

Autism Spectrum Disorder Learning Application Framework (ASDLAF) Evaluation: ASD Users' Perspectives

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Abstract—Autism Spectrum Disorder (ASD) is a developmental condition that causes lifelong impairments in social interaction and communication skills. Besides early interventions and ASD services, technology has become essential in assisting ASD individuals in building and improving their communication and social skills. However, most technological innovations have been developed for Western countries. When considering Saudi Arabia as a developing country, people with ASD may have to deal with other difficulties, such as culture, privacy, and societal integration. To address this, we developed and evaluated a framework to investigate the factors that most influence the adoption of ASD Learning Applications (LA). Additionally, 16 hypotheses were defined to test specific relationships between the factors. A quantitative method was utilised to design our experimental study. This paper presents an evaluation of the Autism Spectrum Disorder Learning Application Framework (ASDLAF) from the perspective of individuals with ASD in Saudi Arabia. Utilising a quantitative approach, data was gathered through a survey with a total of 395 participants. Results of hypotheses testing revealed significant support for most factors except social rules (SR), religion (RE), and age (AG). These findings underscore the importance of cultural, technological, and pedagogical considerations in technology adoption for ASD individuals. The results also suggest that while the ASDLAF may be effective in addressing certain factors of ASD learning applications, there are still areas that need to be further developed to meet the specific cultural and religious needs of individuals in Saudi Arabia. Furthermore, it will be essential for developers and stakeholders to consider these factors in order to create more beneficial and effective learning tools for individuals with ASD in this region.

Index Terms—Autism Spectrum Disorder (ASD), Learning Applications (LA), Adoption Intention, Technology Acceptance Model, Saudi Arabia.

I. INTRODUCTION

AUTISM Spectrum Disorder (ASD) is a complex neurodevelopmental disorder that impacts an individual's social, communication, and behavioural skills. Impairment in these skills reduces the ability of ASD individuals to understand social interaction [1], for instance, difficulty recognising facial expressions [2], which impacts their ability to engage in social activities. Globally, ASD prevalence has increased in recent decades. The estimated prevalence of ASD in Saudi Arabia is 42,000 cases [3]. According to Rapp et al. in their study [4], 4,900 adults in

Canada have been diagnosed with ASD, while in the US, there are 48,500 American adults with ASD. To put these numbers in perspective, consider that the prevalence of ASD in the US is about 1 in 54 children, according to the Centers for Disease Control and Prevention (CDC), indicating a significant public health concern [5]. Given the prevalence of autism spectrum disorders (ASD) worldwide and their effects on diverse societies, it becomes evident that early interventions are essential in addressing the needs of individuals with ASD and improving their development.

Early interventions play a crucial role in helping individuals with ASD shape their behaviour and improve their social and communication skills, which can have a significant impact on overall development. Early interventions include a combination of therapies such as applied behaviour analysis (ABA), speech therapy, and developmental interventions. Research has emphasised the importance of early interventions in improving long-term outcomes for individuals with ASD, which can lead to significant improvements in communication, social skills, and adaptive behaviour [6]. These early interventions generally involve the family and caregivers in significant ways, empowering them to effectively support their child's needs and search for appropriate services. Many Arab countries experienced a shortage of ASD diagnoses, which led to burdens and complex impairments to ASD individuals and their families [7]. The lack of early interventions and diagnoses in these countries may be due to a lack of ASD awareness among societies. It is also possible that some individuals with autism remain undiagnosed due to the stigma surrounding mental health issues.

Previous studies have shown that technology can be an effective tool to assist individuals with ASD in improving their skills [8], enabling them to work at their own pace and level [9], [10]. The technology aims to mitigate ASD individuals' deficits and provide assistance to overcome difficulties [11]. With Learning Applications (LA), individuals with ASD have access to personalised, engaging, and interactive learning experiences. Mobile LA for individuals with ASD can focus on a variety of areas, including communication, social skills, and

academic performance. Many applications use Video Self Modelling (VSM) based approaches to improve academic skills [12], [13]. VSM is a therapeutic technique that allows users to complete daily tasks effectively while recording themselves as visual evidence of their capabilities, which can result in increasing the confidence, motivation, and satisfaction of ASD users. The visual supports can be particularly beneficial for individuals with ASD who may struggle with verbal communication and language processing. Additionally, the interactive nature of mobile LA can keep individuals engaged and focused, ultimately leading to greater success in their learning and development. Overall, the use of ASD LAs tailored for individuals with ASD aims to enhance their learning experience and help them progress in various aspects of their lives.

