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DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

Design & development of application for iOS devices for persons with autism: Theoretical framework & evaluation

Σχεδίαση και ανάπτυξη εφαρμογής σε συσκευές iOS για άτομα με αυτισμό: Θεωρητικό πλαίσιο, μεθοδολογία και αποτίμηση

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DISSERTATION OF

NIKOLAOS GOULIAS

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Περίληψη

Η παρούσα διπλωματική εργασία παρουσιάζει όλη τη διαδικασία σχεδίασης και ανάπτυξης ενός λογισμικού για συσκευές iOS για άτομα με αυτισμό. Πέρα από την οπτική ενός μηχανικού λογισμικού η οποία έχει εφαρμοσθεί σε όλα τα στάδια της ανάπτυξης, έχει ακόμα υποστηριχθεί θεωρητικά στο επιστημονικό πεδίο του αυτισμού. Η διπλωματική αποτελείται από δύο μέρη, πρώτον το συγγραφικό μέρος το οποίο έχει συνταχθεί στα αγγλικά και δεύτερον το προγραμματιστικό μέρος της εφαρμογής με όνομα «Autonomic» η οποία θα είναι διαθέσιμη στο Apple Store. Η εφαρμογή απευθύνεται σε άτομα στο φάσμα του αυτισμού μέσης και υψηλής λειτουργικότητας.

Η αξία ενός τέτοιου εγχειρήματος στηρίζεται σε δύο βασικούς παράγοντες, αρχικά από όλες τις έρευνες που έχουν γίνει στον αυτισμό και υποδηλώνουν τα άκρως ενθαρρυντικά αποτελέσματα της χρήσης κινητών τεχνολογιών και λογισμικού. Επακολούθως, η αποτελεσματικότητα της χρήσης δομημένης διδασκαλίας και προγραμμάτων με εικόνες που αποδεικνύεται από ένα μεγάλο αριθμό ερευνών σε τέτοια άτομα. Τελος το βασικό κίνητρο για την ανάπτυξη αυτής της εφαρμογής αποτέλεσε το γεγονός ότι υπάρχει ελάχιστο ερευνητικό υλικό για λογισμικά σε φορητές συσκευές το οποίο να είναι στοχευμένο για άτομα στο φάσμα του αυτισμού.

Κλείνοντας αυτή την εισαγωγή αναφέρουμε με λίγα λόγια τι θα παρουσιαστεί στα κεφάλαια που ακολουθούν. Αρχικά έχουμε το κεφάλαιο του αυτισμού με τα χαρακτηριστικά και τις θεωρίες – έρευνες αυτού. Έπειτα συνεχίζουμε με την χρήση της τεχνολογίας στον αυτισμό είτε μέσω υπολογιστή είτε μέσω κινητών τεχνολογιών και το επόμενο κεφάλαιο δίνει μία αναλυτική περιγραφή εφαρμογών για tablet που υπάρχουν ήδη παγκοσμίως. Στη συνέχεια ξεκινάει η ανάλυση της εφαρμογής μας «Autonomic» με τα στάδια της σχεδίασης και της ανάπτυξης παρουσιάζοντας όλα τα βήματα που ακολουθήθηκαν και είναι απαραίτητα για μία τέτοια δημιουργία. Τελευταίο και απαραίτητο εργαλείο στην ανάπτυξη ενός λογισμικού είναι η αξιολόγηση αυτού, η οποία έγινε από εκπαιδευτικούς οι οποίοι διδάσκουν παιδιά που βρίσκονται στο φάσμα του αυτισμού, παρουσιάζοντας ωστόσο και τη μεθοδολογία αξιολόγησης και τους βασικούς άξονες αυτής.

Abstract

This dissertation presents the process of designing and developing an application for iOS device for persons with autism. It is not only supported theoretically in the scientific field of autism spectrum disorders but also thoroughly analyzed from the software engineer's point of view. Our creation consists of two parts delineated both in English, the written dissertation and the programmed application called "Autonomic" available for download on the Apple Store. The application is for persons with autism spectrum disorders that are considered to be medium to high functioning individuals.

