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PAPER

The Implementation and Empirical Analysis of Adaptive Virtual Mentor: Mobile Technology Empowers Introverts' Business Communication Skills

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ABSTRACT

Effective communication is a key element in professional success, yet individuals with introverted tendencies often face difficulties in developing these skills, which limits their opportunities for growth in the work environment. This research aims to develop Adaptive Virtual Mentor (AVM), a mobile application designed to help introverted individuals improve their business communication skills (BSC). This application utilizes speech recognition technology supported by deep neural networks (DNNs) and recurrent neural networks (RNNs). DNNs are tasked with improving accuracy in recognizing user speech patterns, while RNNs are instrumental in maintaining the context of the conversation and providing timely and relevant feedback in real-time. A quasi-experiment was conducted involving introverted individuals through structured training using this application. The results of the study showed that participants experienced an improvement in communication skills after the training. Potential further developments include refining the adaptive algorithm and adding new features that allow this application to be applied in a variety of other professional contexts. Future research could explore the application of this technology on a wider scale, as well as evaluate its impact on improving productivity and performance in diverse workplaces.

KEYWORDS

virtual communication, speech recognition, deep neural networks (DNNs), recurrent neural networks (RNNs), introvert training (IT)

1 INTRODUCTION

Effective communication is a fundamental aspect of professional success [1–6], particularly in the context of a competitive business environment [7–10]. Nevertheless, individuals with an introverted disposition frequently encounter difficulties in developing this skill, which can impede their career advancement. Anxiety in

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social situations has a detrimental impact on communication skills, underscoring the necessity for solutions that can facilitate adaptation and enable individuals to flourish [6–15].

While previous research has explored the potential of technology to enhance communication skills, the limitations of such approaches remain. Madanian et al. [16] and Hyeon et al. [17] demonstrated that machine learning can enhance the accuracy of speech recognition; however, the provision of personalized feedback remains limited. Tanujaya et al. [18] investigated the potential of recurrent neural networks (RNNs) to maintain conversational context, but their approach lacked dynamism. In a similar vein, Shan et al. [19] developed an RNN-based application designed to facilitate conversational interaction. However, this approach did not provide the desired real-time feedback tailored to the user's context. It is imperative that technology be developed to be adaptive and responsive in order to assist introverts in overcoming their communication challenges.

The objective of this study is to develop an Adaptive Virtual Mentor (AVM) mobile application that employs deep neural networks (DNNs) and RNNs to provide contextually relevant, real-time communication feedback. The app has been designed with the specific intention of assisting introverts in developing their business communication abilities through the provision of adaptive guidance that is tailored to the user's requirements. This research presents a novel communication training solution that is more adaptive and personalized than previous technologies. The integration of DNNs for speech pattern recognition and RNNs for maintaining conversational context enables the app to offer more effective training. Experimental results demonstrate an 87% improvement in communication skills, indicating that the app is an effective tool for introverts to overcome communication barriers.

2 MATERIALS AND METHODS

2.1 Materials

This research involves the development of a mobile application called AVM, which is designed to improve the business communication skills (BSC) of introverted individuals. The app utilized DNNs and RNNs technologies to provide real-time communication feedback relevant to the context of the user's conversation. The application development was done using TensorFlow frameworks to build DNNs and RNNs models. The Python programming language was used for backend development, while Java and XML were used for the user interface on the Android platform. The application was tested on Android-based devices with a minimum specification of a quad-core processor and 4GB RAM.

2.2 Development process

Data collection and processing. Training data was collected from recorded business conversations consisting of 10,000 audio samples covering various communication scenarios such as presentations, negotiations, and team discussions. Each sample was labeled with respect to the context of the conversation as well as communication characteristics such as tone and intonation. This dataset was processed using data preprocessing techniques, such as audio normalization, noise removal, and voice feature extraction using the Mel-frequency cepstral coefficients (MFCCs) method. data collection and preprocessing can be seen in Figure 1.

