NEW MONITORING

GUIDELINES TO DEVELOP INNOVATIVE ECEC TEACHERS CURRICULA

ICT Tools for ASD Children

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Country-specific answers and Pilots implementation: NeMo Partnership

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ICT Tools for ASD Children

Introduction

Over the last decade, advances in information and communication technologies have opened innovative and promising scenarios for clinicians to improve both the identification and treatment of young children with autism spectrum disorders (ASD). Such solutions may be further used to help clinicians (and other stakeholders) improve early screening of ASD by allowing them to monitor young children's behaviours in clinical settings as well as in their natural environments.

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Introduction

Over the last decade, advances in information and communication technologies have opened innovative and promising scenarios for clinicians to improve both the identification and treatment of young children with autism spectrum disorders (ASD). Such solutions may be further used to help clinicians (and other stakeholders) improve early screening of ASD by allowing them to monitor young children's behaviours in clinical settings as well as in their natural environments.

The elements of innovation are included in the features related to the tool:

- **Establish conditions for effective participation of educational systems centres, educators and students in the research.**
- **Design prototype monitoring and learning curriculum using off-the-shelf ICT devices and interface software which addresses a range of cognitive abilities and transferable skills, making use of the prototype pedagogy employing ICT;**
- **Implement a structure and reliable ICT-based procedure to apply the Unified monitoring ECEC system;**
- **Design sketch for students engaging learning scenarios – ICT-based activity as an integrated part of the curriculum;**
- **Trial deployment and evaluation of primary case learning scenarios;**
- **Pilot test of the NEMO pedagogy within the target group in the partners' countries.**

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Introduction

The development of the ICT toolkit was undertaken following three consecutive steps:

1 Review of the available evidence to understand the current use of digital ASD screening approaches and tools;

2 Cross-country context analysis involving NEMO partners to explore resources available in the different ECEC settings to implement an ICT toolkit;

3 ICT toolkit design, development, and implementation to test the developed ICT toolkit in real ECEC settings and collect feedback on its potential usefulness and impact.

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2. Review of the available evidence

2.1 Background

Autism spectrum disorder (ASD) is a category of neurodevelopmental disorder characterized by persistent deficits in social communication and social interaction across multiple contexts as well as restricted, repetitive patterns of behaviour, interests, or activities [1]. The care and social needs of preschool children with ASD (typically up to six years of age), in particular, are significant [2,3], usually extend to parents and siblings [2,4,5], and require substantial community resources [2,6,7]. In response to these needs, early detection of ASD has become a priority for primary care and other community settings [8] to provide early intervention services and to improve outcomes [2,9].

Timely (i.e., early) identification of ASD may be achieved by implementing screening methods and instruments that allow health and other professionals (e.g., social care, educators) for a rapid and relatively inexpensive evaluation of this condition in young children [10]. Screening measures that are suitable for use to identify ASD are already available and can vary by format (e.g., parent-report versus direct observation), scope, and target population [11]. With regard to the scope of the screening instruments, "broadband" screens cover multiple developmental domains, while "narrow" screens cover only those signs and symptoms specific to the condition of interest [11,12]. With regard to the target population, screening instruments can be used to conduct universal population-wide testing (also referred to as "universal screening" or Level 1 screening) or to identify possible signs of ASD in high-risk populations, such as siblings of children with ASD or those referred for speech or other developmental concerns to community pediatric services (also referred to as Level 2 screening) [12,13]

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2. Review of the available evidence

2.1 Background

A number of relevant systematic reviews have examined the use of screening instruments for the identification of ASD in pediatric populations (0-6 years; see [13,14] for an overview of recent systematic reviews). Current evidence suggests that the most used and reliable instruments available to clinicians (e.g., paediatricians; developmental/child psychologists, child psychiatrists) are in the form of questionnaires, checklists, or observation scales where parents or clinicians are required to report/observe overt behavioural signs of ASD (e.g., limited smiles, eye contact) [11]. Advantages of these approaches have been extensively recognized and include high predictive values, ease of use, speed of administration, and limited or no specific administration/scoring training [13,14].

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2. Review of the available evidence

2.1 Background

Notwithstanding the advantages and the widespread implementation of these instruments in primary and community care settings as well as specialized services [15], screening instruments are still underused in routine clinical practice because of a number of challenges, such as lack of time, disruption of workflow, lack of familiarity with screening tools, difficulty with scoring, as well as lack of office-based systems for making referrals and monitoring outcomes (for an overview see [9]). As a consequence of these challenges, despite the possibility of reliably diagnosing ASD in children during the first two years of life [2,12,16,17], current evidence reports that the diagnosis remains delayed in many children [18–20]. For instance, in a recent survey involving 1223 families and 760 professionals in 14 European countries [18], only 3.1% of the parents reported having noticed problems after responding to a specific ASD screening survey. In addition, the average age at diagnosis was 36.4 (SD = 17.7) months, with most diagnoses occurring between 32 and 46 months. In light of this evidence, it has been suggested that more effective screening strategies are needed to reduce the proportion of children who receive a late diagnosis or remain undetected [14,21,22]. Specifically, screening strategies are needed that (a) can reduce the workload of clinicians, (b) can be easily implemented within routine clinical practice, and (c) are psychometrically sound.

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2. Review of the available evidence

2.1 Background

Over the past decade, advances in information and communication technologies (ICT) have opened innovative and promising scenarios for clinicians to improve both identification, treatment and support (e.g., [23,24]) of children with ASD. Such solutions may be further used to help clinicians (and other stakeholders) improve early screening of ASD in that they may allow them to monitor young children's behaviours in clinical settings as well as in their natural environments [25].
This report is aimed at providing a picture of the different technology-based solutions to screen for ASD reported in the literature since 2010. This starting date was chosen as it represents the period when most of the current mobile devices (e.g., touch-screen devices) were first introduced in the market [26]. For the scopes of the present study, we use the term "technology" to refer to any ICT-based product, either mainstream (e.g., smartphone, tablet) or emergent (e.g., robots), that was tested for the purpose of screening for ASD.
Accordingly, our objectives are to review studies that implemented technological solutions specifically developed to screen for ASD in clinical practice, laboratory settings, at children's homes, or in community settings, and to determine the level of development (maturity) reached by those solutions, as well as their expected contribution in supporting ASD screening practices. This review focuses on both Level 1 and Level 2 screeners. While Level 1 screening tools may be used to identify children at risk of ASD in the general population, Level 2 screeners are mainly used to distinguish between children with signs of ASD and those with other developmental concerns (e.g., language disorders, intellectual disability, other neurodevelopmental disorders).

