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Analysis of Causal Interrelationships of Digital Translation Tool Usage in Arabic Language Learning: A DEMATEL Approach

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ABSTRACT

This study examines the advancement of digital technology that is transforming language learning approaches, specifically the application of digital translation tools in Arabic language education. Nonetheless, uncertainty persists regarding the impact of specific factors on the effective utilization of this tool. Therefore, this study highlights the importance of understanding the causal relationships between factors that impact the use of digital translation tools in the acquisition of Arabic language by students. In addition to analysing five main factors, namely the frequency of using digital translation tools, reliance on the native language, perception of translation accuracy, student motivation, and lecturer support for technology. The research methodology involved using the DEMATEL method to analyse cause-and-effect relationships by utilising the direct-relation matrix, the overall-relation matrix, and the normalized matrix. Data were obtained through interviews and a 0–4 scale questionnaire involving five experts in the relevant field. The study findings indicate that lecturer support is the dominant factor influencing other factors, while the perception of translation accuracy acts as an initial trigger. On the other hand, student motivation, frequency of use, and reliance on the mother tongue are the resulting factors. In conclusion, the effectiveness of technology use in language learning depends on the guidance of lecturers and the role of educational institutions in enhancing the digital skills of both lecturers and students. Future research needs to examine the impact of digital tool usage on the long-term development of writing skills.

1. Introduction

The rapid advancement of digital technology has led to significant changes in the field of language education worldwide. The availability of various digital translation tools, such as Google Translate, DeepL, and AI-based translation apps, has simplified the process of accessing linguistic meanings for

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students in language learning quickly and conveniently. These tools are not only used to help students understand texts and vocabulary but also become components of self-learning strategies in formal and informal environments. Therefore, digital translation tools are perceived as a pedagogical innovation that can enhance language learning, especially in the high-tech educational world. However, excessive reliance on this technology can reduce students' active engagement in the learning process and adversely affect their overall mastery of grammar and language skills [1]. Meanwhile, the use of translation tools helps reduce cognitive load, increase motivation, and allows students to interact with more challenging authentic materials. On the other hand, uncontrolled use is feared to encourage excessive dependence and undermine deep mastery of language structures. Therefore, the usage of digital translation tools in language learning becomes important to understand their role holistically, including the potential benefits and challenges that exist in efforts to enhance the effectiveness of language teaching and learning.

The rapid advancement of digital technology has resulted in the widespread use of various translation tools by students learning Arabic. Therefore, in the process of teaching and learning Arabic in the digital era, it is necessary to utilize technology and integrate various learning media such as text, audio, and visual to enhance the effectiveness of learning and help address various issues [2]. Kenali et al. [3] found that, in line with the surge in digital transformation in the higher education sector, digital education in Arabic language teaching at Malaysian universities requires more systematic pedagogical adjustments. This adaptation includes enhancing lecturers' digital skills, using effective learning platforms, and institutional support with technology and training to overcome various challenges in online learning during the pandemic.

A systematic review and meta-analysis conducted by Sangmin-Michelle Lee found that the quality of machine translation in foreign language education has significantly improved. Most studies also indicate that the use of machines has a positive impact on language learning, particularly in enhancing students' writing skills [4]. The innovations occurring in technology-based Arabic language learning are capable of enhancing the quality of education, opening new opportunities and challenges in the educational process. According to Rani et al., [5], technology-based Arabic language learning is considered an innovation that can enhance the quality of learning in the digital era; and create new opportunities and challenges in the educational process. The use of digital technology has given rise to various translation tools that are now widely used by Arabic language students.

However, the excessive use of these translation tools in teaching and learning will cause several issues. One of the common issues with digital translation tools is the inaccurate translation of grammar and language structure. This can be seen in the translation of Arabic language materials, which have a complex morphological system, such as tashrif (verb conjugation), i'rab (final vowel markings), and differences in meaning according to the context of the sentence, students' dependence on the produced translations can confuse them and cause them to fail to understand the language structure correctly[6,7]. Additionally, digital translation tools usually fail to capture the various dialects, stylistic nuances, and idiomatic expressions present in the Arabic language, this causes students to lack a comprehensive and contextual understanding of the Arabic language. According to a systematic review by Sapawi and Yusoff [8] that combines recent empirical studies conducted between 2023 and 2025, the use of digital technology in the Arabic language curriculum is crucial for strengthening pedagogical strategies, enhancing student engagement, and supporting a more flexible and student-centered learning approach.