The value of our accomplishment is denoted by a couple of facts, firstly the studies on autism that show how beneficial technology can be through the combination of mobile technologies and the supportive software. Secondly, the effective usage of visual schedules in helping such people. An ardent motive in devoting our dissertation to that cause is the fact that there are very few existing studies on the usage of mobile technologies and applications towards individuals with autism.

To sum up we depict an abstract of the content of all chapters that follow. Starting with autism and its methodologies and theories, we then pass into how technology is currently used in helping such individuals along with some future prospects. All the worldwide applications for tablets regarding autism constitute the next chapter, followed by an introduction to the development process of our application. Finally, the actual design and development of the "Autonomic" app are presented on chapters 3 and 4, followed by the evaluation of the final product by teachers with a specification in special education and autism.

Contents

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In conclusion, we would like to sincerely thank our families and friends for the constant support, encouragement, and intriguing ideas in order to fulfill our ambition of creating a perfectly developed, scientifically supported, and extremely useful application for persons with autism spectrum disorders.

To our families and friends.

Introduction

The current dissertation presents all stages of the design, development, and the evaluation procedure of an application for iOS devices for persons with autism. It is essential to support the writing part theoretically on the scientific field of autism spectrum disorders and its characteristics in order to implement helpful, innovative, and fully functional software for those individuals. As a result, the main feature of the application is based on the educational method of visual schedules and structured teaching that contribute greatly to the needs of such users. That kind of schedules can be created through a sequential selection of pictures that represent activities from their daily life in a chronological order. Meanwhile, teachers and parents can also use the application to create visual schedules for a class or at home respectively.

To begin with the theoretical framework that is presented on the 1st chapter of the dissertation that depicts all the theories, methodologies, and characteristics of autism spectrum disorders (ASD). In addition, technology can be a contributory factor in helping people with such unique needs thus we present studies that support this fact. Some of the studies show the levels of usability of applications and mobile technologies while others enumerate the computer based efforts that were made in assisting those persons. Finally, some predictions for the future regarding innovation, creativity, and technology are been made to broaden our horizons and think about novel ways to assist people and their families. Worth mentioning is the fact that all revisions and references on autism are up to date, with the most recent to be the "Diagnostic & Statistical Manual of Mental Disorders, 5th Edition, 2013".

On the 2nd chapter, a selection of applications for tablets for persons with ASD are shown in order to make a register of useful software that is currently available worldwide. As the chapter comes to an end, our application called "Autonomic" is introduced along with its basic concept. Consequently, the design and development of the app are shown on the chapter that follows in order to clarify all the implementation phases. The first phase is considered to be an analysis on the requirements of the potential users as well as the systems ones. The design phase is the one that follows in order to come up with the actual graphics and application views that will influence the visual result of the app. The last phase of the implementation process is the actual development of the application for iOS devices

that is presented through some proper programming techniques and methods. Some of these methods are the pair programming by two developers, the agile software development, and finally the programming through separate components that are then consolidated to achieve the final project.

A detailed users manual and some use cases are depicted on the 4th chapter that represents the actual features of the application and helps a potential user to comprehend the proper way of using it. Lastly, the evaluation process follows on chapter 5, which took place in schools of special education for children with ASD and was conducted through the completion of a questionnaire by teachers not only experienced on that scientific field but also aware of the teaching method of visual schedules. In general, all teachers were pleased and amazed with the usefulness, ease of use, and visual result of our application. They also, made lots of comments, especially on how the app would assist them in conducting the daily lesson and how would help children into the classroom or at home with their parents. All that feedback will be the basis of all future improvements and updates of the application due to the fact that it is derived from the actual users that do have the knowledge of exploiting such a scientific tool towards persons with ASD.

To sum up the writing part of our dissertation, we present a conclusions section that enumerates the valuable results from the evaluation process as well as all the future prospects that our application might have. Both negative and positive outcomes of the applications' usage can effectively contribute in improving and updating the software to meet the needs of both individuals with ASD and teachers or parents.