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2. Review of the available evidence

2.1 Background

In this view, screening for ASD may be conceived as a multistep process, according to which children who fail a Level 1 screening would require a secondary (i.e., Level 2) screener before being referred to a more comprehensive and diagnostic assessment process [12,13,27] Providing such a comprehensive overview of the literature (including both levels of ASD screening) was thought to be useful to guide researchers and professionals in their choice of technology options in daily practice, as well as to stimulate their research initiatives aimed at adding essential evidence about technology-based ASD screeners.

To this end, a systematic search was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) reporting guideline recommendations to identify studies reporting on commercially available ICT solutions or assistive technology products for screening children aged 0–6 years for ASD.

The review identified 28 studies that used mainstream or adapted information technologies to screen children up to 6 years for ASD (see Table 1, Appendix 1). The methodology, as well as the results of the systematic review conducted, are reported elsewhere[1]. In this document, we provide only a concise overview of the key findings.

[1] https://doi.org/10.3390/children8020093

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2. Review of the available evidence

Types of Technologies Used

The studies included in the review involved four main interface modalities, namely (a) natural user interface (NUI), (b) PC or mobile, (c) wearable, and (d) robotics. Figure 1 illustrates the frequencies of the different interfaces used within each category.

The former category (i.e., NUI) included 11 papers. Of these, five papers involved the use of eye trackers, two studies used voice-based recording systems, two studies employed face recognition to detect facial expressions, one paper involved motion recognition using touch screen sensor technologies, and one paper tracked pupil diameter.

The second category (i.e., PC or mobile) included 16 papers, of which 11 papers reported on the use of computerized solutions (PC or mobile platforms) to administer parent-reported questionnaires, and seven papers employed screening tools in which videos were collected from or showed via parents' mobile/PC devices.

The third category (i.e., wearable) included two papers that used wearable sensors to track the kinematics of children's movements while they were performing specific reaching and grasping movements.

The fourth category (i.e., robot) included one paper that reported on the use of a humanoid robot to assess joint attention skills.

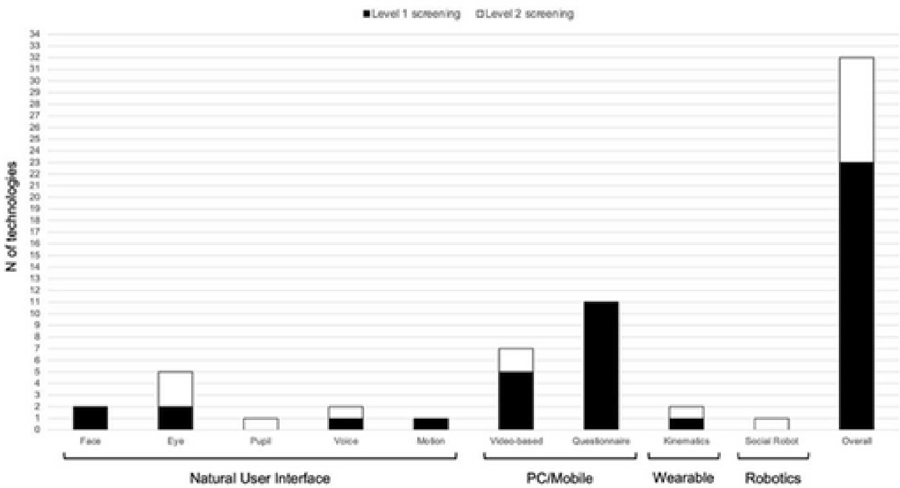

Figure 1. Frequency of technologies used in the papers included grouped according to interface category.

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2. Review of the available evidence

Screening Level

The majority of the papers included in the review (71%; n = 20) involved the use of L1 screening tools. A detailed analysis of the differences between the two screening approaches according to relevant study characteristics (e.g., target population; type of interface used) was not performed because of the relatively low number of L2 papers. However, it should be noted that all papers involving parent-reported questionnaires (n = 11) focused on the L1 screening approach. In contrast, papers involving L2 screening tools were mostly focused on using objective screening measures such as eye-tracking (n = 3), audio recording (n = 1), or kinematics (n = 1). The identified papers were grouped according to the different age ranges of the populations involved. Detailed descriptions of each study are provided in Table 2 (Appendix 1).

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2. Review of the available evidence

Technology Maturity

About half (57%; n = 16) of the papers identified reported on the use of the screening tools were classified as reporting on a Functional Prototype (see Figure 3). Of these prototypes, 10 (62%) were L1 screening tools. Similarly, of the papers reporting on technologies classified as publicly available (n = 12), the majority (92%; n = 11) reported on L1 screening tools. Almost all the screening tools classified as publicly available (n = 10) were PC/Mobile interfaces used to administer parent-reported questionnaires for L1 screening. In contrast, functional prototypes were mostly represented by NUI interfaces (56%; n = 9), of which five involved the use of eye trackers.

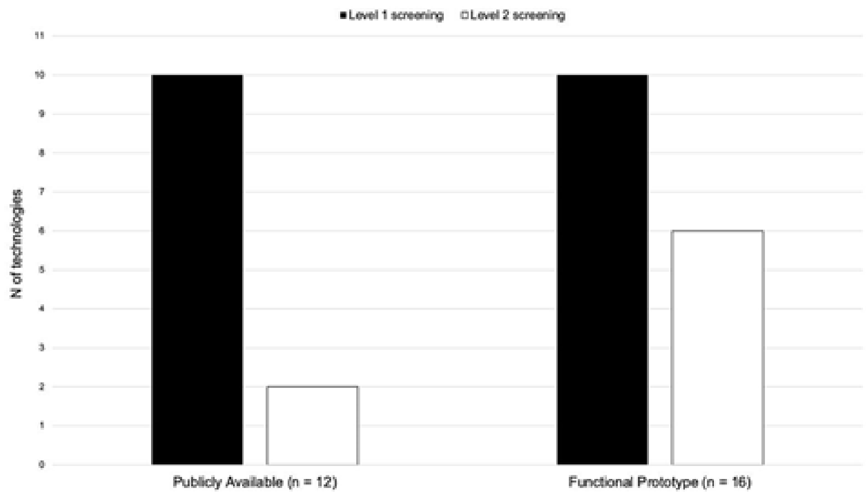

Figure 2. Papers included in the review are grouped according to maturity and screening levels.