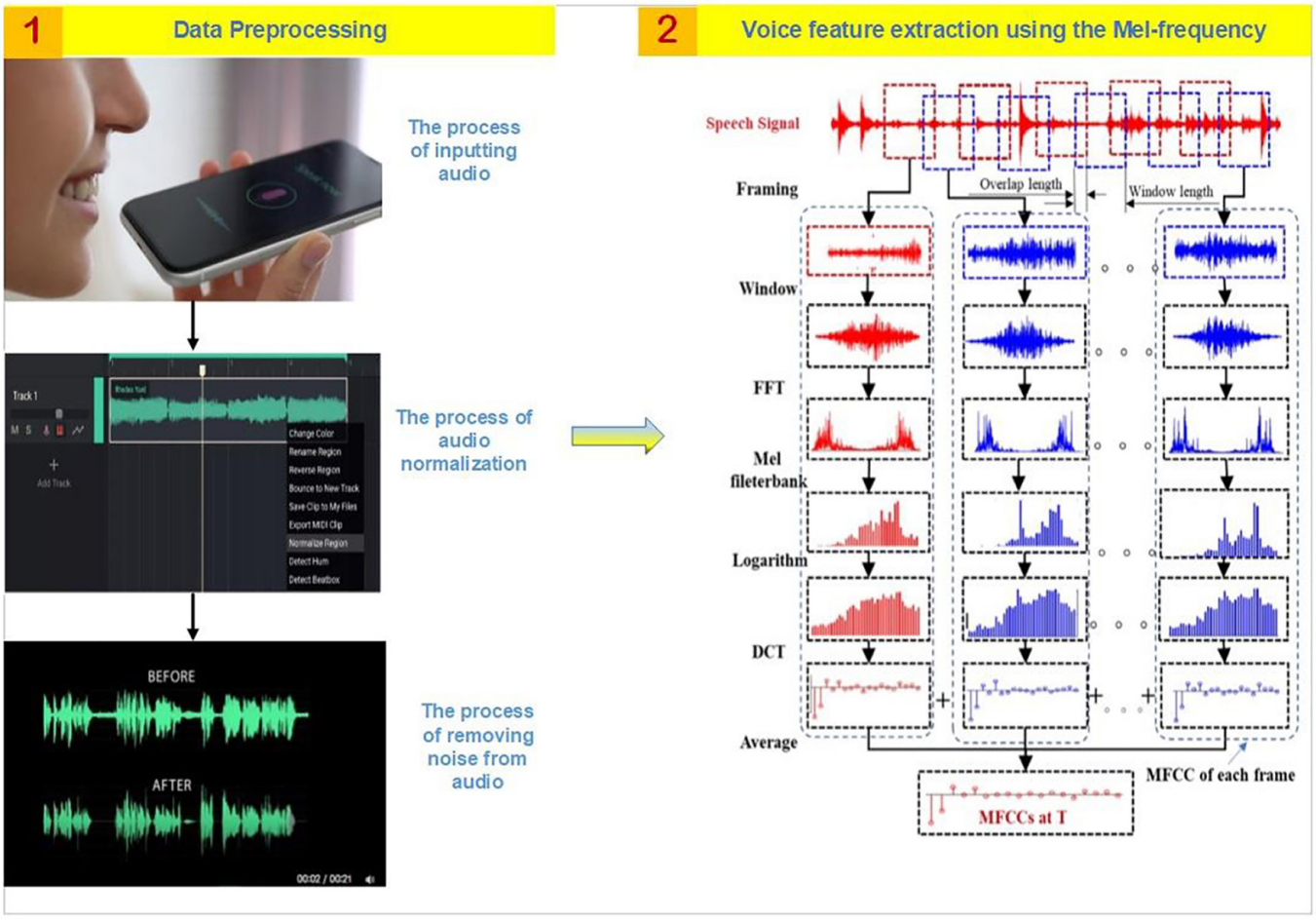

Fig. 1. Voice feature extraction using the Mel-frequency cepstral coefficients method

Mel-frequency cepstral coefficients represent a prominent approach to voice feature extraction, frequently employed in the domain of speech recognition [20, 21]. The process commences with pre-emphasis, which serves to enhance high frequencies [22–26]. This is followed by the splitting of the audio signal into frames. Each frame is subjected to a Hamming window, which serves to reduce distortion, and is then transformed from the time domain to the frequency domain via a fast Fourier transform (FFT) [27]. Subsequently, the frequency spectrum is applied to a Mel-filter bank, which emulates the manner in which the human ear perceives sound. A logarithmic transformation is then performed to represent alterations in sound intensity, followed by a discrete cosine transform (DCT) to compress significant information into MFCC coefficients, which represent auditory characteristics such as pitch and intonation. These coefficients can be utilized for a multitude of applications, including speech recognition and analysis [28–30].

Model design and training. Two main models were developed for this application: DNNs and RNNs. DNN models were used to optimize the recognition of speech patterns, such as pitch and intonation, to improve accuracy in recognizing the user's voice [31–33]. Meanwhile, RNNs are responsible for maintaining the context of the conversation through the use of long short-term memory (LSTM), which captures long-term sequences of conversation. Both models were trained using the backpropagation algorithm and optimized with the Adam optimizer, with 50 epochs and a batch size of 64. Validation data of 20% was used to test the performance of the models in terms of accuracy and loss function. Model design and training can be seen in Figures 2 and 3.