1 Autism

1.1 Autism & Epidemiology

Autism spectrum disorders (ASDs) represent a continuum of neurodevelopmental disorders characterized by impairments in social interaction, and restricted or repetitive interests and behaviors (American Psychiatric Association 2000). The 5th edition of the Diagnostical and Statistical Manual of Mental Disorders represents a revised definition for the clinical diagnosis of individuals with autism-related disorders. The diagnostic criteria require that symptoms must be present in early childhood (from six months to the age of two or three years old) but may not become fully manifested until the social demands exceed limited capacities. The diagnosis is based on two categories of criteria: The first one includes deficits in social communication and social interaction across contexts; not accounted for by general developmental delays and are manifested by all three following forms. Deficits in social-emotional reciprocity; raging from abnormal social approach and failure of normal back and forth conversation through reduced sharing of interests, emotions, and affect and response to total lack of initiation of social interaction. Moreover deficits in nonverbal communicative behaviors used for social interaction; ranging from poorly integrated-verbal and nonverbal communication, through abnormalities in eye contact and body language, or deficits in understanding and use of nonverbal communication, to total lack of facial expressions or gestures. Lastly deficits in developing and maintaining relationships, appropriate to developmental level (beyond those with caregivers); ranging from difficulties adjusting behavior to suit different social contexts through difficulties in sharing imaginative play and in making friends to an apparent absence of interest in people (APA, 2013).

The second category of diagnostic features is the presence of restricted, repetitive patterns or behavior, interests, or activities Children with Autism Spectrum Disorder (ASD) may use stereotyped or repetitive speech, motor movements, or stereotypical use of objects echolalia, repetitive use of objects or idiosyncratic phrases. They may show excessive adherence to routines, ritualized patterns of verbal or nonverbal behavior, or excessive resistance to change, such as rituals, insistence on same route or food, repetitive questioning or extreme distress with minimal changes.

In addition, children with ASD may develop highly restricted, fixated interests that are abnormal in intensity or focus such as strong attachment to or preoccupation with unusual objects, excessively circumscribed perseverative interests. Finally, persons with ASD exhibit hyper-or hypo-reactivity to sensory input or unusual interest in sensory aspects of environment, such as apparent indifference to pain, heat or cold, adverse response to specific sounds or textures, excessive smelling or touching of objects, fascination with lights or spinning objects.

Epidemiology

Determining the prevalence of autism spectrum disorder (ASDs) and monitoring over time are very important for ensuring the training of diagnosticians in ASD, for improving access to necessary interventions, and understanding the casual mechanisms of ASDs (Fombonne, 2012). Since ASD is a behaviorally defined disorder, it remains a challenge to determine its prevalence compared to another disorder with clear biological markers. The symptoms of ASD vary in severity and may present differently in a children with mixture of cognitive abilities (King & Bearman 2009). Based on current estimates of the prevalence of the ASD, studies published in English in the last decade show that the prevalence of autistic disorder is 20-30/10,000, while the rate of ASDs is approximately 90-120/10,000, where males consistently outnumber females by approximately 5:1 (Fombonne, Quirke, & Hagen 2011). While these estimates are predominately based on studies in North America and Northern Europe, a recent systematic review that included a wider representation of global prevalence estimates yielded similar figures (Elsabbagh, Divan, Koh, & Others, 2012).

1.2 Cognitive Theories of ASD

Currently there are three leading theories for explaining the cognitive deficits in autism; each one of those is focusing on a different group of symptoms. The first theory is Theory of Mind, which refers to the ability to infer what others are thinking in order to predict their behavior; this is an ability impaired in those with autism (Baron-Cohen 2000). The second theory describes a local processing bias, which refers to the tendency of individual with autism to focus on local details, rather than