2. Review of the available evidence

Psychometric Properties

Table 2 (Appendix 1) reports key information on the psychometric properties of the screening tools assessed in the papers identified. Five studies reported all the four metrics considered relevant for a screening tool, and 18 papers reported at least one of such psychometric metrics or provided information on accuracy in detecting the risk of ASD. Of the papers reporting psychometric information (n = 23), eight papers reported sensitivity and specificity values equal to or over 75%. It should be noted, however, that sensitivity values below this threshold may be not indicative of poor psychometric properties, as the tool may be reliable in detecting specific ASD subgroups.

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2. Review of the available evidence

2.2 Implications for NEMO

Prospective identification of early signs of ASD is widely considered a priority to ensure that children at risk of this condition have timely access to specialized services and interventions. This review aimed to provide NEMO's partners with an overview of the technologies available to support them in the identification of overt behavioural signs of ASD in children up to six years of age. Overall, the solutions identified varied greatly in terms of screening modalities (e.g., questionnaires, behaviour observations), type of interface used (e.g., tablets, eye tracker), the granularity of behavioural indicators used to estimate the risk for ASD (e.g., from subtle eye movements to behaviourally defined clinical symptoms), intended technology users (e.g., parents, clinicians), and age ranges covered by the screening tools developed. Notwithstanding such variability, psychometric information point to considering available technologies as promising support in clinical practice to detect early sign of ASD in young children. In light of these findings, some considerations may be put forward.

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2. Review of the available evidence

2.2 Implications for NEMO

First, one of the main barriers to ASD screening seems to be implementing such activity within routine clinical practice due to lack of administration or scoring time. The literature identified in the current review suggests that the administration and the scoring of either existing (e.g., M-CHAT) or newly developed parent-reported questionnaires can be automated through machine learning (ML). Such ML-based solutions can be implemented within the EHR of specific primary care or specialized services (e.g., CHICA), and are effective in reducing the burden on care staff. Specifically, the evidence reviewed indicates a rapid increase in the number of children screened for ASD during the visits. Despite such encouraging results, however, it remains unclear whether clinicians would take advantage of this automated approach to screening.

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2. Review of the available evidence

2.2 Implications for NEMO

Second, several mobile solutions have been developed that allow data collection on children's behaviours in non-clinical settings (e.g., home). The most affordable and effective solutions include the use of smartphones to record videos of children in their daily contexts which are subsequently analyzed (i.e., scored) by expert clinicians. In these studies, homemade videos could be further supplemented by short questionnaires to improve the accuracy of the screening process. Alternatively, others substituted text-based with video-based questionnaires to enable detection of ASD in infancy and clearly showed that video can be used to improve parent reporting of early development. Together, mobile-based solutions may be considered a strategy to (a) reduce the burden on health services, (b) increase the number of screened children, and (c) accelerate the diagnostic process. Further research is needed, however, to explore whether these mobile-based screening strategies can be effective also when used in other settings and by other users, such as kindergartens and preschool teachers. Indeed, there are limited screening tools developed for these stakeholders (i.e., pre-school teachers), despite their importance as informants of ASD children's social behaviours compared to their normative peer groups. As mobile, interactive, and smart technologies (e.g., smartphones, tablets, robots) are becoming increasingly available in educational settings to foster children's learning and creativity, teachers can be trained to use them also to contribute to the screening of young children, thus providing valuable in-formation on children's behaviour in socially rich environments (e.g., kindergartens; primary schools).

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2. Review of the available evidence

2.2 Implications for NEMO

Third, encouraging evidence is available on the use of technology combined with ML to detect early signs of ASD through the monitoring and successive analysis of bio-behavioural markers, such as speech, movement and gaze behaviour. In particular, monitoring of eye gaze behaviour by means of an eye tracker resulted in the most used screening strategy to (a) distinguish between children at risk and neurotypical children, (b) perform L2 screening procedures, or (c) identify ASD sub-groups. Overall, current evidence suggests that monitoring of eye gaze should not be considered as a replacement of more traditional screening practices (e.g., parent-reported questionnaires), but an additional source of information about early signs of ASD. As already mentioned, screening is indeed widely considered a multistep process, whereby failing a L1 assessment would require a secondary screener (L2) before initiating a diagnostic process. Likely, based on present findings, we argue that the increased availability of affordable and reliable eye trackers could facilitate the diffusion of this screening strategy in a variety of contexts as L2 screeners. However, more research is needed on (a) the integration of this technology in routine clinical practice, (b) whether the use of eye trackers is acceptable to clinicians, and (c) how the information gathered from the analysis of the eye movement of children can be integrated with the results obtained from more traditional screening tests.

Voice recordings and movement observation, as well as social robots, were also further strategies identified in the present review to screen for ASD in young children. Although promising, however, these emerging technologies may be considered at an earlier stage of development compared to eye tracking.

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2. Review of the available evidence

2.2 Implications for NEMO

Fourth, maturity of screening solutions in terms of technological development was found to be well balanced across maturity levels (i.e., Publicly Available, Functional Prototypes), but highly unbalanced for what concerns the level of screening. Specifically, almost all the solutions included in the Publicly Available category belong to L1 (or universal) screening tools. This is not surprising given that the majority of the L1 screening solutions identified are parent-reported questionnaires which included already validated (and available) tools (e.g., M-CHAT). Based on this finding, it can be argued that the transition from traditional to technology-based screening tools may be primarily based on adaptation from currently available forms of screening strategies (i.e., questionnaires).

Fifth, understanding the feasibility, acceptability, and effectiveness of implementing telehealth assessment is becoming of fundamental importance to cope with the limitations to health services delivery due to either low resources available (e.g., lack of trained staff), or public health emergencies (e.g., coronavirus disease 2019). This approach requires the active involvement of parents who had to elicit target behaviours and collect data to be shared with expert clinicians. Though telehealth assessment resulted acceptable to parents, more research is needed to under-stand the applicability of telehealth assessment to those parents who may experience language barriers or are less confident with technology.

2. Review of the available evidence

2.2 Implications for NEMO

In conclusion, the results of the present review of the literature suggest that technology may be a valuable support for ASD screening. Already validated parent-reported questionnaires may be easily adapted to be administered through mobile platforms to speed up the administration and scoring processes. Commercially available mobile technologies may be used to extend the screening process to children’s life settings (e.g., home, kindergartens). In addition, more sophisticated technologies such as eye-trackers may be considered as a valid supplement to traditional screening measure.