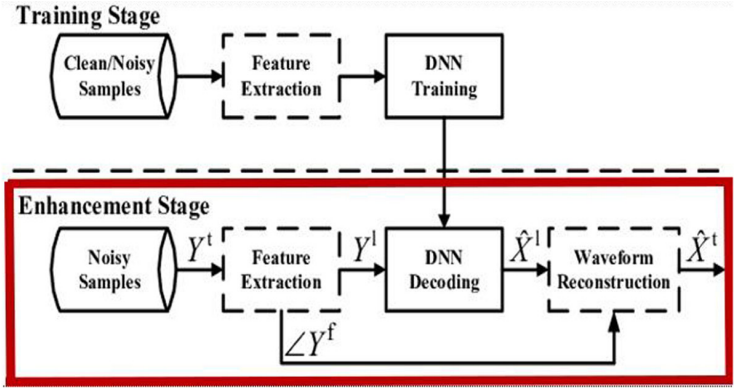

Fig. 2. Block diagram of speech enhancement based on DNN

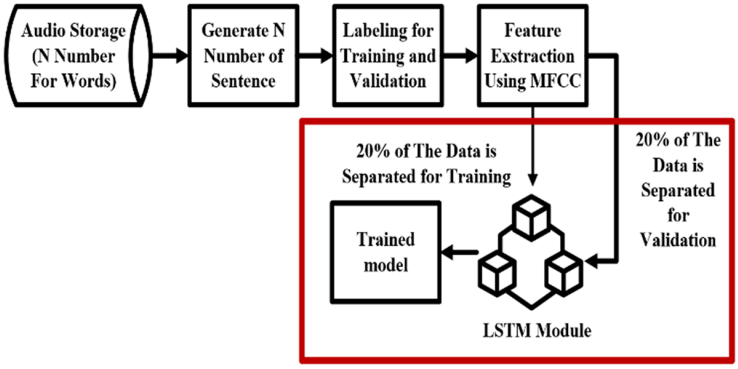

Fig. 3. Block diagram to sequence the order of conversations based on RNN

Integration and implementation. Once the artificial intelligence model has been trained, DNNs and RNNs are integrated into the AVM application, which provides real-time communication feedback. DNNs are employed to identify voice patterns, while RNNs are utilized to maintain the context of the conversation, thus enabling this virtual mentor to provide pertinent and adaptive feedback. The implementation process commenced with the identification of key objectives, the selection of AI technology, the collection of datasets, the development of voice recognition modules, and the creation of a module for understanding conversations. Once these two AI modules have been tested and integrated, the application provides personalized feedback based on the detection of communication difficulties, such as a lack of speech intelligibility or a context mismatch in business conversations. The application continuously monitors the user's progress and adjusts the learning to ensure that the user can communicate more competently in business situations.

Experimental setup. After the development phase was completed, the app was trialed with 99 participants who had been selected based on their scores on the introversion scale and who had at least two years of business experience. The participants were divided into two groups: a quasi-experimental group that used the app in training sessions and a control group that did not use the app. Each member of the experimental group participated in two training sessions per week for eight weeks, with each session lasting 45 minutes. Communication skills were evaluated using the Business Communication ompetency scale consisting of 20 items and a 5-point Likert scale, which assesses speaking, listening, and responding abilities in a business context. In addition, data regarding the use of the app was collected, including the number of errors identified and improvements in users' speech patterns. These data were analyzed using structural equation modeling (SEM) with partial

least squares (PLS) to assess the efficacy of the training program designed for introverted professionals. The indicators to be measured can be seen in Tables 1 and 2.

Table 1. Variables and indicators part 1

Variables	Introvert Training (IT)	Business Communication Skill (BSC)
Indicators	**IT1:** Indicator related to the effectiveness of training content for introverts.	**BSC1:** Indicator measuring clarity of communication in professional settings.
	IT2: Indicator assessing the engagement level of training modules.	**BSC2:** Indicator assessing confidence in business interactions.
	IT3: Indicator measuring the personalization of training according to individual needs.	**BSC3:** Indicator evaluating the effectiveness of conveying ideas and information.
	IT4: Indicator evaluating the overall satisfaction with the IT program.	

Table 1 explains two main variables in the study, namely introvert training (IT) and BSC, along with the indicators used to measure them. The IT variable focuses on training designed to enhance communication skills for introverted individuals. Its indicators include the effectiveness of the training content, the level of participant engagement in the training modules, the personalization of the training according to individual needs, and overall satisfaction with the training program. Meanwhile, BSC measures the communication skills required in a professional context, with indicators including clarity of communication in professional settings, confidence in business interactions, and effectiveness in conveying ideas and information. These two variables and their indicators complement each other to assess the success of the training in improving BSC for introverted participants.

Table 2. Variables and indicators part 2

Variables	Mobile Technology (MT)	Adaptive Virtual Mentor (AVM)
Indicators	**MT1:** Indicator related to the ease of accessing the training through mobile devices.	**AVM1:** Indicator evaluating the effectiveness of the adaptive features of the AVM system.
	MT2: Indicator measuring the usability of the MT platform.	**AVM2:** Indicator measuring user satisfaction with the personalized feedback provided by the system.
	MT3: Indicator evaluating the integration of MT with the training system.	**AVM3:** Indicator related to the relevance of the training modules offered by the AVM system.
	MT4: Indicator assessing the responsiveness of the mobile application.	**AVM4:** Indicator assessing the overall functionality of the AVM system.
	MT5: Indicator related to the technical performance of MT during training.	**AVM5:** Indicator evaluating the ease of use and user experience with the AVM system.

