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# Effect of a Mobile App Based Intervention on Digital Competence among Children with Autism Spectrum Disorder: Bridging the Gap in Information Literacy and Digital Safety

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**Abstract**

The current study investigated the efficacy of the GrowAble mobile app-based intervention in improving digital competence in children with Autism Spectrum Disorder (ASD), with a focus on information and data literacy and safety. A quasi-experimental pre-test/post-test design was used with 60 children aged 5 to 12 years from Amritsar district, Punjab, India. The experimental group included 30 children with ASD who received the GrowAble mobile app-based intervention, while the control group consisted of 30 typically developing children who served as a developmental reference group for the comparative analysis. Data were gathered using a researcher-created Digital Competence Scale and analyzed using descriptive statistics and the Mann-Whitney U test. The results showed significant differences between the groups at the pre-test stage, indicating that children with ASD have lower levels of digital competence. However, no significant differences were found at the post-test stage, indicating significant improvement after the intervention. The study concludes that structured and developmentally appropriate mobile app-based interventions can effectively support digital competence development among children with ASD while also encouraging meaningful participation in digital learning environments. Implications, limitations, and future directions were discussed.

**Keywords:** Digital competence; mobile app-based intervention; information and data literacy; safety; children with ASD

## INTRODUCTION

Digital technologies have experienced a very fast growth, which has come to change the nature of the modern societies, impacting every aspect of the learning, communication and social life of people (Condruz-Bacescu, 2019; Timotheou et al., 2023; Kauts & Rather, 2025a). This shift has given rise to a growing focus on providing students with skills that will enable them to thrive in digital environments (Makarova & Makarova, 2018; Olszewski & Crompton, 2020). At the international level, it is recognized to develop learners' digital competencies from early childhood. For example, the European Commission model like Digital Competence Framework DigComp 2018, sees digital competence as a multi-dimensional concept that comprises five key areas: information and data literacy, communication and collaboration, digital content creation, and safety. Likewise, educational reforms in different countries

highlight the inclusion of digital skills in school curricula to equip students with skills for a technologically driven world. In India, the National Education Policy (NEP) 2020 is emphasizing the digital competence as important aspect of equitable and inclusive education, and digital literacy, technological integration in teaching learning processes. Information and data literacy and digital safety are two areas of particular concern in relation to younger learners' digital competence (Robertson & Tisdall, 2020; Tomczyk & Eger, 2020). With the increased use of digital platforms by children for learning and socializing (Yusof et al., 2022) these are important skills needed to ensure the effective and responsible use of technology in the present times.

As digital competence is increasingly being identified as a key learning priority, differences in attainment of digital competence between learners still exist (Krueder et al., 2024). Technology access, socio-cultural environments and personal learner profiles are factors that shape digital competence development (Loureiro & Messias, 2018; Korkeaniemi et al., 2025). Especially, there are children with diverse learning needs who might face specific challenges in learning and applying digital skills, which needs specific and inclusive approaches to digital education (Bachtsis et al., 2024). Research that investigates the effective development of digital competence in a range of learners, particularly in innovative and accessible ways, is therefore needed.

**Digital Competence Challenges of Children with Autism Spectrum Disorder (ASD)**

Children with ASD have unique patterns of development that affect their learning, communicating and interacting with their surroundings (Kauts & Rather, 2025a). ASD traits, such as social communication differences, limited/repetitive behaviors, and atypical patterns of cognition could influence children's experiences and interactions with digital technologies. Digital environments are organized, structured, visual and predictable, and can be advantageous to children with ASD (Boucenna et al., 2014), but also have challenges that need to be considered when developing digital competence. Majority of the challenges are related to literacy skills (Westerveld et al., 2016; Westerveld et al., 2017). Difficulties in social understanding and risk perception may increase their vulnerability in online environments (Lough et al., 2015). The health and wellness in digital usage is also a critical factor for children suffering from ASD. Screen-based supervised and guided activities may be preferred by many children with ASD (Stiller et al., 2019). This can be used as a learning tool, but too much and unguided screen time can cause issues with physical wellbeing, emotional management and a lack of social interaction in the real world (Stiller et al., 2019). Thus, promoting balanced and conscious use of digital media becomes part of digital safety for this population.