However, most of the innovations regarding ASD have taken root in developed countries [14] or were primarily designed with Western cultural norms and values [15], which may not always be applicable or effective in other parts of the world. People with ASD in non-Western cultures may face difficulties as a result and may not benefit from interventions that are not appropriate for their culture. For example, in many Arab countries, including Saudi Arabia, there is a significant stigma surrounding mental health issues [16] [17], which can discourage families from seeking support for their loved ones with ASD. Additionally, language barriers can also cause significant challenges as the majority of the technological aids are designed with language and cultural considerations that differ significantly from those of native Arabic-speaking users [18], limiting their accessibility for people in need. Moreover, privacy is highly valued in Saudi Arabian

culture [19], which can cause challenges for ASD individuals and their families when they seek support and services. This may decrease the possibility of ASD individuals being integrated into mainstream society. Thus, as mentioned earlier, there is a clear need for tailored interventions for individuals with ASD in non-Western cultures like Saudi Arabia, taking into consideration the unique cultural and societal context.

This paper aims to present our quantitative data analysis results of the survey conducted with ASD individuals in Saudi Arabia—the survey aimed at gathering data about ASD individuals' experiences with ASD LA. The analysis results are presented to provide a comprehensive understanding of the participants' views. First, we present a brief summary of our ASDLAF framework to set the context [20]. After that, we delve into our methodology validation process. Subsequently, we present the outcomes obtained from implementing our hypotheses testing, providing insightful analysis and interpretation of the results.

II. THE PROPOSED FRAMEWORK

The proposed framework called "Autism Spectrum Disorder Learning Application Framework for Saudi Adults (ASDLAF)" has been developed by the authors based on a critical evaluation of such models, including the technology acceptance model (TAM), and based on the existing literature, which aims to explore and examine the significant factors that assist adults with ASD in Saudi Arabia [20]. As shown in Fig. 1, the framework has a dependent variable that assesses the adoption of ASD LA, intermediate variables that analyse the usability, trust, acceptance, and effectiveness of

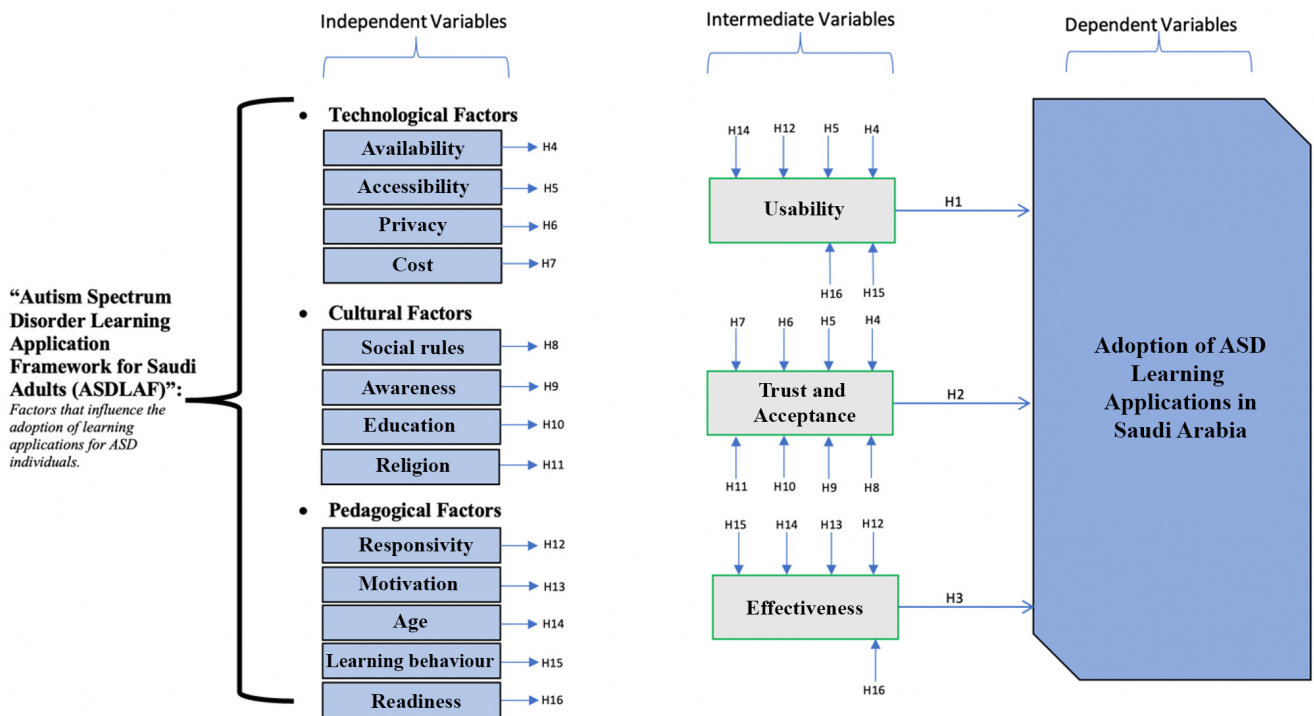


Fig. 1: Autism Spectrum Disorder Learning Application Framework for Saudi adults (ASDLAF) [16]

the technologies, and independent variables focused on technology, culture, and pedagogy that influence the adoption of ASD LA.