Over-reliance on digital translation can have negative impacts on students' learning and psychological well-being. Students who frequently utilise AI and digital translation tools will be less actively engaged in internalising vocabulary and grammar rules, and will have a propensity to disregard the thinking process. For instance, the Arabic grammar method's primary pillars of grammar and syntax analysis are hardly practiced, vocabulary is rarely actively memorised, and meaning is inferred from sentence context. As a result, critical thinking skills and language proficiency are not effectively developed. Furthermore, the calibre of the translations offered no longer accurately represents the pupils' true skills [9].

Therefore, a more rational approach is needed to integrate digital translation tools into learning as an aid in the learning process and monitored by skilled teachers [4,10,2]. Warschauer and Grimes [9] also highlight that the utilization of digital translation tools can lead to an illusion of understanding, giving students a false sense of comprehension. This can prevent the full processes of linguistic comprehension and in-depth analysis of meaning from taking place.

The study conducted by Shen [11] indicates that students who actively use the method of manually searching for word meanings through conventional dictionaries exhibit an improvement in vocabulary retention, and the ability to understand texts more deeply. The process of searching for meanings encourages students' cognitive engagement, which in turn supports more effective language acquisition. According to Abimbola [12], the use of machine translation in second language learning aims to facilitate understanding of meaning quickly. However, the use of machine translation without pedagogical guidance has the potential to reduce students' cognitive effort in processing the target language, thereby impairing their ability to understand texts in depth and develop critical reading skills. There are two implications of using digital translation tools in Arabic language learning: the tools are destructive when used without guidance; however, they have the potential to be constructive when strategically utilized within a pedagogical context based on critical thinking.

2. Methodology

This study used the DEMATEL method. The Decision-Making Trial and Evaluation Laboratory (DEMATEL) method represents a sophisticated structural modeling technique originally developed by the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva between 1972 and 1976 to analyze complex world problems [13]. This method has evolved into a powerful multi-criteria decision-making tool that enables researchers to visualize the causal relationships among factors in complex systems through the construction of structural models and impact-relation maps [14]. The fundamental premise of DEMATEL lies in its ability to transform qualitative assessments into quantitative indices, thereby revealing the interdependencies and feedback mechanisms among system elements [15]. Unlike traditional analytical methods that assume independence among criteria, DEMATEL acknowledges the intricate interrelationships and mutual influences that characterize real-world decision-making scenarios, making it particularly valuable for identifying key factors and understanding their direct and indirect effects on other elements within a system [16]. The method has been extensively applied across diverse domains including supply chain management, environmental assessment, technology evaluation, and organizational performance analysis, demonstrating its versatility and robustness in handling complex decision problems [17,18].

2.1 DEMATEL Procedural Framework

The implementation of DEMATEL follows a systematic five-step procedure that transforms expert judgments into structural matrices revealing causal relationships. The first step involves establishing a direct-relation matrix through expert evaluation, where participants assess the degree of direct influence between each pair of factors using a predetermined scale, typically ranging from 0 (no influence) to 4 (very high influence) [19]. The second step normalizes the direct-relation matrix by dividing each element by the maximum row sum, ensuring all values fall within a standardized range [20]. The third step calculates the total-relation matrix by incorporating both direct and indirect effects through matrix manipulation, specifically using the formula T = X(I - X)^-1, where X represents the normalized direct-relation matrix and I is the identity matrix [21]. The fourth step computes the prominence and relation indices by calculating the sum of rows (D) and columns (R) of the total-relation matrix, where D + R indicates the prominence of each factor in the system, while D - R distinguishes between cause factors (positive values) and effect factors (negative values) [22]. The fifth step involves constructing a causal diagram by plotting these indices on a two-dimensional graph, with the horizontal axis representing prominence and the vertical axis representing relation, thereby providing a visual representation of the structural model that facilitates decision-making and strategic planning [23,24].