Despite the above difficulties, it is important to be aware that digital technologies offer significant opportunities for children with ASD. Digital tools can be visual, based on audio instructions, interactive and can be used to assist learning to suit their strengths, like visual information, audio instructions and structured learning environments (Gopal et al., 2020; Khasawneh, 2023; Gallud et al., 2023; Urrea et al., 2024; Kauts & Rather, 2025a; Kauts & Rather, 2025b). The effective use of these opportunities will, however, depend on the availability of interventions which are specific and well designed to meet their learning needs. Taking these factors into account, it is evident that interventions to improve digital competence must be developed to target the digital competence of children with ASD.

Digital interventions via mobile technologies have proven to be effective tools in helping to support learning among children with ASD in a variety of educational settings in recent years (Leung et al., 2021; Kauts & Rather, 2025a). This has led to the adoption of mobile app-based interventions as suitable methods to promote digital competence among learners especially children with ASD. In the context of

digital competence, mobile applications can be designed to address specific dimensions such as information and data literacy and digital safety through interactive activities and guided practice based on tap-based activities, drag and drop based activities, tap in order-based activities and drag and sort-based activities. All of these activities are supported with visual cues, audio instructions and proper feedback at the end of each activity.

**Research Gap and the Present Study**

Past research has tended to be on general digital literacy, digital literacy among teacher educators, access to digital technology, or digital tools for communication and social skills development. Less attention has been paid to digital competence as a structured multidimensional concept with children with ASD, particularly regarding specific competencies that are needed to information and literacy and safely and meaningfully engage in digital space. A notable limitation within existing research is that there are no interventions that are dimension specific and specifically address aspects of digital competence. Another critical area of concern is the lack of studies on mobile app-based interventions specifically focusing on children with ASD on the topic of digital competence. Mobile technology has become one of the more established means of intervention in special education settings, but previous interventions have focused primarily on communication skills, behavioral management, and social interaction skills. There is little research examining how mobile apps can be used to build skills and competencies around browsing, searching, filtering information, digital safety and healthy digital practices within digital environments. This is an important gap in the context of the growing involvement of children in educational and daily use of digital technologies. So, keeping in view these gaps, the present study was conducted to investigate the effects of a mobile app intervention on digital competencies for children with ASD. Accordingly, the study was guided by the following objectives:

(i) to develop a mobile app based digital intervention aimed at enhancing digital competence among children with ASD; (ii) to implement the developed intervention and examine its effectiveness; (iii) to compare the pre-test and post-test levels of digital competence between the experimental and control groups across the dimensions of information and data literacy and safety.

Based on these objectives, the following hypotheses were formulated:

H01: There is no significant difference between the experimental and control groups in pre-test scores of digital competence (information and data literacy and safety dimensions).

H02: There is no significant difference between the experimental and control groups in post-test scores of digital competence (information and data literacy and safety dimensions).

## METHOD

### Research Design

In the present study, a quasi-experimental research design with pre-test/post-test control group was utilized to investigate the effectiveness of the GrowAble mobile app-based intervention on digital competence among children with ASD. The study involved two groups: one experimental group of children with ASD and the other group of typically developing (TD) children (who used the conventional teaching methods). The control group was incorporated to explore the degree of difference between the children with ASD and their TD peers in their baseline level of digital competence and to see if the intervention helped to close this gap at the end of the intervention period. The control group was primarily used as a developmental reference group to be compared with the experimental group in the frame work of quasi-experimental study.

**Participants**

The participants of the present study were 60 children (5-12 years) from educational institutions (Anonymized). This age has been chosen deliberately, as it covers an important developmental period for young learners in learning different skills. Children diagnosed with ASD (N = 30) and typically developing children (N = 30) were included in the sample used. The participants were selected from the three educational institutions from three different types of educational setting such as special educational setting, inclusive educational setting and regular educational setting in (Anonymized). The institutions were chosen because they were accessible, had children that met the criteria for the study and were willing to be part of the research process. The map of the selected institutions is shown in Figure 1.