The intermediate variables of the proposed framework include Usability, Trust and Acceptance, and Effectiveness, while the technological factors are discussed in terms of how they affect the adoption of new technology. Culture is considered a vital factor that influences new technology adoption, and some cultural factors, such as education, social rules, awareness, and religion, shape the lifestyle of a society in a particular region. Pedagogical factors are also considered, as some individuals with ASD have learning difficulties, which can create significant barriers that influence them to accept and use LA. This study can contribute to a deeper understanding of how defined factors shape ASD individuals' perceptions of the adoption of ASD LAs. It also offers practical insights for policymakers, caregivers, and technology developers, which will help provide better solutions for individuals with ASD in Saudi Arabia.

III. METHODOLOGY VALIDATION

This study aims to investigate the factors that most influence the intention to adopt ASD LAs. The data was collected from a 68-item online survey which was distributed among ASD individuals in autism centres which provide care for people with autism aged above 18 years old. The respondents are informed that they can ask their family or caregivers for help completing the survey if they need it at any time. This occurred in the period between November and December 2023, with a total of 395 responses. The survey included 5-point Likert scale questions, aiming to validate our proposed ASDLAF framework and improve our understanding of the ASD users' experience of accepting ASD LA adoption. SPSS was used to analyse the survey data.

The study sample size was calculated based on the population of ASD in Saudi Arabia, which was estimated by [3]; therefore, the sample size required at least 381 responses to be gathered, with a confidence level of 95% and a confidence interval of 5%. Overall, a total of 412 responses were collected. In order to ensure data quality and validity, incomplete surveys were excluded, resulting in 395 responses for the statistical analysis phase.

A. Reliability and validity of the study

To ensure the survey's reliability, Cronbach's Alpha α was used to assess the extent to which items in a scale are correlated with each other using the internal consistency method before proceeding to the hypotheses testing phase. Table I shows the Cronbach's Alpha results and indicates that the reliability of all constructs is above 0.7, which is considered within the acceptable range according to [21], suggesting that α needs to be higher than or equal to 0.7.

This study uses face and content validity to ensure that the items or questions in the survey are relevant and appropriate for measuring the intended construct and, consequentially, enhance the validity of the findings. Validity is not directly

TABLE I.
INTERNAL CONSISTENCY OF THE STUDY SURVEY INSTRUMENT

Construct	No of items	Cronbach's Alpha
Usability (US)	3	0.869
Trust and Acceptance (TA)	3	0.844
Effectiveness (EF)	3	0.831
Availability (AV)	3	0.771
Accessibility (AC)	3	0.796
Privacy (PR)	3	0.881
Cost (CO)	3	0.874
Social rules (SR)	3	0.742
Awareness (AW)	3	0.876
Education (ED)	3	0.897
Religion (RE)	3	0.732
Responsivity (RS)	3	0.927
Motivation (MO)	3	0.887
Age (AG)	3	0.768
Learning behaviour (LB)	3	0.774
Readiness (RD)	3	0.794
Adoption of ASD Learning Applications in Saudi Arabia (AL)	3	0.909

calculable but rather inferred from accumulated evidence [22]; thus, the survey was reviewed and tested by 15 academic experts in both M-learning and ASD fields.

IV. RESULTS

This section provides an overview of the study results of the respondents including demographic characteristics and descriptive analysis, summarised in Table II. This section also delves into the framework analysis to explain the correlations between constructs.

A. Respondents' demographic data

This study reflects the age statistics in Saudi Arabia as, according to the Saudi General Authority for Statistics, 51.1% of the overall population is less than 30 years old, and the median age of the population is 29 years old [23]. In recent decades, Saudi Arabia has experienced prompt demographic changes, with a growing youth population reshaping the social and economic landscape of the country. As more young Saudis rely on smartphones and mobile applications as essential parts of their daily lives [24], stakeholders need to adapt their strategies to target this demographic range effectively, especially for people needing healthcare services. Moreover, individuals often rely heavily on digital technologies during the adulthood transition period. Interestingly, the study also revealed that 29% of the survey respondents were in their 30s and 40s. It's possible that older respondents obtained their diagnosis later in life. Overall, there is a general trend of high agreement rates across all age groups, which indicates a positive attitude towards using ASD LAs regardless of age.