processing the whole picture (Firth 1989). The third theory is about Executive Dysfunction, which refers to inability of autistic individuals to be flexible, while still maintaining appropriate plans and inhibitions (Hill 2004; Pennington & Ozonoff, 1996; Russell, 1997). This is often manifested in the form of behavior that perseveres inappropriately despite changing goals (Ozonoff, 1997). In the past decades many researchers have tried to find a single underlying cognitive deficit that could provide a unifying explanation (Pellicano, 2010). Happe and colleagues have argued that at the cognitive level, similarly to the symptom/behavioral and genetic levels, autism may be characterized by fractional impairments (Happe & Ronald, 2008). Consequently they have called for researchers to abandon the attempt to find a single cognitive explanation (Happe & Ronald, et al 2006) in favor of an explanation encompassing coexisting atypical ties in multiple cognitive domains (Pellicano, 2010). Research and theory suggest that non-verbal social communication, specifically joint attention, is predictive of later language for both typically developing children and children with autism (Baldwin, 1991; Mundy & Sigman, 1989; Mundy, Sigman & Kasari, 1990). In addition to that Baldwin (1991) supported that learning words and object labels depends critically on the achievement of joint attention. In order to learn a new word, a learner must link the object with that word as referenced by another person (Sigman & McGovern, 2005). There is a great variation in the cognitive and language skills of individuals across the spectrum of autism. Although the percentages differ from one study to another, a sizeable number of individuals with autism are quite capable in terms of language and cognitive skills while a considerable number of individuals have more limited abilities (Sigman & McGovern, 2005). The cognitive features of children with autism include deficits in attending to relevant cues and information, and in attending in multiple cues. Moreover they present receptive and expressive language impairments, particularly in abstract and pragmatic language. Also children with autism show deficits in concept formation and abstract reasoning impairments in the ability for planning and problem solving. In addition to that, they show impairments in social cognition, including deficits in the capacity to share attention and emotions with others, and to understand the feeling of others. There are also indications of a relative strength in rote memory, and in the ability to recall simple information. However, they do have difficulties in encoding more complex information. Lastly children with autism show relative strengths in processes involved in visuo-spatial organization. The above cognitive features associated with autism

have been summarized from previous research in this field (Bristol et al., 1996; Minshew, 1998; Minshew, Goldstein, Quill 1995b; Taylor & Seigel, 1994).

1.3 Local Processing Bias

The central coherence account, first conceptualized by Firth (1989), is one of the most prominent cognitive-psychological theories on Autism Spectrum Disorder (Noens & Berckelaer-Onnes, 2007). Central coherence is defined as tendency to integrate information into meaningful representations (Frith, 1989). It has been proposed that autism is characterized by weak central coherence, which manifests in a bias towards attending to the local features of objects (Ropar & Mitchell, 2001; Shah & Firth, 1983, 1993), and a relative impairment in global perception (Mottron & Belleville, 1993). This processing-bias should not be considered as a deficit but instead a specific cognitive style, since a weaker drive for central coherence predicts skills as well as weaknesses (Happe, 1999, 2000). Evidence for weak central coherence is derived from observations that children with autism actually do better than controls on measures that require detailed rather than global information processing (Shah & Firth, 1983). Aspects of social information processing demand this type of integration, such as a young's child ability to process faces (Kaufman & Kaufman, 1983) or the meaning of context-dependent language (Happe, 1997). Therefore, a cognitive perceptual deficit in global information processing may be associated with the social deficits of autism (Jarrold, Butler, Cottington, & Jimenez, 2000). Nonetheless, people with autism can connect information of certain sorts, for example, in putting together the elements of their daily routine, accumulating connected facts within a narrow domain, or placing visual elements in a coherent connection to one another in drawing (Happe & Frith, 2006). Moreover, there seems to be a strong and growing body of evidence that people with autism are characterized by superior performance on tasks requiring detailed-focused processing, whether this superiority is achieved at the cost of normal global processing is less clear (Happe & Firth, 2006). Thus, the weak coherence account has moved towards an emphasis on superiority in local processing rather than a deficit in global processing (Happe & Firth, 2006). While the other cognitive theories have focused more on the deficits of the individual with autism, the theory of weak central coherence emphasizes more the

advantages that predominance in local processing has to offer. Consequently, while an individual with weak coherence may be impaired of seeing the bigger picture, the person with strong coherence may be a terrible proof reader (Happe & Frith, 2006).