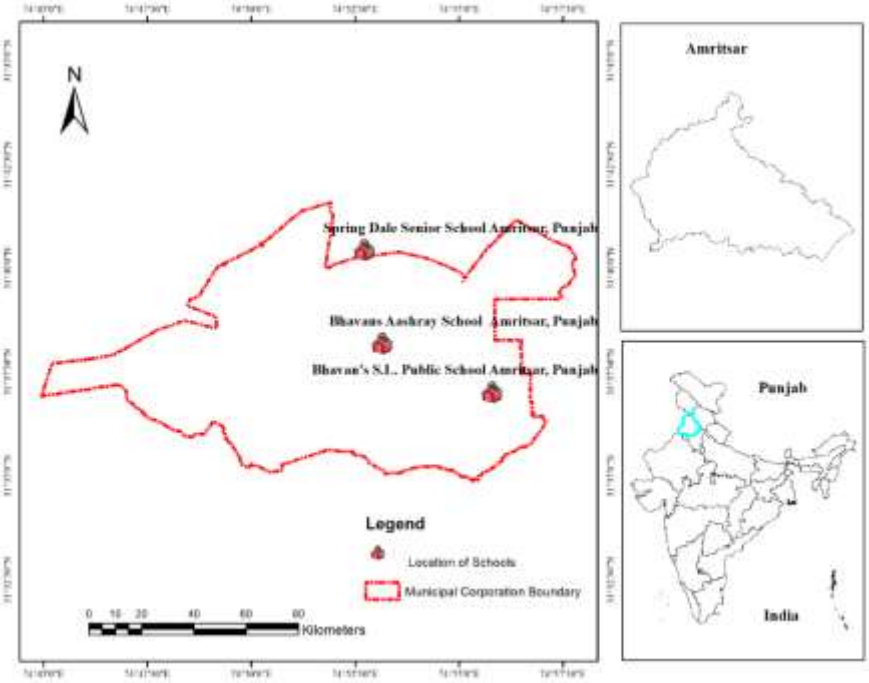


**Fig. 1. Geographical Location of Selected Schools in Amritsar, Punjab.**

The demographic distribution of the participants showed that the experimental group comprised of 24 boys and 6 girls while the control group had 15 boys and 15 girls. The demographic profile of the sample is given in Table 1.

**Table 1 Demographic Characteristics of the Participants**

| Group | Age Group (Years) | Boys | Girls | Total |
|---|---|---|---|---|
| Experimental Group | 5–12 | 24 | 6 | 30 |
| Control Group | 5–12 | 15 | 15 | 30 |
| Total | --- | 39 | 21 | 60 |

**Sample and Sampling Technique**

Mixed method sampling was used in the present study, that is, a purposive sampling technique along with a random sampling technique. Children who were diagnosed as having ASD were identified by purposive sampling and included in the experimental group. This method was deemed suitable due to the target population and the requirement for participants to be diagnosed for the intervention. In the control group,

the children who were typically developing were selected using a random sampling procedure based on the chit method, from among the identified educational settings.

**Variables**

In the quasi-experimental design, variables are systematically identified and classified to explore a relationship between intervention and outcomes. Table 2 shows the classification of variables used in this study.

**Table 2 Classification of Variables in the Study**

| Type of Variable | Variables Included |
|---|---|
| Independent Variable | GrowAble Mobile App-Based Intervention |
| Dependent Variable | Digital Competence |
| Dimensions of Digital Competence | Information and Data Literacy; Safety |
| Demographic Variables | Age Range (5-12 years), Gender |

**Procedure**

This study aimed to systematically investigate the effectiveness of the GrowAble intervention, which is based on the mobile application, in improving digital competence among children with ASD. The overall study procedure consisted of four broad phases, beginning with the development of the intervention and concluding with the administration of the post-test. The phases of the study are illustrated in Figure 2.


**Fig. 2. Phases of Conducting the Quasi-Experimental Study.**

**Layout of the Experiment**

The design of the experiment is the quasi-experimental design used for the present study to investigate the effectiveness of the GrowAble mobile app-based intervention. Total sample was split into two groups, experimental group and a control group. Refer to figure 3 experimental layout of the study.