2.2 Step in DEMATEL

Table 1
Step in DEMATEL

Step 1	**Step 1: Generate the direct relation matrix** To identify the model of the relations among the n criteria, an n × n matrix is first generated. The effect of the element in each row is exerted on the element of each column of this matrix. If multiple experts' opinions are used, all experts must complete the matrix. Arithmetic means all of the experts ' opinions are used, and then a direct relation matrix X is generated. $$\mathrm{X} = \begin{bmatrix} 0 & \cdots & x_{n1} \\ \vdots & \ddots & \vdots \\ x_{1n} & \cdots & 0 \end{bmatrix}$$
Step 2	**Compute the normalized direct-relation matrix** To normalize, the sum of all rows and columns of the matrix is calculated directly. The largest number of the row and column sums can be represented by k. To normalize, it is necessary that each element of the direct-relation matrix is divided by k. $k = max\left\{max\sum_{j=1}^{n} x_{ij}, \sum_{i=1}^{n} x_{ij}\right\}$ $$N = \frac{1}{k} * X$$
Step 3	**Compute the total relation matrix** After calculating the normalized matrix, the fuzzy total-relation matrix can be computed as follows: $T = \lim_{k \to +\infty} (N^1 + N^2 + \cdots + N^k)$ In other words, an n × n identity matrix is first generated, then this identity matrix is subtracted from normalized matrix and the resulting matrix is reversed. The normalized matrix is multiplied by the resulting matrix to obtain the total relation matrix. $$\mathrm{T} = \mathrm{N} \times (I - N)^{-1}$$
Step 4	**Set the threshold value** The threshold value must be obtained in order to calculate the internal relations matrix. Accordingly, partial relations are neglected and the network relationship map

	(NRM) is plotted. Only relations whose values in matrix T is greater than the threshold value are depicted in the NRM. To compute the threshold value for relations, it is sufficient to calculate the average values of the matrix T. After the threshold intensity is determined, all values in matrix T which are smaller than the threshold value are set to zero, that is, the causal relation mentioned above is not considered. In this study, the threshold value is equal to 1.0892
Step 5	**Final output and create a causal diagram** The next step is to find out the sum of each row and each column of T (in step 3). The sum of rows (D) and columns (R) can be calculated as follows: $D = \sum_{j=1}^{n} T_{ij}$ $R = \sum_{i=1}^{n} T_{ij}$ Then, the values of D+R and D-R can be calculated by D and R, where D+R represent the degree of importance of factor i in the entire system and D-R represent net effects that factor *i* contributes to the system.

3. Results

3.1 Finding 1: Generate the direct relation matrix

Table 2

The average direct-relation matrix is computed by averaging all expert input matrices

	Frequency of Using Digital Translation Tools	Dependence on the Mother Tongue	Perception of Translation Accuracy	Student Motivation	Support from Lecturers for Technology
Frequency of Using Digital Translation Tools	0.0000	3.0000	2.8000	2.8000	1.4000
Dependence on the Mother Tongue	3.0000	0.0000	1.8000	2.8000	1.4000
Perception of Translation Accuracy	3.4000	2.6000	0.0000	3.0000	2.4000
Student Motivation	3.2000	2.4000	3.0000	0.0000	2.6000
Support from Lecturers for Technology	3.2000	2.6000	3.2000	3.6000	0.0000

Table 1 above shows the Direct Influence Matrix (Initial Direct Relationship Matrix) to measure the relationship between five factors, namely: Frequency of Digital Translation Tool Use, Dependence on Native Language, Perception of Translation Accuracy, Student Motivation, and Lecturer Support for Technology. The values in each box represent the level of influence of the factor (row) on the factor (column), calculated using a scale that indicates a cause-and-effect relationship where higher numbers indicate a stronger cause-and-effect relationship. The diagonal of the matrix contains a value of 0.0000 because a factor is considered to have no direct influence on itself. Based on the data, "Lecturer Support for Technology" is seen as the main driver in this system, recording the highest influence score of 3.6000 on "Student Motivation". The mathematical foundation functions to calculate the overall relationship matrix, which will ultimately categorize these factors into groups referred to as "Cause" or "Effect.".