TABLE II.
SAMPLE CHARACTERISTICS (N = 395)

		Frequency	Percentage			Frequency	Percentage
Age	18–19	108	27.3	Gender	Male	211	53.4
	20–29	165	41.8		Female	184	46.6
	30–39	98	24.8	Education level	Never studied	9	2.3
	40–49	17	4.3		Elementary School	6	1.5
	50–59	7	1.8		Middle School	15	3.8
Time of Using Mobile Devices	1–3 hours	136	34.4		High school	136	34.4
	4–10 hours	159	40.3		Bachelor's degree	129	32.7
	11–20 hours	100	25.3		Master's degree	95	24.1
				PhD degree	5	1.3	

In terms of gender, 53.4% of respondents were male, and 46.6 were female, as expected, given that the male population outnumbers the female population in Saudi Arabia [25]. Furthermore, the prevalence of autism in Saudi males is higher than in females [26]. This study reflects current gender demographics and autism prevalence rates in the Saudi context. It has been found that both genders generally express positive attitudes towards using ASD LAs.

Our study indicates a diverse range of educational backgrounds among individuals diagnosed with ASD. This variety of educational levels emphasises the necessity of understanding their unique challenges and the support they require, as the majority of respondents (34.4%) have a high school diploma, while 32.7% have a bachelor's degree. The relatively small percentage of respondents who never studied, attended elementary school, or went to middle school, with a total of 7.6%, indicates that the study sample mostly consists of individuals who have completed these early educational stages.

The survey analysis results indicated that participants with elementary school education levels have less intention of accepting ASD LAs adoption than others. This could be due to digital literacy skills, as people with limited education may face barriers to accessing and using technology [27]. Individuals with higher levels of education may have a better understanding of the potential benefits of ASD LAs in education, which may correspond with greater access to resources.

The widespread use of digital technologies in society is reflected in the high frequency of mobile device use among people with ASD. The examination of mobile device usage showed that the majority of respondents spend 1–10 hours per day on their devices, with 34.4% spending 1–3 hours. 40.3% of the examined population spends 4–10 hours, whereas 25.3% spend 11–20 hours. It is worth mentioning that excessive use of mobile devices can hinder ASD individuals' daily routines and their social interaction skills growth, leading to more severe issues such as isolation [28]. Overall, our data analysis results indicate that people engage with mobile devices in various ways. It also reveals the high agreement rates across different time categories (1–3 hours, 4–10 hours, and

11–20 hours), which indicates a positive intention to use autism learning applications.

B. Hypotheses fit testing

In this part, we evaluate the fit of our hypothesised framework to the actual data obtained from our survey. The framework was developed using theoretical considerations and past research to highlight the relationships between key factors influencing the adoption of ASD LAs among individuals with ASD in Saudi Arabia.

First, a series of statistical studies were performed to determine the fit of each hypothesised relationship between structural factors (e.g., technical, cultural, and pedagogical) and ASD users' perceptions. These analyses included correlation coefficients and significance tests to examine the strength of the relationships proposed in our framework. The outcomes of our hypothesis fit testing offer valuable insights into the sufficiency of our theoretical framework. All of the hypotheses, H1 to H16, tested were formulated in our previous paper along with the ASDLAF framework development [20].

Usability (US)

The study indicates that there is a statistically significant moderately positive relationship between usability (US) and the intention to use ASD LAs (AL) with a correlation coefficient of 0.313 and a significance level (p-value) of less than 0.001. In other words, as the US of ASD LAs improves, individuals with ASD are more likely to use them. This underscores the importance of designing ASD learning applications with more US consideration by actively involving individuals with ASD in the design process and considering their unique needs. The findings support the hypothesised relationship between US and AL: "H1. If ASD LAs' usability is increased, then this will lead to ASD users' increased intention to the adoption of ASD LAs."

Trust and acceptance (TA)

It appears to be a strong positive relationship between the intention to utilise ASD LAs (AL) and trust and acceptance (TA) of the applications, as indicated by a correlation value of 0.448 at a significance level of less than 0.001. This suggests that there is an enormous increase in the intention of

ASD users to adopt these applications as trust and acceptance of ASD learning applications grow. It is crucial for developers and stakeholders to focus on building trust when designing ASD LAs, which can enhance the acceptance of these applications. Developers can ensure ASD LAs align with best practices by collaborating with ASD professionals to understand important considerations such as ethical guidelines and ASD users' privacy. The findings support the hypothesised relationship between TA and AL: *"H2. If ASD LAs' trust and acceptance is increased, then this will lead to ASD users' increased intention to the adoption of ASD LAs."*

Effectiveness (EF)

The findings reveal a strong positive correlation ($rs = 0.414, p < 0.001$) between the effectiveness (EF) of ASD LAs and the intention to use these applications, shedding light on a critical relationship in educational technology adoption within the ASD community. This result implies that as the effectiveness (ED) of ASD learning applications increases, there is a corresponding increase in the intention of individuals with ASD to adopt LAs. Computer-assisted learning (CAL) approaches can be effective in teaching social skills [29]. The findings support the hypothesised relationship between EF and AL: *"H3. If ASD LAs' effectiveness is increased, then this will lead to ASD users' increased intention to the adoption of ASD LAs."*