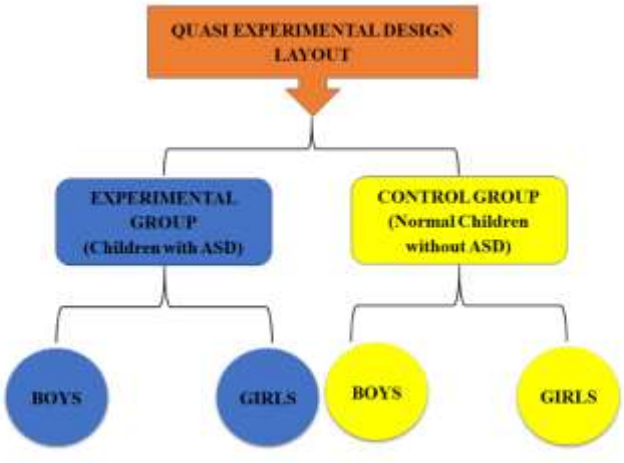


**Fig. 3. Layout of the Quasi-Experimental Design.**

**Inclusion/Exclusion Criteria**

In the present study, Children ages 5-12 were included in the study; Children who were diagnosed with ASD and typically developing children used for comparison; Children enrolled in schools and institutions involving children with ASD and typically developing children within (Anonymized); Children with ASD included in the experimental group were required to meet the prescribed diagnostic criteria identified through the Indian Scale for Assessment of Autism (ISAA) and only mild to moderate level ASD children were included in this study; Children with severe intellectual disabilities or significant comorbid conditions were excluded from participation.

**Setting**

The present study was carried out in educational institutions located in Amritsar district, Punjab, India. Special, inclusive and regular schools for children with ASD and typically developing children were selected. The intervention was carried out in the selected schools, one-on-one with each child in the experimental group for a 21-day period with mutual work of both special educators of the schools and the investigator of the study. The duration of each session per child was 5-10 minutes. The implementation of the GrowAble mobile app-based intervention was conducted on one on one basis by the special educators of the selected schools along with the investigators of this study.

**Tools used in the Study**

*GrowAble Mobile Application.* The most important intervention tool in the present study was the GrowAble (GA) mobile application, a structured, child-centred digital intervention specifically developed to improve digital competence of children with ASD. The application was developed as an educational approach and pedagogically grounded intervention platform, based on the inclusive education, digital learning and developmental appropriateness concepts for children aged 5-12 years. Refer to supplementary materials **APPENDIX-C** (figures 5 and 6) for various interfaces of the Growable mobile app along with the details.

*Digital Competence Scale.* For the present study the investigator created a Digital Competence Scale to evaluate the digital competences of children with ASD. The need for the development of the scale arose due to the paucity of culturally relevant and developmentally appropriate instruments and the lack of dimension specific tools to evaluate the child's digital competence in the Indian educational context with people with ASD. The scale was developed following the Digital Competence Framework for Citizens

(DigComp), two dimensions selected include information and data competence and safety. The information & data literacy dimension encompassed the skills of browsing, searching, filtering, and managing information, while the safety dimension covered sub skills related to device safety, privacy, and health and wellness.

The Digital Competence Scale was developed through scientifically organized process of planning, designing, making of the items, expert review, initial try-out, item analysis and reliability and validity determination. The item analyses were conducted to determine the appropriate items for the final draft of the scale, using difficulty value and discrimination index calculations. 32 items remained in the final form of the instrument on the basis of statistical analysis and expert suggestions (refer to supplementary materials **APPENDIX B** for digital competence scale.

A three-point Likert scale of "Always," "Sometimes," and "Never" was used for the final scale. The answers were given the values of 2, 1 and 0, with the latter value representing a higher level of digital competence. The final scale was designed to have three points: Always, Sometimes and Never. The answers were awarded a score of 2, 1 and 0 for each answer, respectively, where 2 was the highest level of digital competence, 1 the medium level, and 0 the lowest level. The reliability and validity were determined to ensure the scientific standard of the instrument. Cronbach's alpha method was used to estimate the reliability of the Digital Competence Scale, and the result was 0.90, which means that the scale has excellent internal consistency. The face and content validity of the instrument was obtained through expert assessment by experts in education, special education and digital learning. The experts confirmed that the selected dimensions and sub-skills of digital competence are well represented on the scale and that it is suitable for children with ASD.