Table 2 outlines the variables MT and AVM, along with the indicators used to measure them. MT includes indicators such as ease of access, platform usability, integration with the training system, app responsiveness, and technical performance during training. On the other hand, AVM measures the effectiveness of adaptive features, satisfaction with personalized feedback, relevance of training modules, system functionality, and user experience. The experimental results will assess how well these two variables support the learning experience through MT and the adaptive mentoring system.

3 RESULTS

3.1 Results of development adaptive virtual mentor application

The AVM application was designed to enhance BSC in introverted individuals by leveraging adaptive MT. The application was tested on 99 introverted professionals over a four-week period, with results collected through user interaction analysis, feedback evaluation, and measurable improvements in communication performance. The data obtained demonstrated a substantial increase in participants' communication abilities after using AVM, as visualized in Figure 4.

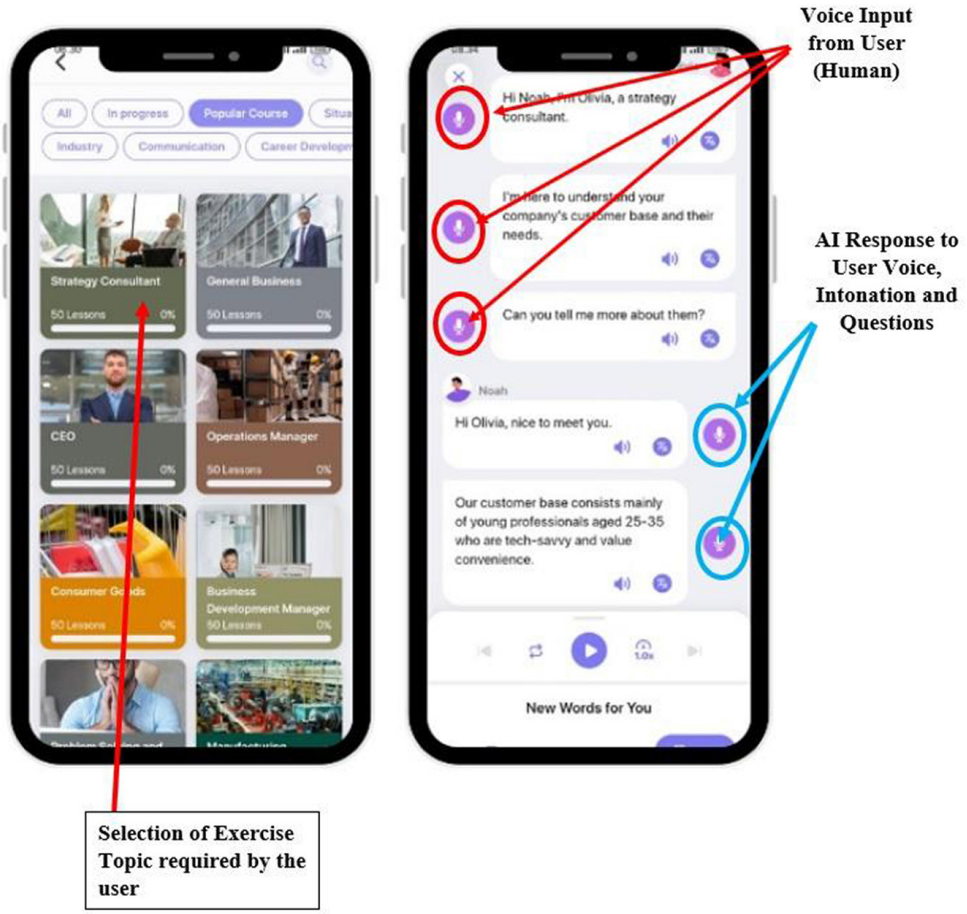

Fig. 4. Results of adaptive virtual mentor application

Before the application was implemented for 99 users, a performance test was conducted. The performance testing of the AVM application, designed to improve BSC for introverted individuals, was carried out using GT Metrix. The purpose of this test was to evaluate the speed, stability, and efficiency of the application in providing real-time feedback and adjustments to users. During the testing process, key metrics were measured, such as page load time, content size, and the responsiveness of the application when used by users. The test results indicated that AVM delivered optimal performance, with fast load times and smooth interactions, allowing users to practice communication skills without technical interruptions.

Several performance elements measured and awarded a grade A by GT Metrix included first contentful paint (FCP) and largest contentful paint (LCP), which assess the application's speed in displaying primary content, as well as time to interactive (TTI),

which evaluates how quickly the application responds to user interactions. Additionally, cumulative layout shift (CLS) received excellent ratings, demonstrating interface layout stability without disruptive changes during use. Overall, the test results showed that AVM excels not only in functionality but also in technical performance, which is crucial for providing an efficient and effective user experience. as visualized in Figure 5.