Availability (AV)

There is a statistically significant positive link ($p < 0.001$) between the intention to use ASD learning applications (AL) and availability (AV), as indicated by the observed correlation value of 0.454. This implies that there is an evident rise in the intention of ASD (AL) users to adopt these applications when the availability of ASD LAs increases. In addition to focusing on the needs of individuals with ASD, it is essential to support networks surrounding them by providing training and guidance for educators and caregivers on how to effectively integrate ASD LAs into educational and therapeutic settings. This will increase the availability of these applications in practical terms. The findings support the hypothesised relationship between AV and AL: *"H4. If ASD LAs are available to function, then this will lead to ASD users' increased intention to the adoption of ASD LAs because ASD users will trust that this service will be always available to use."*

Accessibility (AC)

The survey analysis results revealed a moderately positive correlation coefficient of 0.157 between accessibility (AC) and the intention to use ASD learning applications (AL) with a significance level of 0.002, indicating the vital relationship between AC and user intention to use ASD LAs. This alignment suggests that enhancing the AC will increase the intention of individuals with ASD to utilise these applications. Considering accessibility features such as visual support, customisation, and sensor-friendly design can ultimately contribute to creating a promising learning tool. The findings support the hypothesised relationship between AV and AL: *"H5. If ASD LAs are accessible properly for autistic users, then this*

will lead to ASD users' increased intention to the adoption of ASD LAs because they will use these applications more easily."

Privacy (PR)

There is a weak positive relationship between privacy (PR) and the intention to use ASD learning applications (AL), as suggested by the obtained correlation coefficient ($r = 0.123$). This relationship has a significance score of 0.015, indicating statistical significance. The effect size is modest, suggesting that privacy concerns alone may not be the primary driver behind users' intention to use ASD LAs. Moreover, the modest correlation implies that users might subconsciously prioritise other factors over privacy. Users with limited technical expertise might find it difficult to assess the benefits and drawbacks of particular privacy measures, which would lead to a weaker correlation with adoption intention. The findings support the hypothesised relationship between PR and AL: *"H6. If ASD LAs' privacy is increased, then this will lead to ASD users' increased intention to the adoption of ASD LAs because they will trust that their personal data will be secured."*

Cost (CO)

Understanding the relationship between the cost (CO) of ASD LAs and the intention to use them is crucial in creating effective technological solutions for individuals with ASD. The findings of the survey revealed that a notable correlation coefficient of 0.174 was observed, with a statistically significant p-value of less than 0.001. These findings also indicate a positive relationship between the CO and AL, underscoring the essential role of affordability in technology adoption within the context of supporting individuals with ASD. Simply put, as the cost (CO) of ASD learning applications decreases or remains reasonable, there is an increase in the intention of ASD (AL) users to adopt these applications. This result is consistent with economic theories of demand, which suggest that lower costs encourage higher adoption rates [30]. The findings support the hypothesised relationship between CO and AL: *"H7. If ASD LAs are at a free or reasonable cost, then this will lead to ASD users' increased intention to the adoption of ASD LAs because they will accept these applications available with low cost."*

Social rules (SR)

The findings show a correlation coefficient of 0.087, with a significance level of 0.083, suggesting an insignificant relationship between social rules (SR) and the intention to use ASD LAs (AL). The result fails to reach conventional levels of significance ($p < 0.05$), implying that social rules may not be considered a substantial influence on the intention of individuals with ASD to engage with LAs designed specifically for their needs. Social rules might be a major barrier for certain people to use ASD LAs, but they might not have much of an impact on other individuals' decisions to accept technology; individuals are not the same [31]. This diversity can result in a wider range of responses, leading to a weaker correlation value. The findings reject the hypothesised relationship between SR and AL: *"H8. If social rules prevent ASD users*

to use learning applications, then this will lead to ASD users' decreased intention to the adoption of ASD LAs because they will not socially accept these applications."