**Statistical Techniques Used in the Study**

Descriptive statistical measures were used to describe and summarize the characteristics of the data collected. Moreover, skewness and kurtosis were computed to check the normality of data distribution. The normality test showed deviations from normal distribution and so non-parametric techniques of statistics were used for further analysis (refer to supplementary materials **APPENDIX-A** (Tables 1-12 and Figures 1-4) for normality test data. A non-parametric test, the Mann-Whitney U test, was used to analyze the significance of differences in the dimensions of digital competence for the experimental group and the control group.

This test was used specifically to compare:

(i) pre-test scores of the experimental and control groups, and (ii) post-test scores of the experimental and control groups.

**Community Involvement Statement**

The present study involved collaboration with special educators, school administrators, and parents of children with Autism Spectrum Disorder (ASD) and typically developing children during the implementation of the intervention. Feedback from special educators and rehabilitation professionals was considered during the development and refinement of the GrowAble mobile application to ensure its developmental appropriateness, usability, and relevance for children with ASD and typically developing children. Parents and school authorities were informed about the objectives and procedures of the study, and participation was undertaken only after obtaining voluntary consent.

## RESULTS

The two hypotheses developed for the study to assess the impact of the GrowAble mobile app-based inter-

vention on digital competence in children with ASD are addressed by the results. In order to assess differences in digital competence and ascertain whether the intervention helped close this gap after the intervention period, the study included an experimental group of children with ASD who received the intervention and a control group of typically developing children.

**Pre-Test Comparison of Digital Competence between Experimental and Control Groups**

The following null hypothesis was tested:

$H^{01}$: There is no significant difference between the experimental and control groups in pre-test scores of digital competence (information and data literacy and safety dimensions).

The descriptive statistics of the pre-test scores of digital competence for the experimental and control groups are presented in Table 3.

**Table 3 Descriptive Statistics of Pre-Test Scores of Digital Competence**

| Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| **Dimension** | **N** | **Mean** | **Std. Deviation** | **Minimum** | **Maximum** |
| Information and Data Literacy | 60 | 17.97 | 13.396 | 1 | 34 |
| Safety | 60 | 18.33 | 13.229 | 1 | 34 |
| Group | 60 | 1.50 | .504 | 1 | 2 |

As presented in Table 3, the mean scores for the dimensions of information and data literacy, and safety, suggest that a variety of baseline levels of digital competence among the participants. The Mann–Whitney U test was used to analyze the distribution of mean ranks for the experimental and control groups to further investigate the group-wise differences. Table 4 shows the mean rank distribution.

**Table 4 Mean Ranks of Pre-Test Scores of Digital Competence**

| Ranks | | | | |
|---|---|---|---|---|
| **Dimension** | **Group** | **N** | **Mean Rank** | **Sum of Ranks** |
| Information and Data Literacy | Experimental Group | 30 | 15.50 | 465.00 |
| | Control Group | 30 | 45.50 | 1365.00 |
| | Total | 60 | | |
| Safety | Experimental Group | 30 | 15.50 | 465.00 |
| | Control Group | 30 | 45.50 | 1365.00 |
| | Total | 60 | | |

As can be seen from Table 4, in the pre-test stage, the difference in the mean rank score of the experimental group and the control group showed the control group had a higher score for both dimensions of digital competence. The Mann–Whitney U test was used to conduct a further statistical analysis to determine the significance of these differences. Table 5 shows the results of the test.

**Table 5 Mann-Whitney U Test for Pre-Test Scores of Digital Competence**

| **Test Statistics** [a] | | |
|---|---|---|
| **Dimension** | Information and Data Literacy | Safety |
| **Mann-Whitney U** | .000 | .000 |
| **Wilcoxon W** | 465.000 | 465.000 |
| **Z** | -6.696 | -6.685 |
| **Asymp. Sig. (2-tailed)** | .000 | .000 |

Table 5 showed that the obtained values for information and data literacy and safety were lower than 0.05, which means it had statistically significant differences between pre-test scores of digital competence of experimental group and control group. Figure 4 depicts the comparison of the mean pre-test results, according to the two dimensions of the digital competence. The results indicate that the ASD children showed earlier deficits in digital competence in the domains of information and data literacy and safety compared to the TD children. These baseline differences serve as an indication of the need for systematic and focused digital interventions to foster acquisition of critical digital skills for children with ASD. Hence, the null hypothesis which claimed there was no significant difference between the experimental and control group in their pre-tests scores on digital competence was rejected.