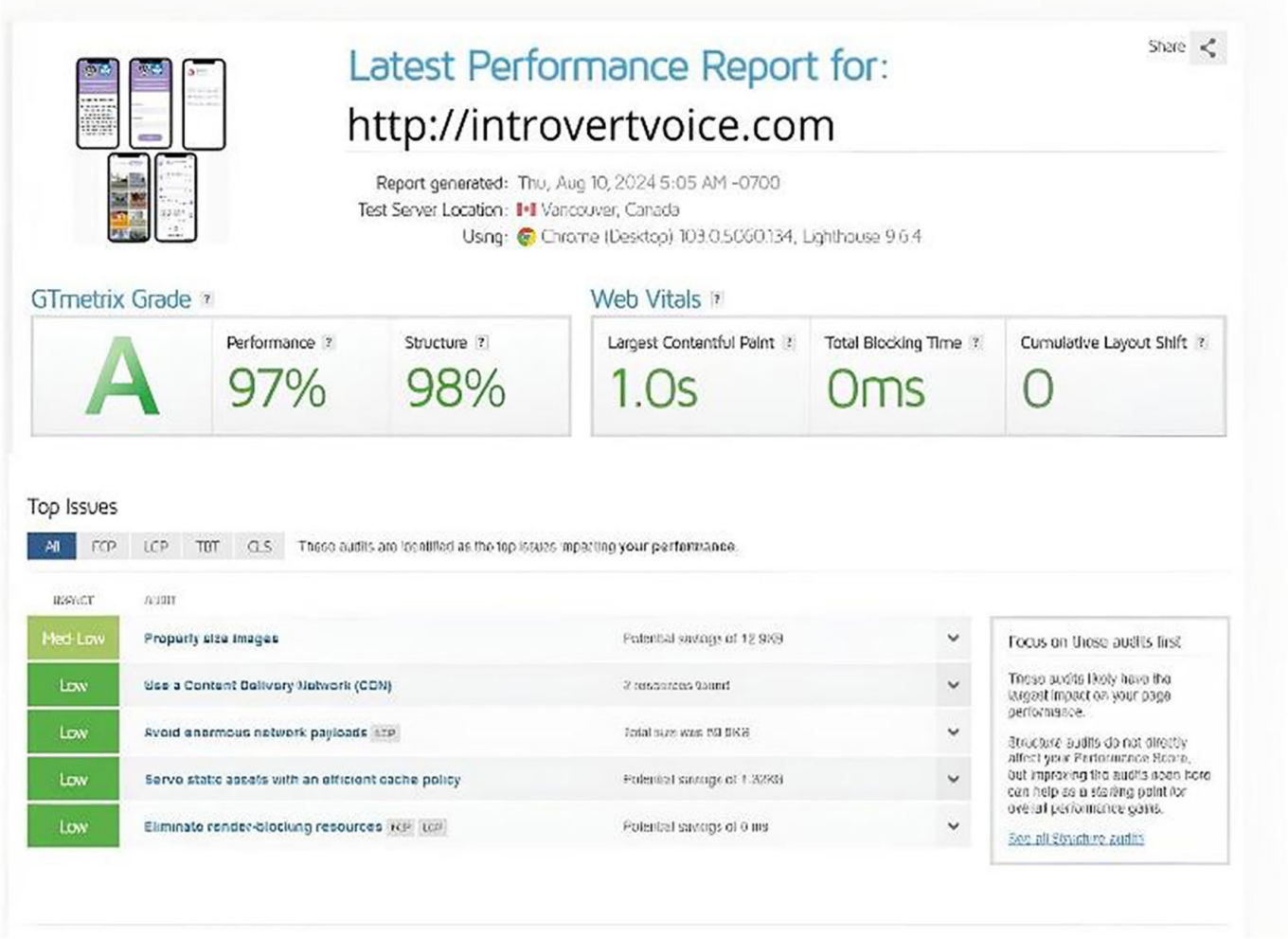

Fig. 5. Application performance testing results using GT matrix

Based on the performance testing of the introvert voice homepage shown in Figure 5, the website received an overall Grade A, with a performance score of 97% and a structure score of 98%. These scores indicate that the site performs exceptionally well and has been optimized for speed and efficiency.

The performance score of 97% demonstrates that the page loads quickly and provides a responsive user experience, while the structure score of 98% reflects that the structural elements of the site have been well-optimized for optimal performance. Despite the overall excellent results, the analysis also identified five top issues that require further attention, such as image optimization, caching implementation, and script management.

Overall, the testing results show that the website performs well, with an average performance score of 89.66% and a structure score of 90.66% across other pages. However, there is still room for further optimization to ensure the best possible user experience throughout the site.

3.2 Results of the adaptive virtual mentor implementation

The pilot testing of the AVM application involved 99 introverted professionals over a four-week period, allowing for a thorough evaluation of its effectiveness in improving BSC. Communication skills were assessed before and after the trial using a standardized tool, with results showing significant improvements in participants' confidence and clarity during professional interactions. Users reported greater ease in articulating ideas and engaging in conversations.