Awareness (AW)

The correlation coefficient of 0.160 and a significance level of 0.001 suggest a weak positive correlation between awareness (AW) and the intention to engage with ASD learning applications (AL). This implies that individuals with ASD have the intention to be more interested in using LAs as autism awareness grows. This finding highlights the value of raising awareness of ASD and the advantages of using particular LAs for those who are on the spectrum. Awareness is not just about understanding ASD individuals—it's about enhancing their quality of life [32], by increasing their empowerment, inclusion, and access to resources that support ASD individuals' unique way of learning. The findings support the hypothesised relationship between AW and AL: *H9. "If awareness of autism is increased, then this will lead to ASD users' increased intention to the adoption of ASD LAs because they will have a better understanding to accept these LAs."*

Education (ED)

The results indicate a weakly positive correlation between education (ED) and the intention to use ASD learning applications (AL), with a correlation coefficient value of 0.211 and a statistically significant p-value of less than 0.001. In other words, as the level of education of ASD users increases, there is also a significant increase in their interest in using these applications. Higher education levels might be associated with a better appreciation of the potential benefits of ASD LAs in supporting their learning skills. Furthermore, individuals with higher education levels may be more proficient in using technology or are more likely to use ASD learning applications. The findings support the hypothesised relationship between ED and AL: *H10. "If ASD users are educated, then this will lead to ASD users' increased intention to the adoption of ASD LAs because they will have proper skills and accept these LAs."*

Religion (RE)

The results revealed that the correlation coefficient is 0.019, suggesting a very weak relationship between religion (RE) and the intention to use ASD learning applications (AL). Furthermore, the high p-value of 0.706 indicates that this correlation is not statistically significant at the conventional level of 0.05. Religion is a complex phenomenon, as there are different religious traditions and beliefs that have been practiced for centuries. The findings reject the hypothesised relationship between RE and AL: *H11. "If religious rules limit the use of ASD LA, then this will lead to ASD users' decreased intention to the adoption of ASD LAs because they will not accept these LAs."*

Responsivity (RS)

The result of the correlation test showed a positive relationship between RS and AL, $r = 0.206$, $p < 0.001$. This indicates that users with ASD tend to adopt ASD learning applications

that have more responsive interfaces. Developers can use this finding to prioritise features that enhance the responsivity within ASD learning applications, such as customisable settings, clear instructions, and sensory-friendly design elements. Individuals with ASD often have unique preferences [33] and various learning styles; thus, it is important to consider these individual differences and design proper applications that meet the specific needs of each user. The findings support the hypothesised relationship between RS and AL: *"H12. If ASD LAs provide proper responsive interfaces, then this will lead to ASD users' increased intention to the adoption of ASD LAs because ASD LAs will be effective and easy to use."*

Motivation (MO)

The survey analysis results revealed a strong positive correlation coefficient of 0.531 between motivation (MO) and the intention to use ASD learning applications (AL) with a significance level of < 0.001 . It suggests that the motivation factor acts as a driving force behind the intention to adopt and use ASD learning applications. People with ASD can certainly learn continuously in a comfortable environment, thanks to the revolution of current technological advancements such as artificial intelligence and augmented reality. These trending technologies can enhance the learning experience of ASD individuals and improve their social skills and communication abilities by creating virtual scenarios for practicing real-life interactions in a safe setting. The findings support the hypothesised relationship between MO and AL: *H13. "If ASD users have motivations to use learning applications, then this will lead to ASD users' increased intention to the adoption of ASD LAs because they will use these LAs effectively."*

Age (AG)

Despite the weak positive correlation, $r_s = 0.092$, between age (AG) and the intention to use ASD learning applications (AL), the correlation is not statistically significant at the conventional level of 0.05. While the correlation coefficient indicates a weak relationship, there might still be some influence of age on the intention to use ASD learning applications. However, in today's digital era, age has become less restricted by traditional age principles. Nevertheless, the digital age has also allowed older individuals to adapt to new technologies. It can be concluded that there is no significant relationship between age and the intention to use ASD learning applications based on the data collected; thus, the findings reject the hypothesised relationship between AG and AL: *"H14. If ASD LAs are suitable for adultescent age, then this will lead to ASD users' increased intention to the adoption of ASD LAs because they will find these LAs effective and easy to use."*

Learning behaviour (LB)

The correlation coefficient of 0.209, with a significance level of $p < 0.001$, emphasises a positive statistically significant relationship between learning behaviour (LB) and (AL). This correlation suggests that certain learning behaviours may encourage individuals with ASD towards the adoption of

ASD LAs. More importantly, technology can be a promising tool to provide a proper learning approach, as visual processing is a powerful choice for people with ASD [34]. Therefore, individuals with ASD can improve their communication skills and engage more effectively in social interactions in a safe environment. The findings support the hypothesised relationship between RS and AL: *“H15. If ASD LAs are aligned with ASD individuals learning behaviours, then this will lead to ASD users’ increased intention to the adoption of ASD LAs because they will use these LAs effectively and easily.”*

Readiness (RD)

The intention to use ASD learning applications (LA) and readiness (RD) appear to have a positive relationship, as indicated by the correlation coefficient of 0.214, with a significance level of less than 0.001, indicating a statistically significant relationship. Simply put, when individuals feel confident enough to use LAs, they are more likely to have the intention to adopt them. Therefore, this intention to adopt can lead to increased usage, which can ultimately result in the individual experiencing the full benefits of LAs. Using ASD LAs in their daily routine can contribute to improving their overall personal skills. The findings support the hypothesised relationship between RS and AL: *“H16. If ASD users are ready to use LA independently, then this will lead to ASD users’ increased intention to the adoption of ASD LA because they will use these LA effectively and easily.”*