3. Cross-country context analysis

3.1 Overview of the survey methodology

An online survey conducted on Qualtrics has been carried out among ECEC teachers in Italy, Spain, Cyprus, Slovenia, and Sweden to explore the characteristics of the educational contexts in which the ICT toolkit could be implemented. The key information collected through the online survey included (a) experience in ASD teaching (e.g., “Have you ever had in your classroom a child with a diagnosis of autism?”) and screening (e.g., “Have you ever received formal training in recognizing signs of autism in your students?”); (b) ECEC teachers’ attitudes toward technology (e.g., “How would you rate the usefulness of the following technologies for your teaching/educational purposes?” and “Which of the following technologies would you feel more comfortable with if used with children with autism spectrum disorders?”); and (c) Resources available (e.g., “How much do you think would be the budget considering the amount of funding usually available?”).

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3. Cross-country context analysis

3.2 Key results

The full results of the survey are available in full in Appendix 2. In this document, we provide a concise overview of the findings that have been instrumental for the development of the ICT toolkit. In total, 380 ECEC teachers in Italy and 54 pre-school teachers across Spain (n = 10), Cyprus (n = 15), Slovenia (n = 12), and Sweden (n = 11) responded to the survey. Due to differences in the number of respondents across participating countries, descriptive analyses were carried out for Italy separately from the other countries (hereafter, EU).

With reference to teachers' experience with ASD, the percentage of those who did report to have no experience in teaching to ASD students was 54% for EU respondents and 71% for Italian respondents. Half of EU respondents and 60% of Italian respondents, however, reported to have received some training in recognizing signs of ASD. With reference to teachers' attitudes towards technologies, very similar responses were provided by the two groups (see Figure 3), with the Laptop/PC and the mobile devices (i.e., smartphone and tablet) considered the most useful solutions by teachers.

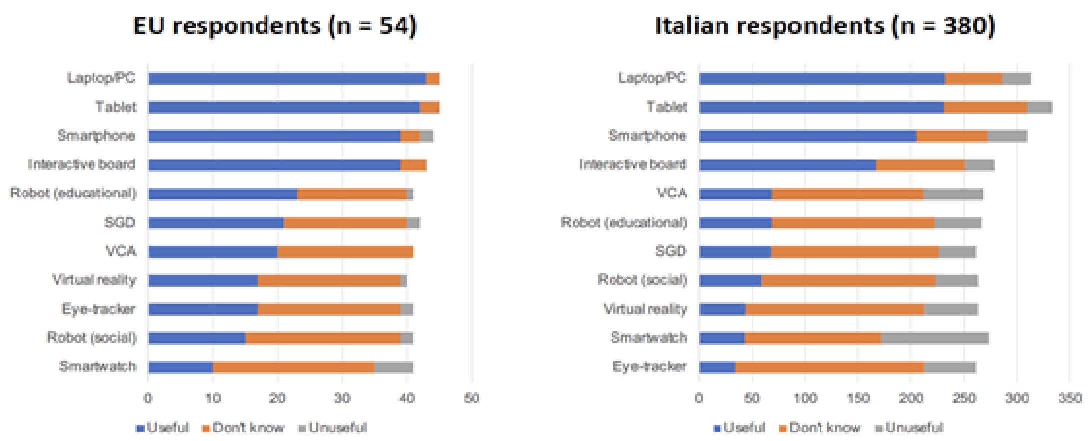

Figure 3. Answers to the question: How would you rate the usefulness of the following technologies for your teaching/educational purposes? (cumulative responses). VCA, voice-base conversational agent; SGD, speech-generating device.

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3. Cross-country context analysis

3.2 Key results

On a similar vein, teachers in the two groups provided also comparable answers to the question about which of the products they would be more confident with in case of ASD, indicating both laptop/PC and tablet in the top positions (Figure 4).

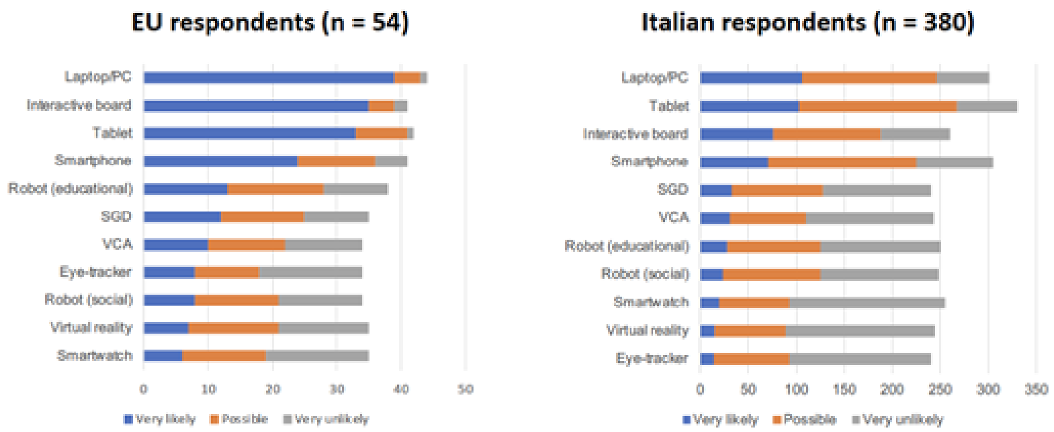

Figure 4. Answers to the question: Which of the following technologies would you feel more comfortable with if used with children with autism spectrum disorders? (cumulative responses). VCA, voice-base conversational agent; SGD, speech-generating device.

Lastly, considering the budget available for the two groups, most EU (43%) and Italian (44%) respondents indicated a range of 50-300 euros as the maximum possible amount of funding they could obtain to buy a digital solution.

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4. ICT toolkit design, development, and implementation

Overall, the online survey confirmed that, across countries, tablets and PCs can be the preferred technological solutions within which implement the toolkit. Furthermore, to be accepted by teachers, the survey stressed that the technologies included in the toolkit must be affordable. Based on these results, a mobile application was adapted to the scope of the current project with a view to provide teachers with both an ASD screening tool and a platform to design teaching activities. After analyzing various technological proposals currently on the market, based on discussions among team members and other stakeholders, it was decided that the central element of the NEMO toolkit would be based on VIVO, a web application that implements an educational network allowing teachers to create custom educational activities tailored on students' needs and keep tracks of student progress. Activities in VIVO are structured in form of task analysis, that represents an effective and widely used educational strategy, commonly used for learning multistep activities, even with people with ASD. Based on VIVO, some extra development was required to improve usability and user experience for the NEMO target group. The resulting app is a forked version of the original VIVO.