3.2 Finding 1: Compute the normalized direct-relation matrix

Table *3*
The matrix is normalized so that the maximum row or column sum equals 1

	Frequency of Using Digital Translation Tools	Dependence on the Mother Tongue	Perception of Translation Accuracy	Student Motivation	Support from Lecturers for Technology
Frequency of Using Digital Translation Tools	0.0000	0.2344	0.2187	0.2187	0.1094
Dependence on the Mother Tongue	0.2344	0.0000	0.1406	0.2187	0.1094
Perception of Translation Accuracy	0.2656	0.2031	0.0000	0.2344	0.1875
Student Motivation	0.2500	0.1875	0.2344	0.0000	0.2031
Support from Lecturers for Technology	0.2500	0.2031	0.2500	0.2813	0.0000

Table 2 shows the Normalized Direct-Relation Matrix, which is derived from scaling the values in the initial matrix to ensure all elements are within the range of 0 to 1. According to a detailed analysis of the data, "Lecturer Support for Technology" has the highest value of 0.2813 and is the main driving factor for "Student Motivation." This indicates that academic guidance is a catalyst for students' emotions in the use of technology. Meanwhile, the relationship between "Frequency of Tool Use" and "Lecturer Support" has the lowest value of 0.1094, indicating that "Lecturer Support" is not necessarily influenced by the frequency of students using digital tools or vice versa. The Overall Relationship Matrix (T) is calculated using the formula T=X(I-X)^(-1), where X is the normalized matrix. This method reveals both direct and indirect effects among all variables.

3.3 *Finding 1:* Compute the total relation matrix

Table 4
Total relation matrix (t)

	Frequency of Using Digital Translation Tools	Dependence on the Mother Tongue	Perception of Translation Accuracy	Student Motivation	Support from Lecturers for Technology
Frequency of Using Digital Translation Tools	0.0000	0.2344	0.2187	0.2187	0.1094
Dependence on the Mother Tongue	0.2344	0.0000	0.1406	0.2187	0.1094
Perception of Translation Accuracy	0.2656	0.2031	0.0000	0.2344	0.1875

Student Motivation	0.2500	0.1875	0.2344	0.0000	0.2031
Support from Lecturers for Technology	0.2500	0.2031	0.2500	0.2813	0.0000

Table 3 Analysis of the Normalized Direct Relationship Matrix and the Overall Relationship Matrix shows complex changes in the digital learning environment. This transition significantly affects the overall outcome, either directly or indirectly. The T matrix is calculated using the formula T = X(I - X)-1, which shows that "Lecturer Support for Technology" maintains its position as the most impactful system driver. The overall influence on the "Frequency of Digital Translation Tool Usage" significantly increased to 1.4044, far exceeding its original direct influence value of 0.2500. This significant increase indicates a strong chain effect with the assistance and support from lecturers, which not only encourages direct use of the tools but also builds "Student Motivation" (1.3680) and enhances "Perception of Translation Accuracy" (1.2463). In general, this analysis affirms that institutional support is the primary "Cause" factor with significant influence over all other variables, and the frequency of tool usage is the most responsive "Effect" factor to fluctuations in that support or motivation.