This study discusses the critical factors that influence the adoption of ASD LAs by examining the validity of our proposed framework, ASDLAF. Statistical analyses were conducted to evaluate the relationships between various factors and users' intentions to adopt ASD LAs. As shown in Table III, the findings indicate significant positive correlations be-

tween usability, trust and acceptance, effectiveness, availability, accessibility, motivation, learning behaviour, and readiness and the intention to use ASD LAs. Thus, developers and stakeholders are encouraged to prioritise these factors to increase the intention of ASD individuals to adopt the LAs.

Factors such as readiness and motivation are crucial in driving the intention to adopt ASD LAs. These two factors can also be important incentives that increase the independence and empowerment of the ASD individuals. However, social rules, religion, and age factors showed weaker or insignificant correlations, which made their impact less pronounced. These factors may not directly influence the decisions to use LAs since ASD individuals and their families may prioritise immediate factors such as usability and effectiveness. Despite that, these factors should also be considered when designing LAs as they may have significant indirect implications. The updated framework that is presented in Fig. 2, has been revised after the evaluation of the factors in ASDLAF [20] and the results of the hypotheses testing.

Developers can create ASD learning applications that are not only effective in educational settings but also a tool that will be considered supportive for those ASD individuals requiring unique needs. These applications should be tailored to each individual's specific learning style and needs to increase the level of LAs effectiveness. For example, individuals with ASD have different sensory preferences. When it comes to the use of smart phones, it is crucial to consider the need to customise these stimuli to avoid overwhelming users who might be sensitive to bright lights, sudden noises, or persistent vibrations. Thus, some adjustments should be applied such as having a customisable alerts for the sudden noise issue, and using gentle vibrations in order to decrease the defects of persistent vibrations [35]. The sensory considerations are crucial

TABLE III.
SUMMARY OF THE HYPOTHESES TESTS RESULTS

Factors	Hypotheses test	Relationship direction	Relationship Strength
US → AL	Supported	Positive	Moderate (rs = 0.313 **) sig
TA → AL	Supported	Positive	Strong (rs = 0.448 **) sig
EF → AL	Supported	Positive	Strong (rs = 0.414 **) sig
AV → AL	Supported	Positive	Strong (rs = 0.454 **) sig
AC → AL	Supported	Positive	Weak (rs = 0.157 **) sig
PR → AL	Supported	Positive	Weak (rs = 0.123 **) sig
CO → AL	Supported	Positive	Weak (rs = 0.174 **) sig
SR → AL	Rejected	Positive	No Significant Relationship
AW → AL	Supported	Positive	Weak (rs = 0.160 **) sig
ED → AL	Supported	Positive	Weak (rs = 0.211 **) sig
RE → AL	Rejected	Positive	No Significant Relationship
RS → AL	Supported	Positive	Weak (rs = 0.206 **) sig
MO → AL	Supported	Positive	Strong (rs = 0.531 **) sig
AG → AL	Rejected	Positive	No Significant Relationship
LB → AL	Supported	Positive	Weak (rs = 0.209 **) sig
RD → AL	Supported	Positive	Weak (rs = 0.214 **) sig