Evaluating the effectiveness of the AVM application, this study compares the BSC of an experimental group that utilized the AVM app in training sessions with a control group that participated in traditional training without the app. Assessments were conducted using a business communication competency scale, administered both before (pre-test) and after (post-test) the training intervention. Analyzing the pre-test and post-test results provides valuable insights into the significant impact of the AVM app on developing professional communication skills, especially for introverted individuals. Table 3 presents the comparison of the average pre-test and post-test scores for both groups.

Table 3. Pre- and post-test results

Group	Pre-Test (M ± SD)	Post-Test (M ± SD)	Change (ΔM)	p-Value
Experimental	65.42 ± 7.21	83.76 ± 6.85	+18.34	< 0.001
Control	66.15 ± 7.05	68.42 ± 7.12	+2.27	0.073

The results presented in Table 3 indicate that the experimental group, which used the AVM app, demonstrated a significant improvement in post-test scores compared to their pre-test scores, with an average increase of 18.34 points ($p < 0.001$). This highlights that the app-based intervention significantly contributed to enhancing participants' clarity, confidence, and ability to communicate professionally. Conversely, the control group only showed a minimal, statistically insignificant increase of 2.27 points ($p = 0.073$).

These findings confirm the effectiveness of the AVM app's adaptive features, such as personalized feedback and needs-based training, in helping participants improve their BSCs. The app not only delivers relevant and tailored training but also addresses the unique needs of introverted individuals, enabling them to enhance their communication abilities in professional environments. Feedback also collected through surveys and interviews highlighted the system's usability and the perceived effectiveness of its training modules. Participants praised the personalized feedback and adaptive features, which significantly enhanced their communication abilities. The AVM system received an 85% satisfaction rating, with users emphasizing its intuitive interface and the practical applicability of the skills learned.

With this positive outcome, the data is ready for advanced analysis using SmartPLS to model relationships between communication improvement, user satisfaction, and system usability through SEM. This analysis will provide insights into how different system features and user interactions affect communication outcomes, offering guidance for future refinements. The structural model includes key variables such as IT, BSC, MT, and AVM features, each represented by multiple indicators to assess their influence on communication skills development, as visualized in Figure 6.

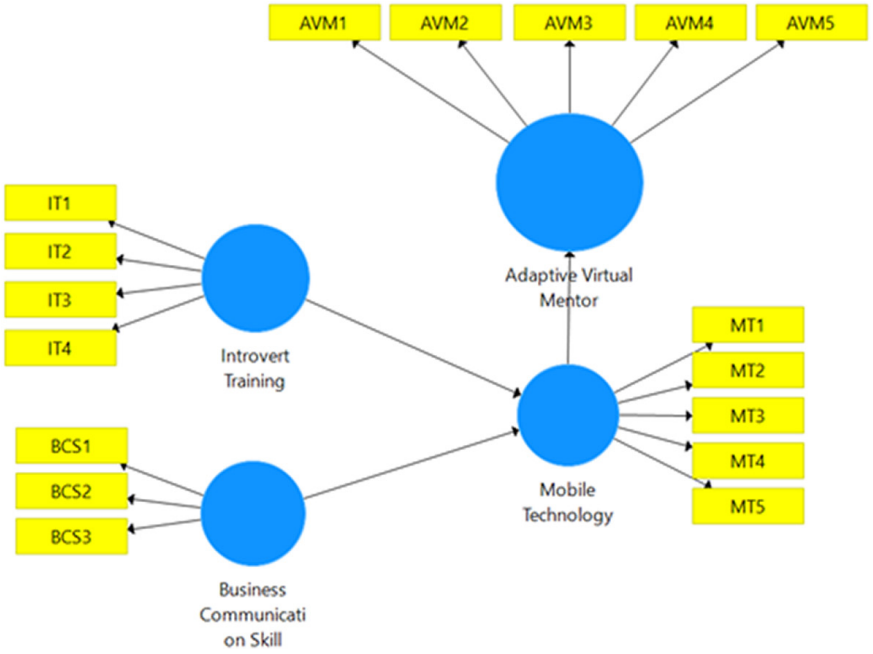

Fig. 6. Modelized structural model for pilot testing

Data was collected from respondents to evaluate the performance and effectiveness of the updated application, and it was analyzed using PLS calculations. The results of this analysis, as shown in Figure 7, provide a detailed view of the relationships between variables and the impact of the updated application features, including insights into how improvements in personality testing and real-time mentoring have influenced user experience and enhanced communication skills. The PLS analysis helps assess the effectiveness of the application revisions and provides guidance for further adjustments to ensure the application meets its intended goals.