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4. ICT toolkit design, development, and implementation

As a screening tool, the first version of the NEMO toolkit was endowed with the EDUTEA questionnaire. EDUTEA is a multi-language teacher-reported questionnaire to screen for early signs of ASD in school settings. The NEMO toolkit has been also conceived as an application to assist pre-school teachers to easily design educational activities for children tailored on their needs. As educational activities we mean both task analysis activities and quiz activities. Teachers have the possibility to keep track of the activities executed by each child and monitoring their progress over time. Furthermore, just like the original version of VIVO, it is possible to share the created activities among other teachers within the same country.

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4.1 - Feasibility study

LThe implementation and testing of the first version of the ICT Toolkit described in the previous section has taken place according to the feasibility study protocol reported in Appendix 3. In brief, a workshop was held by NEMO researchers to train the selected ECEC teacher (or teachers) in the use of the ICT toolkit. Then, the trained teacher was further required to use the Toolkit to conduct the identified educational activities for 4 consecutive weeks.

Within this time frame, it was highly recommended that the teacher used the Toolkit for at least 30 minutes, once a week, so to gain sufficient confidence in its use and being able to provide meaningful feedback at the end of the use experience. At the end of each session of use the teacher was required to complete the Accessible Usability Scale (AUS). The AUS is a brief 10-item scale to measure the usability of a digital product. An example of the scale is available here: https://app.makeitfable.com/AUS. The teacher was provided with the translated version of the AUS through a Google Form.

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4.1 - Feasibility study

At the end of the 4-week experience, teachers were required to answer a brief evaluation questionnaire addressing four main dimensions of use: (1) Usefulness (“e.g., Do you think the NEMO Toolkit may be useful in your daily practice? Please explain why yes or not”); (2) ASD Applications (e.g., “Do you see any possible applications in your daily context in case of children with a diagnosis of ASD?”), (3) Barriers (e.g., “What are the main barriers to its use in your daily context?”), and (4) Improvements (e.g., “What other functionalities would you like to find in this toolkit?”).

All NEMO partners were involved both in the development of the protocol and the testing of the ICT toolkit. A concise summary of the results is provided below for each participating country.

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4.1 - Feasibility study

Cyprus

Implementation of the IO3 workshop

During Phase 1, a first evaluation of the functionality of the toolbox was made in a BETA Testing process, with the participation of one (1) teacher from a private school in Nicosia, Cyprus. The training took place online, on December 15, 2021 and it was coordinated by Lisa Cesario. The coordinator of NEMO in Cyprus, Dr. Katerina Mavrou attended the meeting as well as the other two local researchers of NEMO that are involved in the project (Dr. Chrystalla Papadimitri and Mrs. Marianna Efstathiadou). The training lasted about 2 hours.
Once the teacher familiarized with the NEMO Toolkit and understood its main functionalities as well as areas of applications, she implemented an activity with a 4-year-old child. At the end, she gave feedback on the use of the toolkit to the local NEMO researchers as well as to partners from Italy.

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4.1 - Feasibility study

Cyprus

In preparation for the IO3 local pilot in Cyprus, the local researchers contacted teachers from private early childhood settings for their possible participation in the pilot implementation and evaluation of the NEMO digital toolkit. Five (5) teachers were willing to participate in the program. An online meeting was scheduled, on a date that was convenient for all them, in order to present the NEMO IO3 toolkit. The meeting took place on 13/4/2022 and lasted 1.5 hours. During this time, a brief presentation (attached document 2) was made on the following topics:

- the content and objectives of the NEMO research program
- the NEMO toolkit of IO3 - they were given access to the tool and at the same time we tested the toolkit together in order to familiarize themselves with its functions
- an explanation of the number of activities that should be implemented

Due to the Easter holidays (holidays usually last from 5-10 working days) and the fact they needed 4 consecutive weeks to complete their activities, they were asked to complete all of the activities by 5/31/22. At the end of each activity, which lasted at least 30 minutes, once a week, the teacher was required to complete the Accessible Usability Scale (AUS) through google form. While the activities were implemented by all of the teachers (5), the AUS was completed by only three (3) teachers. The answers given were processed, elaborated and summarized below:

4.1 - Feasibility study

Cyprus

As far as the questions regarding the use of the application and its functionality (Q.1,2,3), the answers given were positive from all participants. More specifically, their answers were "I completely agree" or "I agree". Only in 3 cases, the answers were "neutral". In the same way in Q7 and 8, which also concern the use of the toolkit by people with educational background, they all agree that they could easily use it.
Question 4, had to do with any help that the teachers needed for the functions of the toolkit. Only two responses seem to agree that more explanation was needed in some functions. Nevertheless, all the participants found the various functions of the application logical and compatible with the technology that they had on their disposal.
75% (9 ratings) seem to have taken the time to familiarize themselves with the toolkit before being able to use it effectively (Q. 10). Approximately the same percentage (8 ratings), they felt a lot of confidence and comfort in using the application with the completion of the activities (Q. 9). It is important to mention, that the other 4 ratings did not express an opinion and therefore were neutral in this dimension of the toolkit.

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4.1 - Feasibility study

Cyprus

Evaluation of the pilot phase

At the end of the 4-week experience, three (3) of the five (5) teachers answered a brief evaluation questionnaire addressing four main dimensions of use: (1) Usefulness (2) ASD Applications (3) Barriers, and (4) Improvements. The answers given were processed and summarized below.
For question 1, which asks teachers to evaluate whether the NEMO Toolkit would be useful in their daily professional practice, the answer was unanimously yes. Regarding its use with children diagnosed with Autism Spectrum Disorder, two teachers were positive while one was negative (Q.2).
When asked about the main obstacles to using the toolkit, they all agreed that if you do not have the technology (tablets, pc) then you can not use it. Private schools in Cyprus usually do not have the technology. The teachers used their personal devices for the implementation of the activities.
Finally, in terms of toolkit improvements, they referred to more complex activities that would develop children's metacognitive skills. To sum up, the feedback from teachers on the IO3 toolkit is visibly positive in a general context and in line with the objectives set.