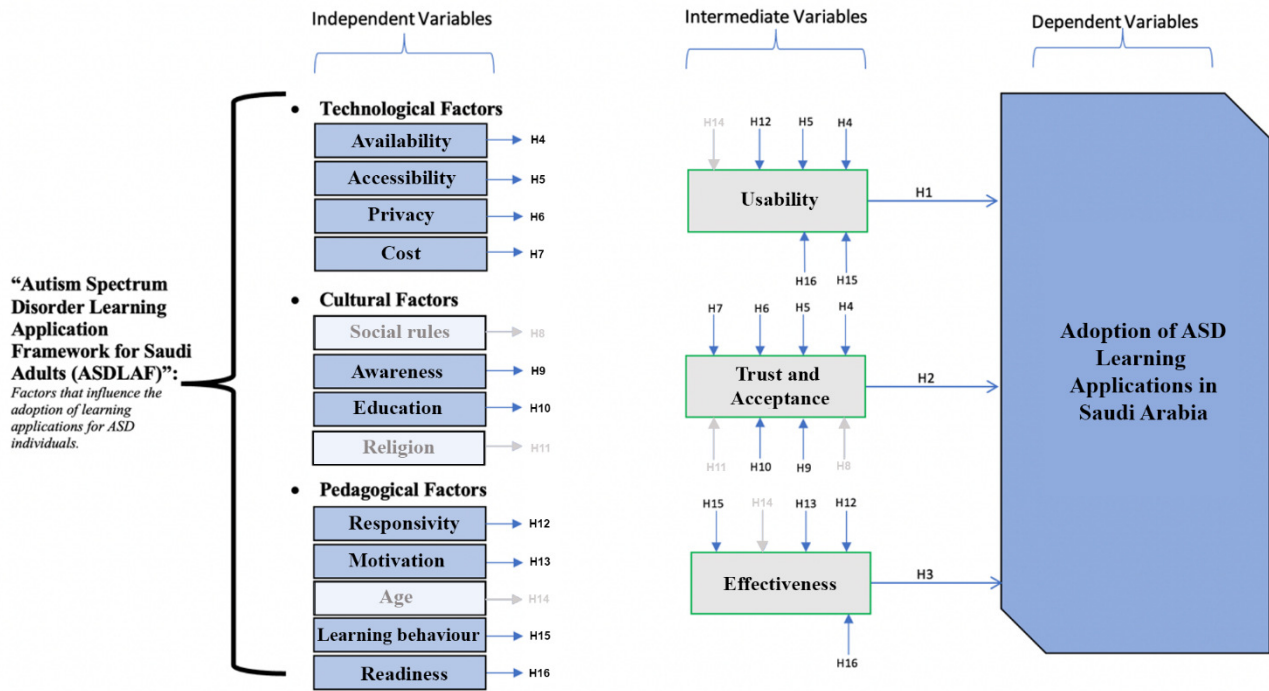


Fig. 2: The revised framework

to increase the motivation of ASD individuals to use technology as a supportive tool.

Another important consideration is the applications usability as our survey analysis found that usability is a vital factor in adopting the use of ASD LAs. A user-friendly interface is essential for facilitating ease of use and reducing frustration, which can impact the overall user experience of the users. Designing a user-friendly interfaces can help ASD users interact ideally [36], by creating a simple and predictable interfaces with clear instructions. The usability of LAs plays a significant role in how well the application is utilized by its target users. Therefore, how ready ASD users are to use LAs and the level of their learning behaviour are also considered key factors in increasing the likelihood of ASD users accepting and engaging with the application.

Additionally, this study emphasises the prominence education and awareness in enhancing the learning experiences of individuals with ASD. Several studies [13][33] have revealed that, in Arab countries, individuals with ASD are not provided with proper support. This could be due to the lack of awareness in this region. Participants of our survey have emphasised that better awareness leads to increase their intention to adopt ASD LAs.

The financial aspect is another essential consideration for ASD individuals and their families as some of them face significant financial burdens due to therapeutic and medical expenses. Thus, LAs developers should consider their price models so that users can afford using them. Plus, providing trial demos can allow the users to evaluate the effectiveness of the applications features before purchasing. Moreover, developers may collaborate with non-profit organizations to

provide a financial assistance for the families who cannot afford the applications. During the transition to adulthood, the cost of providing care for ASD individuals is high [38], as well as the medical expenses [39]; thus, keeping the price of applications at a reasonable range will greatly increase their acceptance among ASD society.

As stated earlier, privacy is a valuable factor in the Saudi society [19], let alone the unique sensitivities that ASD individuals usually have. Maintaining sensitive information such as sexual, physical, psychological information is considered very vital and exposing them could impact their dignity[40]. Therefore, developers must priorities this ethical consideration by involving ASD individuals, their families, and caregivers in the design process, which will increase the trust and acceptance of the ASD LAs. This involvement will help in creating a more personalised and effective learning experience and also minimise the risk of information exposure and unauthorised access.

V.CONCLUSION

In conclusion, this study sheds light on the critical factors influencing the adoption of Autism Spectrum Disorder Learning Applications (ASD LAs) among individuals in Saudi Arabia. By conducting a quantitative survey analysis, we validated the proposed Autism Spectrum Disorder Learning Application Framework (ASDLAF) and tested 16 hypotheses. This research provides valuable insights into the experiences of individuals with ASD regarding ASD LAs.

These findings highlight the importance of factors such as usability, trust and acceptance, effectiveness, availability, accessibility, motivation, learning behaviour, and readiness.

Whereas the impact of the social rules, religion, and age factors is less significant in determining the success of this type of technology. Overall, these results emphasise the need for further research and development in the field of technology adoption to gain a deeper comprehension of the factors that influence individuals' decisions to accept new innovations.

The future work involves a qualitative interview analysis, which can offer deeper insights into the experiences, perspectives, and challenges faced by individuals with Autism Spectrum Disorder (ASD) regarding the adoption of Learning Applications (LAs) in Saudi Arabia. The interview will be conducted with ASD caregivers, providing rich data that can support the quantitative findings.

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