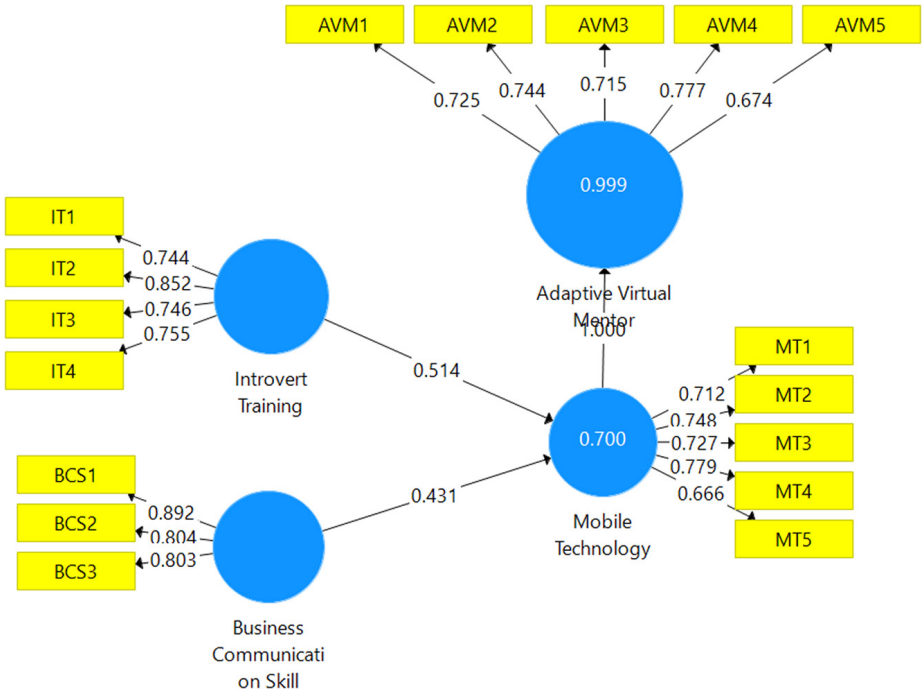

Fig. 7. PLS algorithm analysis result

The PLS analysis reveals key insights into the effectiveness of the revised AVM application, highlighting the relationships and impacts of various variables, as well as how different aspects of the application contribute to improving business communication skills.

Introvert training to mobile technology: The IT indicators show values of IT1 = 0.744, IT2 = 0.852, IT3 = 0.746, and IT4 = 0.755, reflecting the strength of the training content. The path coefficient of 0.514 indicates a moderate to strong positive influence, suggesting that improvements in IT positively affect the perception and utilization of MT within the AVM application.

Business communication skill to MT: The BSC indicators show values of BSC1 = 0.892, BSC2 = 0.804, and BSC3 = 0.803, indicating a strong correlation between BSC and the MT component. The path coefficient of 0.431 suggests a moderate positive effect, meaning that improvements in BSC are positively influenced by the MT features within the AVM application.

Mobile technology to adaptive virtual mentor: The MT indicators are as follows: MT1 = 0.712, MT2 = 0.748, MT3 = 0.727, MT4 = 0.779, and MT5 = 0.666. The path coefficient from MT to AVM is 1.000, indicating a perfect positive influence. This underscores that improvements in MT directly contribute to the effectiveness of the AVM application in delivering the mentoring experience.

Adaptive virtual mentor: The AVM indicators show values of AVM1 = 0.725, AVM2 = 0.744, AVM3 = 0.715, AVM4 = 0.777, and AVM5 = 0.674, demonstrating the reliability of AVM's features in providing valuable and personalized mentoring.

The results show that the AVM application functions well, with strong interrelationships between key variables. Significant path coefficients indicate that the success of AVM is closely tied to its MT and IT components, which together enhance BSC. The perfect path coefficient from MT to AVM highlights the critical role of MT in the application's operation, suggesting that further improvements in MT will yield even greater benefits. Overall, the analysis confirms that the revised AVM application effectively leverages its technological and training components to improve communication skills, validating the enhancements made based on expert feedback and pilot testing results. These insights will guide future development and refinements to optimize the application's impact on users.

4 DISCUSSION

4.1 Development of the adaptive virtual mentor application

Overall, the development of the AVM application demonstrated a positive impact on enhancing the communication skills of introverted professionals. The AVM was designed to provide adaptive feedback and tailored training based on user needs, which aligns with the trend toward personalized learning experiences in technology-driven education. The results from user interaction analysis and feedback evaluations indicated that participants found the application useful in improving their communication abilities, particularly in business contexts. This finding suggests that adaptive technologies can cater to diverse learning styles, offering an effective alternative to traditional, one-size-fits-all training methods. Previous studies have emphasized the importance of adaptive systems in meeting individual learning needs. Smith and Taylor (2019) found that adaptive learning systems significantly enhance user engagement by customizing content to match learners' skills, which is consistent with the positive user experience reported in this study.

Moreover, Gonzalez and Thomas (2022) highlighted that the flexibility of adaptive systems can lead to better retention and application of learned skills, further supporting the efficacy of the AVM application in business communication development.