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4.1 - Feasibility study

Italy

Implementation of the IO3 workshop

The workshop took place at a kindergarten close to the municipality of Bologna (Medicina) and involved two teachers working with children above age 3. The AIAS team introduced the teachers to the scopes of the NEMO project and then proceed to show all the functionalities of the app directly on a tablet used. Once the teachers were shown the main functions of the app, they tried to develop activities with the support of the AIAS team members. Due to connection problems, creating the activity took more than expected but eventually, the two teachers managed to create their own educational scenarios on the app. The whole workshop lasted approximately two hours.

The teachers involved in the workshop were skilled in the use of tablet (and digital devices in general), but they never used any digital device for educational purposes. Despite such a lack of experience, the teachers seemed to easily familiarize themselves with the use of the app and its potential. They particularly liked the possibility to use the tablet to train children with ASD in daily tasks, mainly related to hygiene (e.g., washing the hands). The lack of a reliable internet connection in the educational facility, however, was considered a serious barrier for the continuous use of the app and its uptake over a longer period of use.

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4.1 - Feasibility study

Italy

Evaluation of the pilot phase

One teacher used the app for the whole pilot period (4 weeks). She decided to use the app in individual sessions involving one student with suspect ASD, behavioural problems, and developmental delay. Due to organizational challenges, the teacher was able to use the app only once a week to prepare the target activity, that is, supporting the student in washing his hands. As mentioned, unfortunately the teacher had no possibility to try the app involving the student as planned, but she had the possibility to further familiarize with the digital strategy proposed. Overall, as also illustrated in Figure 5, the app was considered easy to use without external support only after a brief training took place. Importantly, the app was considered useful in the pre-school setting and easy to learn also for those with a similar background as that of the teacher who participated in the testing.

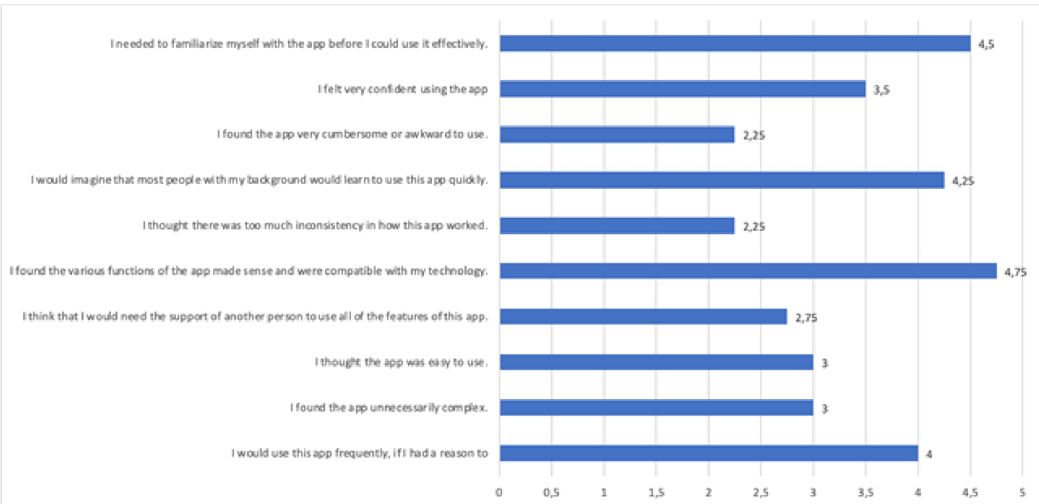

Figure 5. Average answers to items on the Accessible Usability Scale
(across one participant and four time-points). Higher scores imply higher agreement with the statement.

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4.1 - Feasibility study

Italy

Evaluation of the pilot phase

At the end of the testing period, the teacher has been interviewed by one AIAS researcher asking the four debriefing questions mentioned earlier. The key points emerged are summarized below:
Usefulness
The teacher found the app engaging (for her) and potentially for the students using it. It has been considered especially useful in teaching new behaviours and helping teachers stay focused on the tasks.

Children with ASD
The teacher suggested that the app could be used in group activities to help children with ASD stay engaged in social interactions.

Barriers
Internet connection and availability of digital devices (i.e., tablets, smartphones) was considered the main barrier. The interface may also be experienced as too complex for beginner users.

Improvements
Reducing the complexity of the interface emerged as a key improvement.

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4.1 - Feasibility study

Slovenia

Implementation of the IO3 workshop

The workshop was implemented on-site, in a kindergarten, with three preschool teachers who work with children older than 3 years of age. Researchers from the Educational research institute introduced the project, its aims, the NEMO application, its functionalities and its usage (using a Powerpoint presentation and printed handouts). This was followed by a guided practice of developing activities on the app. Each teacher created its own educational activity in the app on the site. All of them used a laptop computer. The training lasted for three hours.

The teachers displayed different digital abilities. The youngest teacher included in our sample had no difficulty in learning how to use the app; while the other two older teachers, possessing fewer digital skills, needed to be guided a little more in the usage of the app. For example, the app did not work on Firefox and one of the teachers did not know she could use another browser. The teachers liked the possibility of including their own context (i.e., pictures of the kindergarten) in the app. One of the teachers involved built an activity based on learning the words of a song by using pictures and a speech synthesizer. Unfortunately, the Slovenian language is not equipped well in this AI/does not work properly most of the time.

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4.1 - Feasibility study

Slovenia

Evaluation of the pilot phase

The teachers were asked to use the app with their students in the classrooms for four consecutive weeks. They reported they used the app both with individuals as well as the whole group. Teachers reported that the app worked better on mobile devices and that quizzes were more useful for them than the activities. At the end of each exercise with the child/ren, they answered a questionnaire Accessible Usability Scale using a Likert-type scale (from 1 = “Strongly disagree” to 5 = “Strongly agree”; see their answers in Figure 6). They reported that the app made sense and that the app is compatible with their technology. They also felt confident when using it and thought it was easy to use. On another note, they did not think they would need additional support to use the app and did not think there was much inconsistency in how the app worked.

