criteria, meets the criteria or exceeds the criteria. By employing a weighted scoring system derived from stakeholder feedback and survey results, the matrix would generate comprehensive scores for each software option. These scores would enable stakeholders to objectively evaluate and prioritise the options, ultimately guiding decision-making processes regarding the evaluation, selection and procurement of the most suitable CALL software for Grade 7 to 9 English First Additional Language (EFAL) classes within the South African educational context.

The weighted criteria included in the matrix encompass a comprehensive spectrum of factors crucial for the effective integration of CALL software into EFAL education. Notably, the emphasis on *trial version and appraisal* highlights the importance of accessibility and compatibility of the software with existing infrastructure, ensuring a seamless transition and efficient utilisation within school environments. Furthermore, the significance assigned to *curriculum alignment* underscores the necessity for software solutions that closely align with educational objectives and policy imperatives, thereby maximising their contribution to pedagogical outcomes.

Assessment of learner performance emerges as a pivotal criterion, reflecting the imperative for CALL software to offer robust assessment tools aligned with national curriculum standards. The inclusion of both summative and formative assessment methods is instrumental in facilitating ongoing evaluation and feedback, thereby fostering continuous improvement in student learning outcomes. Moreover, the emphasis on *support for teaching approaches* underscores the need for software solutions that complement EFAL teaching methodologies and strategies, thereby enhancing language learning outcomes and instructional effectiveness.

Socio-cultural diversity represents a critical dimension in the evaluation of CALL software, emphasising the importance of culturally relevant content that resonates with the socio-cultural backgrounds of South African learners. By incorporating diverse perspectives and experiences, software solutions can promote inclusivity and cater to the unique needs of a multicultural student population. Additionally, the consideration of *affordability* acknowledges the financial constraints faced by educational institutions, emphasizing the importance of cost-effective solutions that ensure long-term sustainability and accessibility.

The inclusion of *learner-centred features* underscores the shift towards personalised learning experiences, wherein CALL software plays a pivotal role in catering to individual learning needs and preferences. By offering multimedia-rich content and interactive learning experiences, software solutions can foster learner engagement and motivation, thereby enhancing the overall quality of education delivery. Finally, the emphasis on *teacher training* highlights the need for ongoing professional development and support mechanisms to empower educators in harnessing the full potential of CALL software within their instructional practices.

Overall, the findings derived from the Pugh Matrix provide valuable insights into the multifaceted considerations involved in selecting suitable CALL software for EFAL education in South African schools. By prioritising criteria aligned with pedagogical objectives, cultural relevance, affordability, and teacher support, educational stakeholders can make informed decisions that optimise the integration of technology-enhanced learning solutions into the classroom environment, thereby enriching the educational experiences and outcomes of learners across diverse linguistic and cultural backgrounds.

5.1 Limitations and challenges

The study opens avenues for further exploration and refinement of the framework to ensure its applicability and sustainability in the face of the dynamic digital landscape.

Future research could incorporate broader stakeholder perspectives, evaluate the practical implementation of the framework, and adapt it to emerging technologies and pedagogical strategies. Moreover, quantitatively validating the framework and examining its impact on educational outcomes will be crucial in establishing its efficacy as a tool for enhancing the quality and inclusivity of language learning in South African schools and beyond.

6. Conclusion

This study achieved its objectives by developing a comprehensive framework for selecting CALL software in South African schools. The Pugh Matrix, informed by stakeholder input and grounded in key evaluation criteria, provides a valuable tool for educators and decision-makers. The importance of developing systematic, evidence-based tools for evaluating CALL software within the context of South African educational settings is underscored. As we move forward, it is imperative that we continue to engage in research that bridges the gap between technological advancement and pedagogical practice, ensuring that the potential of digital technologies to transform education is fully realised in a manner that is both inclusive and equitable.

Furthermore, the study represents a significant stride towards integrating digital technologies into language learning. By introducing a structured, systematic approach to evaluating CALL software, this study addresses the critical need for appropriate selection mechanisms that reflect the unique attributes and complexities of digital educational tools. The Pugh Matrix framework, grounded in guiding principles formulated through an iterative developmental research approach, provides educators and decision-makers with a comprehensive and objective tool to assess and select CALL software that aligns with educational objectives, instructional approaches, technical requirements, and budgetary constraints.

Addressing the identified gaps will not only enhance the Pugh Matrix framework's relevance and effectiveness but also contribute to the broader discourse on integrating digital technologies in education. This endeavour aligns with global educational goals of promoting inclusive, equitable quality education and lifelong learning opportunities for all. As digital technologies continue to evolve, so too must our approaches to selecting and implementing educational software. The development and continuous refinement of tools like the Pugh Matrix framework are pivotal in navigating the complexities of digital technology integration, ensuring that educational institutions can make informed decisions that foster an engaging, accessible, and effective learning environment for all learners.

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