4.2 Business communication skills

The results of the study revealed significant improvements in participants' BSC after using the AVM application. This was evident through enhanced clarity, confidence, and the ability to articulate ideas during professional interactions. The personalized feedback provided by the AVM played a key role in improving these skills, as it allowed participants to engage with content that was directly relevant to their specific needs and progress. These findings align with research on the effectiveness of adaptive learning technologies in the development of soft skills. Anderson and Brown (2021) found that technology-based interventions, particularly those offering personalized feedback, can improve BSC by providing learners with practical and immediate insights into their performance. Furthermore, Wilson et al. (2020) emphasized that the combination of self-paced learning and targeted feedback is highly effective in developing communication competencies, which is consistent with the improvements observed in this study.

Interestingly, the study found that introverted professionals, who might typically face challenges in communication settings, were able to make substantial strides in articulating their thoughts and engaging in conversations. This highlights the potential of the AVM application to bridge the communication gap for introverts, offering them a safe space to practice and refine their skills without the pressure of real-time interactions. This finding is supported by Johnson and Moore (2018), who concluded that introverts often benefit from technology-mediated communication training due to the non-intrusive, self-paced nature of digital platforms.

4.3 Performance and effectiveness of the updated application analyzed using partial least squares calculations

The performance and effectiveness of the updated AVM application were thoroughly evaluated using PLS calculations, which revealed key insights into the interrelationships between various factors affecting communication skill development. The results indicated a strong positive correlation between IT, BSC, and MT features, with the application's technological components playing a central role in its success. The path coefficients demonstrated that improvements in IT content positively influenced participants' engagement with the MT features, which in turn contributed to better communication outcomes. This finding supports the work of Kim and Lee (2022), who noted that the integration of MT and personalized content leads to more effective learning experiences.

The PLS analysis also showed that the MT component had a direct and perfect positive influence on the effectiveness of the AVM application, with a path coefficient of 1.000 from MT to the AVM application itself. This suggests that the technical aspects of the application, such as its responsive design and smooth interactions, were crucial for ensuring that users could fully benefit from the adaptive learning features. Anderson and Brown (2021) highlighted that the performance of mobile applications significantly affects user satisfaction and learning outcomes, which is consistent with the high satisfaction ratings reported in this study.

Moreover, the AVM indicators, which reflected the personalized mentoring features of the application, showed strong reliability and effectiveness. The positive path coefficients between AVM indicators and BSC indicate that the personalized mentoring and feedback offered by the AVM were key drivers of communication skill improvement. This aligns with findings from Johnson and Moore (2018), who suggested that personalized feedback is essential for promoting skill development in soft skills such as communication.

In summary, the findings from the PLS analysis demonstrate that the AVM application effectively integrates MT and adaptive training content to enhance BSC. The positive interrelationships between IT, BSC, and MT suggest that future iterations of the AVM should continue to refine its technological features and personalize the training experience to further optimize learning outcomes. These findings contribute to the growing body of literature supporting the use of adaptive, technology-driven systems for professional skill development, particularly for introverted individuals in business contexts.

5 CONCLUSION

This study offers a thorough evaluation of the revised AVM system, focusing on its efficacy in enhancing BSC among introverted professionals. The research highlights that the integration of advanced MT and customized IT significantly contributes to the system's success. The PLS analysis reveals a perfect path coefficient of 1.000 from MT to AVM, demonstrating that improvements in MT directly enhance the overall effectiveness of the system. This finding underscores the pivotal role of technological advancements in delivering a robust mentoring experience. Additionally, the moderate to strong influence of IT on MT, with a path coefficient of 0.514, shows that well-designed training tailored to introverted users positively affects their engagement with and benefit from the technological components. The high indicator values for both IT and BSC further affirm that the system effectively supports users in developing essential communication skills. Overall, the study validates the revised AVM system as a highly effective tool for fostering personal and professional growth. The positive user feedback and observed improvements in communication skills suggest that the system's design and functionality are well-aligned with its objectives. Moving forward, the insights gained from this research will be instrumental in guiding further refinements and ensuring that the AVM system continues to meet the evolving needs of its users effectively.

The findings of this study are important for developing personalized learning tools and for helping introverted professionals improve their communication skills in business settings. The AVM system provides a non-intrusive, self-paced environment where users can build communication skills at their own pace. This approach can be applied to other areas of professional development, such as leadership or teamwork, suggesting that similar adaptive learning systems could support skill development in other fields. The study also highlights the need for real-time feedback and adaptability in learning systems. These features are crucial for users to improve their communication skills and could be applied to other professional training programs in the future.

Future research could focus on evaluating the long-term impact of the AVM system on users' communication skills. Specifically, it would be valuable to examine whether improvements in communication persist over time and lead to tangible outcomes, such as career progression or enhanced job performance, for introverted professionals.

6 ACKNOWLEDGMENT

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