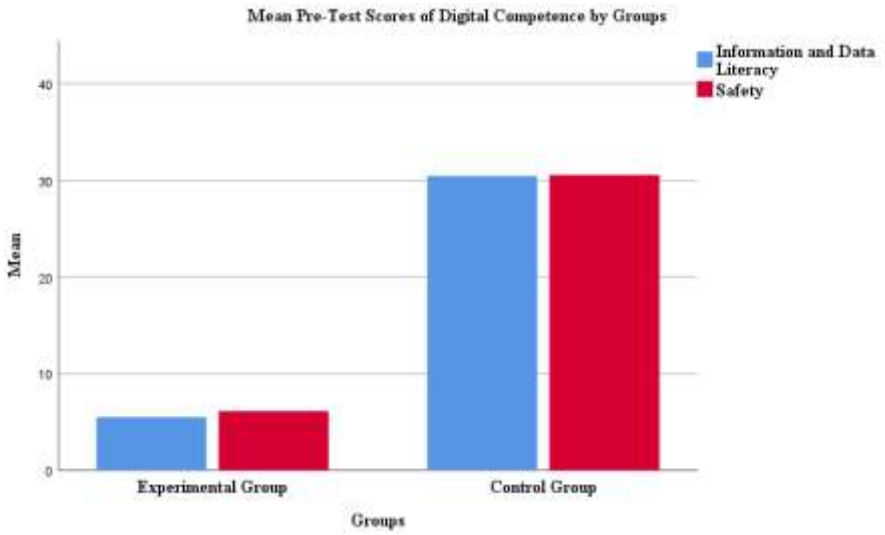


**Fig. 4 Clustered Bar Graph of Mean Pre-Test Scores of Digital Competence (Information and Data Literacy and Safety) for Experimental and Control Groups.**

**Post-Test Comparison of Digital Competence between Experimental and Control Groups**

The following null hypothesis was tested:

$H^{02}$: There is no significant difference between the experimental and control groups in post-test scores of digital competence (information and data literacy and safety dimensions).

The descriptive statistics of the post-test scores of digital competence are presented in Table 6.

**Table 6 Descriptive Statistics of Post-Test Scores of Digital Competence**

| Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| **Dimension** | **N** | **Mean** | **Std. Deviation** | **Minimum** | **Maximum** |
| Information and Data Literacy | 60 | 26.63 | 3.130 | 19 | 33 |
| Safety | 60 | 28.50 | 2.920 | 19 | 32 |
| Groups | 60 | 1.50 | .504 | 1 | 2 |

It can be seen in Table 6 that there was improvement at the post-test stage in the mean scores of digital competence in both dimensions. The relatively lower standard deviation values also indicate more uniformity of participants' performance after the intervention period. Mean rank scores were compared between the experimental group and control group using the Mann–Whitney U test in order to explore the differences more specifically. Table 7 shows the mean rank distribution.

**Table 7 Mean Ranks of Post-Test Scores of Digital Competence**

| Ranks | | | | |
|---|---|---|---|---|
| **Dimension** | **Groups** | **N** | **Mean Rank** | **Sum of Ranks** |
| Information and Data Literacy | Experimental Group | 30 | 30.50 | 915.00 |
| | Control Group | 30 | 30.50 | 915.00 |
| | Total | 60 | | |
| Safety | Experimental Group | 30 | 30.50 | 915.00 |
| | Control Group | 30 | 30.50 | 915.00 |
| | Total | 60 | | |

For the information and data literacy and safety dimensions, as shown in Table 7, all the mean rank scores were equal for the experimental and control groups. This suggests that the children with ASD achieved similar performance as children who do not have autism after the intervention. These differences were further analyzed statistically by Mann Whitney U test. The results are shown in Table 8.