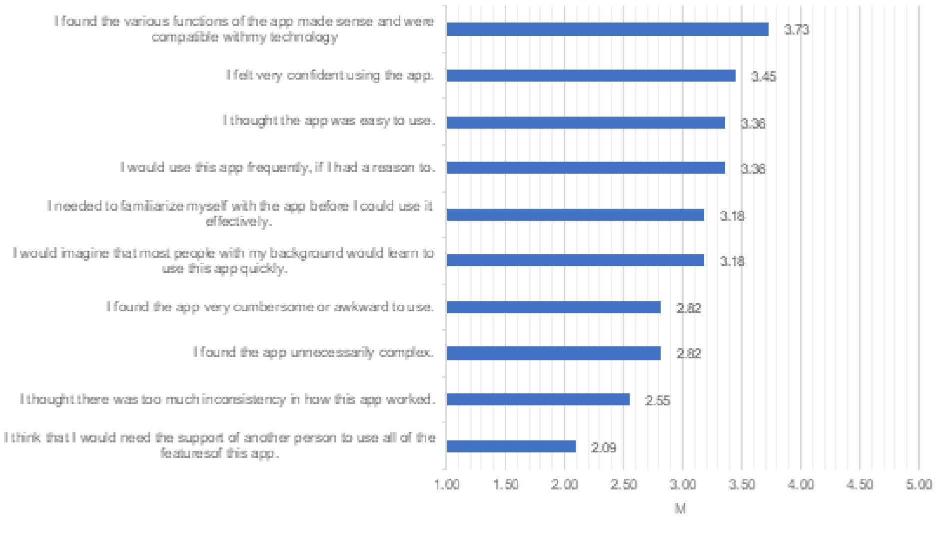

Figure 6. Average answers to items on the Accessible Usability Scale (across three participants and four time-points). Higher scores imply higher agreement with the statement.

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4.1 - Feasibility study

Slovenia

Evaluation of the pilot phase

After the last session, teachers completed the final evaluation, consisting of open-ended questions, where they assessed four main dimensions of the app use: usefulness, ASD applications, barriers and improvements. We provide a summary of their answers below.

Usefulness
The app is very useful, especially when individuals need to reinforce the material(s), for the development of mathematical concepts and spatial relationships. The app should/could not be used with children under the age of 3 years (pictures too small, children like physical photos more).

ASD applications
The app is very useful, especially for children with developmental problems. Furthermore, the app could be more useful than in typical classes, because the groups including children with ASD are smaller.

Barriers
The kindergartens are not as technically equipped as they could be, which would allow for the use of these kinds of apps. Furthermore, if the groups were smaller, it would be easier. It is a great app to work with individuals, separate from others.

Improvements
The function of “recording” would be useful. So that besides the photos, videos could be included and presented to the children.

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4.1 - Feasibility study

Spain

Implementation of the IO3 workshop

The Piloting of the NEMO Toolkit was offered to the School of Child Education “La Encarnacion”, a mainstream 3-6 ECEC service in Ávila (Castilla y León) with special provision and resources for students with Autism Spectrum Disorders. On March 23rd meeting was held with a teacher of a classroom of the last course (5-6 years old), the ‘orange classroom’ where one student with ASD attended the academic course 2022-2023. Cristina Martín Rodríguez, the special education teacher supporting this student in the orange classroom offered herself to participate in the piloting of the NEMO Toolkit. One week later (March 30th) a face-to-face training session was delivered on-site in order to train this teacher about the process to create an account, setting up a student profile, and creating activities, steps and quizzes.

4.1 - Feasibility study

Spain

Evaluation of the pilot phase

The week after, the teacher tried to create an account but reported having difficulties in the functioning of the website, with a never-ending circle in the centre of the screen, so she could not advance in her first attempt. Researchers at AIAS and UV tried to replicate the error unsuccessfully. There was no advance in the next four weeks due to the main teacher of the classroom having Covid which meant an extra workload for the other teachers who substituted her, including Cristina.
In June, a new visit to the school was made by the University of Valencia in order to try to replicate the errors found with new devices running NEMO Toolkit. The errors appeared again and were assumed to be caused by the Wi-Fi network of the School. Finally, the University of Valencia created another profile for the teacher and provided login details so that she could test the Toolkit properly from a different setting. Late in June, the teacher was able to test most functionality of the tool. Despite the initial technical difficulties suffered, the teacher found the tool useful and felt confident using it once the technical difficulties were solved, stressing the need to familiarize herself with the tool before being able to use it effectively.

The teacher highlighted the potential of the tool to foster autonomy through facilitating visual support for task sequences and modelling learning. She considered the tool more appropriate for children aged 5 or older, not so much for younger children due to the implications of screen exposure and the need for adult support to manage it independently.

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4.1 - Feasibility study

Sweden

Implementation of the IO3 workshop

Five pre-school teachers in two different pre-schools took part in the IO3-pilot. These teachers work mainly with children older than 3-years-of-age. The teachers were given general information about the project and the application (app) in advance. At both pre-schools that took part in the IO3-pilot teachers are used to working with digital tablets with the children. The five teachers who were part of the pilot are too varied degree comfortable with using digital technology according to their assessments. Some expressed that they are very comfortable with digital technology and others somewhat comfortable.

A workshop with the teachers was held at each pre-school and lasted 2-3 hours. During the workshop, the app was introduced by NEMO partners from Kristianstad University. The application was presented with hands-on guided instructions on how to use the apps functions. During the workshop, the functions were discussed both from technological and pedagogical perspectives. After the workshop, the teachers were given a written summary with screenshots from the application in the local language which demonstrated the different uses of the app. They were also given two recorded video instructions in the local language where they could watch and listen to how activities and quizzes are created in the app. And they were given access to some examples of activities and quizzes that were already created. This material had been put together by the NEMO partner from Kristianstad University who lead the workshop.

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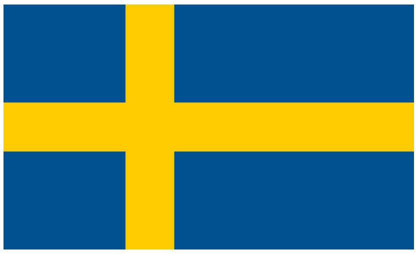
4.1 - Feasibility study



Sweden

Evaluation of the pilot phase

All five pre-school teachers used the application to a varied degree over the evaluation phase between May and June of 2022. They used the application mainly with groups of children and created and used activities that were based on themes or subjects that were of interest to the students or the school, for instance, emotions, recycling, and everyday objects and their uses. The teachers used the app through their digital tablets. All five teachers reported that it was of great importance that the application could be used via a web browser and that it wasn't an application that they had to download. This is due to restrictions by either the local council or the school on what is allowed to be downloaded on school technology such as digital tablets, phones, or computers. These restrictions have to do with GDPR and the need to vet applications, so information is not leaked to unvalidated sources.