3.4 Finding 1: Final output and create a causal diagram

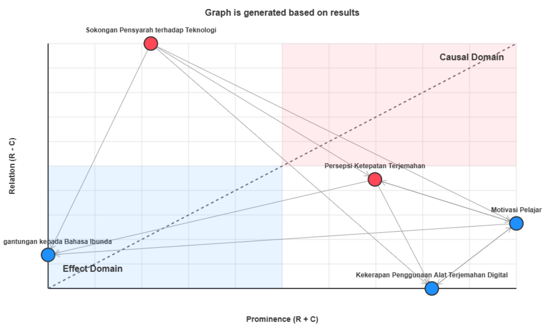

Fig. 1. Network Diagram (Prominence vs Relation)

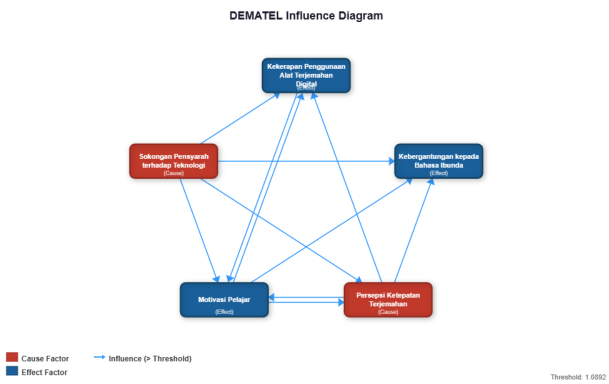

Fig. 2. DEMATEL Influence Diagram

The DEMATEL analysis's final results show that each factor plays a distinct role in terms of importance and cause-and-effect relationships within the system. The Threshold Value result is 1.0892, determined by analyzing input from 5 experts across 5 key factors. Figure 1 Network Diagram (Prominence vs Relation) and Figure 2 DEMATEL Influence Diagram show a comprehensive analysis that connects the Normalized Direct Relation Matrix with the Total Relation Matrix. The value of the Network Relationship Model (NRM) diagram visualization shows that "Lecturer Support for Technology" and "Perception of Translation Accuracy" are the main drivers or "Cause" factors in this ecosystem. The support of lecturers for technology has a very significant impact on the "Frequency of Tool Use" and "Student Motivation," reinforcing its role as the root cause of the dynamic system. On the other hand, variables such as "Dependence on the Native Language," "Frequency of Tool Use," and "Student Motivation" fall within the domain of "Effect," indicating that these factors are merely manifestations of the quality of academic support and perceptions of the technology.

This demonstrates that the most effective way to alter students’ technology usage habits is by encouraging active lecturer participation and enhancing students’ trust in the reliability of digital tools, as these two elements have the most significant impact on motivation and frequency of use. Therefore, when lecturers provide systematic guidance, students will be more confident in using digital tools not as a substitute for knowledge but as cognitive tools that help them understand complex language structures, even though technology allows for faster learning. The use of translation machines among students, who sometimes neglect the Arabic morphological system such as tashrif and i'rab, can be prevented with guidance and assistance from lecturers or teachers.

Meanwhile, the frequency of using digital translation tools, student motivation, and reliance on the mother tongue are consequential factors that are greatly influenced by external factors within this system. The frequency of students using tools such as Google Translate or DeepL is not random occurrence; instead, it reflects their level of motivation and the support they receive from their learning environment. While digital tools can speed up access to linguistic information, they do not necessarily enhance linguistic proficiency unless accompanied by thorough training in grammar and morphology. Changes in students' behavior regarding the use of technology are merely symptoms of the quality of pedagogy being applied, which requires an approach to the root cause that necessitates the guidance of lecturers.

4. Conclusions

In summary, the application of the DEMATEL method in this study is crucial, and it effectively illustrated the cause-and-effect connections related to the utilisation of digital translation tools in Arabic language education. The analysis findings indicate that digital transformation in language education should not depend only on technology; rather, it should focus on enhancing the role of instructors as proficient technology facilitators. Institutional support and academic guidance play a crucial role in transforming digital translation from potentially harmful tools to ones that can improve student motivation and linguistic accuracy. Similarly, rapidly advancing AI technology cannot match or replace human thinking in the process of refining and beautifying language styles and culture. Therefore, the use of technology in the teaching and learning of foreign languages, including Arabic, serves as a motivator and driver for language mastery. The teaching and learning of the Arabic language curriculum in higher education institutions must provide clear and precise guidelines for students to use digital tools that can ensure and guarantee balanced and continuous language skill development.

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