**Table 8 Mann-Whitney U Test for Post-Test Scores of Digital Competence**

| Test Statistics[a] | | |
|---|---|---|
| **Dimension** | Information and Data Literacy | Safety |
| **Mann-Whitney U** | 450.000 | 450.000 |
| **Wilcoxon W** | 915.000 | 915.000 |
| **Z** | .000 | .000 |
| **Asymp. Sig. (2-tailed)** | 1.000 | 1.000 |

Table 8 shows that the significance values for both dimensions of the study were above 0.05 indicating that there was no statistically significant difference between the post-test scores of the experimental and control groups in both dimensions. The results indicate that participants in the ASD group in the experimental condition performed at a similar level after using the GrowAble mobile app-based

intervention as the participants in the control condition who were typically developing children. Figure 5 shows the means for the post-test on the various dimensions of information and data literacy and safety. From the interpretation of the post-test results, a significant increase in the digital competence of children with ASD can be seen when compared with the pre-test results. Findings at the pre-test stage showed that the experimental group had significantly lower levels of digital competence, but there were no significant differences at the post-test stage indicating that the intervention was meaningful in narrowing the competence gap between the two groups at the beginning. These findings indicate that the GrowAble mobile app-based intervention was effective in enhancing competencies related to information and data literacy and digital safety among children with ASD. The intervention helped the students in the experimental group to achieve a level of digital competence similar to that of their TD peers. Thus, the null hypothesis: There is no significant difference between post-test scores of the experimental and control group was accepted.

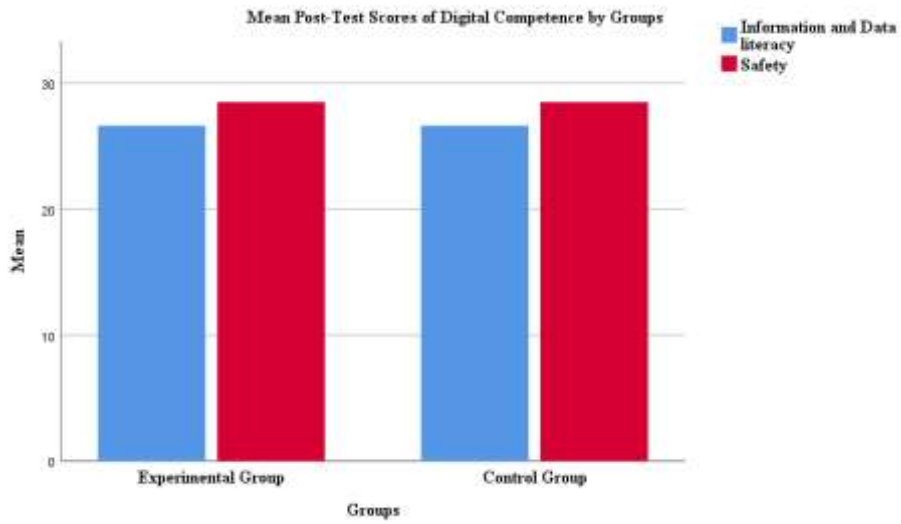


**Fig. 5 Clustered Bar Graph of Mean Post-Test Scores of Digital Competence (Information and Data Literacy and Safety) for Experimental and Control Groups.**

## DISCUSSION

Based on these findings, it can be concluded that these interventions helped significantly to increase the digital competence of children who have ASD, and to narrow the initial digital competence gap between these groups in the first place. Lower pre-test performance of children with ASD may relate to problems with adaptive functioning, information processing, attention regulation and safe interaction with digital environments. Children with ASD are often exposed to digital technologies, but in order to use digital platforms in a meaningful and responsible way, structured guidance and systematic learning opportunities are needed. The results confirm that simply providing technology is not sufficient for children with ASD to develop digital competence.

The results were significant after the intervention, suggesting that the GrowAble mobile application offered to children a developmentally appropriate digital learning environment that was effective and appropriate. The consistent activities, visual aids, practice opportunities, and feedback provided within the application could have helped with engagement and developing the skills of browsing, searching, filtering, managing information, and safe digital use. The results align with previous research indicating structured,

visual and technology-mediated learning environments are beneficial for children with ASD (Grynszpan et al., 2014; Stasolla et al., 2017; Zhang et al., 2019; Gopal et al., 2020; Khasawneh, 2023; Gallud et al., 2023; Urrea et al., 2024; Kauts & Rather, 2025a; Kauts & Rather, 2025b).

The study results further highlight that mobile application (app)-based interventions can help build skills that go beyond just functional technology use to responsible, safe digital citizenship. Improvement on the safety dimension indicates that if competencies in device safety, privacy, and healthy digital use are explicitly taught through guided intervention activities, children with ASD can become aware of these competencies. This is especially important in the current school settings where digital engagement is becoming more and more critical to learning and living.