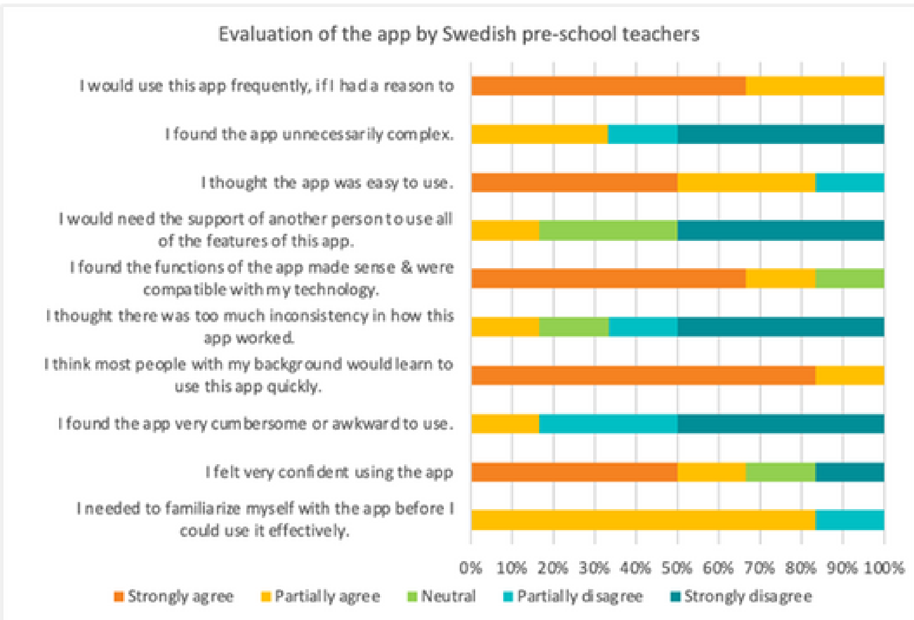


Figure 7. Evaluation of the app by Swedish pre-school teachers.

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4.1 - Feasibility study

Sweden

Evaluation of the pilot phase

At the end of each activity where the app was used with children preschool teachers were asked to answer an Accessible Usability Scale- questionnaire (see answers in Figure 7. Evaluation of the app by Swedish pre-school teachers). Generally, the teachers experienced the app easy to use, cohesive and compatible with the digital technology that they used at the school. They experienced some need to familiarize themselves with the app to be able to use it to its full potential and believe that people with a similar background to themselves would be able to learn to use the app fast.

At the end of the evaluation phase, they answered an open questions questionnaire. Their answers in the final questionnaire in combination with a verbal evaluation with a local project partner from Kristianstad University can be summarized as follows.

Usefulness
The teachers found the app useful in daily activities with children, especially when needing pictures or picture support, communication, and cooperation skills, and to get conversations started on a mutual topic. The possibility to use pictures from the local context was appreciated and teachers could see many possibilities in this feature.

Children with ASD
They could see possible use of the app when working with children with ASD, especially in cases where pictures are of importance.

Barriers
Some teachers felt that there were too many steps in using the app and especially when creating new activities or quizzes.

Improvements
There was a wish for more ready-made activities and to be able to use sound that is compatible with the local language.

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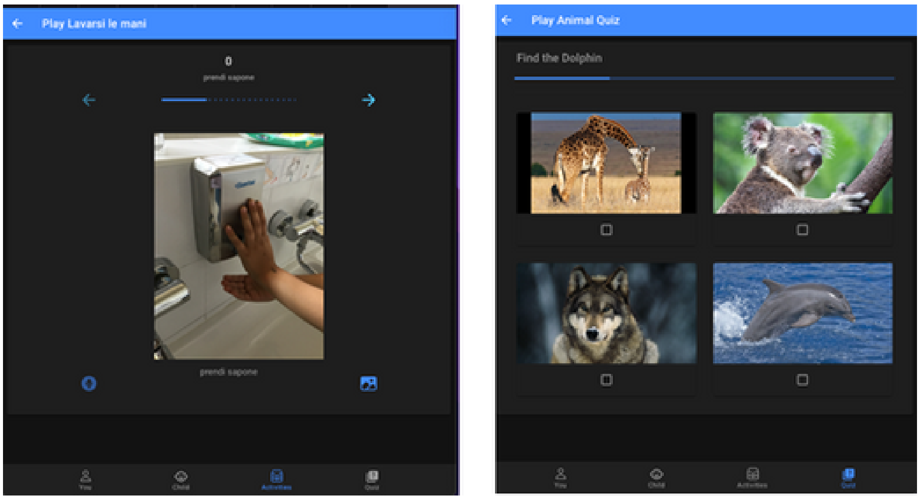
5. Final ICT framework for ASD children

Based on the activities performed within IO3 and described in the previous sections, the first prototype of the NeMo ICT toolkit has been released. Applications belonging to the toolkit have been chosen to provide teachers with both an ASD screening tool and a platform for designing teaching activities. Activities in the toolkit are originally structured in form of task analysis, which represents an effective and widely used educational strategy, commonly used for learning multistep activities. To adapt and improve usability and user experience some extra development was required. As a part of the IO3 Toolkit, there is also the EDUTEA questionnaire. EDUTEA is a multi-language teacher-reported questionnaire to screen for early signs of ASD. The final NeMo ICT toolkit has been also conceived as an application to assist preschool teachers in easily designing educational activities for children tailored to their needs.



F**igure 8.** Types of Activities. On the left side, an example of multi-step activity. On the right side, a quiz activity.

5. Final ICT framework for ASD children

As educational activities, we mean both task analysis activities and quiz activities (Figure 8). Teachers can keep track of the activities executed by each child and monitoring their progress over time. Furthermore, just like the original version of VIVO, it is possible to share the created activities among other teachers within the same country. Further and undergoing developments of the NeMo ICT toolkit are also aimed at including new functionality so that users can easily find new and appropriate apps for the students on the autism spectrum. For doing so, the app is being connected to AppsTEA, a database of nearly 600 useful apps for autism created by project partners. NeMo ICT toolkit will include a 'search box' where ECEC professionals will be able to enter the search topic and the app will retrieve detailed information about the relevant apps for that particular topic.

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NEW MONITORING

GUIDELINES TO DEVELOP INNOVATIVE ECEC TEACHERS CURRICULA

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