The present study is an important contribution in focusing on the dimension-specific digital competence development among children with ASD. Although there is an existing body of knowledge on AT in the field of communication skills, social interaction and behavioral interventions, there has been comparatively little focus on the aspects of information and data literacy and safety. The present study, which specifically addresses information and data literacy and safety, is part of an effort to broaden the notion of digital competence in special and inclusive educational contexts. The results of the study confirm the effectiveness of the GrowAble mobile app intervention, and offer empirical support for the effectiveness of the intervention in improving digital competence among children with ASD within selected dimensions and sub skills focused. The research underscores the promise of structured, and developmentally appropriate, digital interventions in fostering meaningful digital engagement and inclusive participation in today's digital learning contexts.

**Implications**

This study's results suggest the possibility of using structured, mobile app-based interventions as a means of fostering the development of digital competence among children with ASD. For children with ASD, the improvement of information and data literacy measures and safety with digital technologies indicates that meaningful competencies can be achieved in accessing, managing, and safely interacting with digital technologies with developmentally appropriate instruction, and with help of technologies which are multisensory like the Growable mobile app. The study thus reaffirms the need to shift away from the access to technology and towards "guided and purposeful development of digital competences in special and inclusive education settings. The results have implications for teachers and special educators as structured mobile applications with visual supports, audio instructions, immediate feedback and scaffolded learning activities can be effective to use as a supplement to digital learning with children who are affected by ASD. The study also underscores the need to explicitly teach safe and responsible digital practices, especially as digital participation becomes increasingly a part of education and functioning in daily life. Furthermore, the study will make a significant contribution to the larger conversation about inclusive digital education, highlighting the need for accessible and learner-centred digital interventions for children with diverse learning needs. In this context, the results are consistent with the goals of the National Education Policy 2020, which aims to place equitable access to digital learning opportunities and inclusive educational practices at the forefront. The results of the study therefore put forward preliminary evidence for the inclusion of structured digital competence interventions in educational environments of children with ASD.

**Limitations, and Future Directions**

However, the results of this study should be interpreted with some of the limitations mentioned below in mind. The study was conducted in selected educational institutions of Amritsar district in Punjab and a limited number of students (n=30 EG, n=30 CG) participated in the study; this may limit the generalizability of the findings. Moreover, there had been no opportunity to assess the long-term retention and sustainability of the improvements in digital competence observed during the intervention period, as the period was only 21 days long keeping in view the selected dimensions and sub skills focused. Another important consideration is associated with the quasi-experimental design of the study. The control group was composed of typically developing children to be used primarily as a developmental reference group for comparative analyses. Hence, care must be taken when interpreting the findings in the light of the study design, since the groups were not clinical samples of equal size. Moreover, the study concentrated on two aspects of digital competence: information and data literacy as well as safety, which were not considered in other dimensions covered by wider digital competence frameworks. Future studies could use more diverse and larger samples in other educational and geographical contexts to enhance generalizability of results. Long-term studies measuring the impact of digital interventions with children with ASD on the long term would also be of significant value in terms of sustainability of digital competence development. In addition, other dimensions of digital competency could be examined as well as various types of technology-enhanced interventions to determine the most effective interventions to support inclusion and digital learning for children with developmental differences.

## CONCLUSION

This study showed that the GrowAble mobile app-based intervention proved to be effective in improving digital competence in children with ASD for both information and data literacy and safety. Compared with typically developing children, children with ASD had lower levels of digital competence at the beginning of the study, but after the intervention, significant gains were seen, such that at the end of the study, there was no difference between the two groups. The results indicate that the structured, visual and developmentally appropriate digital interventions are meaningful to children with ASD in their development of digital competencies to access, manage and safely engage with digital technologies. The study thus underscores the possibilities of guided mobile application-based learning interventions as assisting tools for enhancing digital inclusion and participation of children with ASD in today's educational environment. In conclusion, the study brings empirical evidence to the ongoing research on inclusive digital education and helps to strengthen the pedagogical approach towards inclusion of children with ASD in digital learning by suggesting pedagogically structured digital learning opportunities that are guided by children's learning needs.

**Acknowledgments**

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