Executive Functioning

The concept of 'executive function' refers to the higher order control processes necessary to guide behavior in a constantly changing environment (Jurado & Rosselli, 2007). Executive functions include goal formation, planning, carrying out goal-directed plans, and effective performance (Jurado & Rosselli, 2007). The concept of executive functioning also includes skills such as working memory, mental flexibility, response initiation, response inhibition, impulse control and monitoring of action (Roberts, Robbins & Weiskrantz, 1998; Struss & Knight, 2002). In a constantly changing environment, executive abilities allow us to shift our mind set quickly and adapt to diverse situations, while at the same time inhibiting inappropriate behaviors. They enable us to create a plan, initiate its execution, and preserve on the task until its completion. In general terms, executive function mediate the ability to organize our thoughts in a goal-directed way and are therefore essential for success in school and work situations, as well as everyday living (Jurado & Rosselli, 2007). Executive dysfunction has been linked to a number of developmental disorders, including autism spectrum disorder (Russell, 1997). The behaviors proposed to be accounted for by the theory of executive dysfunction include: a need for sameness, a strong liking for repetitive behaviors, lack of impulse control, difficulty in initiating new non-routine actions and difficulty switching between tasks (Hill, 2004; Rajendran & Mitchell, 2007). Specifically, deficits in the ability of planning in children and adolescents with autism have been documented (Hill, 2004). Planning is a complex and dynamic operation in which a sequence of planned actions must be constantly monitored, re-evaluated, and updated (Hill, 2004). This requires the conceptualism of changes from the current situation, looking ahead by taking an objective and abstract approach to identify alternatives, making choices, and then implementing the plan and revising accordingly (Hill, 2004). It appears that children, adolescents and adults with autism experience an autism-specific deficit in planning in relation to normally developing individuals and those with other disorders not associated with generalized learning disability (Hill, 2004). Moreover, Turner (1997) has postulated difficulties in the

capacity to generate novel ideas and behaviors spontaneously as an underlying cause of the lack of spontaneity and initiative observed in autism. Such impairment may also be related to the high rates of repetitive behavior characteristic of autism as well as avoidance and dislike of change (Turner, 1997). Another main component of executive function is the concept of self-monitoring, which is the ability of a person to control its thoughts and actions and correct them if it's needed. There is evidence that indicate deficit in self-monitoring in autism as seen through autistic deficits in tests of motor estimation (Frith & Hermelin, 1969; Hermelin & O'Connor, 1975), error correction and avoidance (Russel & Jarrold, 1998), motor error correction (Hughes, 1996), impairments of intention monitoring (Phillips et al., 1998), and memory for actions (Russell & Jarrold, 1999).

Social skills

Impairment in social skills is often considered the defining feature of ASDs (Garcia-Villamisar & Dattilo 2011; Gillis et al. 2011; Mahan & Matson 2011; Rutter 1968; Sevin et al. 2007), with deficits in this domain leading to a multitude of negative consequences. These deficits are also highly correlated to collateral problem behaviors (Matson et al. 2011) (Kozlowski, Matson, & Belva 2011).

A guide on teaching students with autism by Saskatchewan Education Unit (1999) analyzed the impairments of social interaction of such individuals. In detail, individuals with ASDs demonstrate difficulty in establishing relationships, not necessarily due to lack of desire to be with and interact with other people, but may be as a result of the impairment in reciprocal social interaction. In addition, there is impairment in the ability to read and understand social situations, and respond appropriately (Gray & Gerand 1993). To exemplify, individuals with autism face difficulties in attending to relevant cues, shifting attention, language processing and finally in comprehending nonverbal behaviors from others.

In conclusion, one of the defining characteristics of autism and pervasive developmental disorders is the impairment of social interactions. Social skill development is an essential curricular area for people with autism, and is also crucial component of any intervention plan for changing problem behaviors (Teaching students with Autism: A Guide for Educators 1999).

1.4 Visual attention – Attention span

In general, the ability to ignore distracting information in the environment is dependent on top-down control of attention. Individuals with ASD show deficits in social information processing and respond atypically to innocuous stimuli in the environment. Intriguingly, such people can be highly distractible at times, but over focused and resistant to distractions at other times. In short, people with ASD seem to show both highly selective attention and poor attention span. Resent researches suggest that individuals with ASD may be impaired at prioritizing dynamic, transient or rapidly moving stimuli (e.g., Deruelle, Rondan, Gepner, & Tardif 2004) and have higher motion-coherence thresholds (Mine et al. 2002; Spencer et al. 2000); this has implications for social processing impairments in ASDs (Greenaway & Plaisted 2005).

As mentioned above, people with ASD are impaired in their social behavior, including their eye contact with others, but the processes that underlie this impairment remain elusive (Neumann et al. 2006). One of the diagnostic features of autism, as mentioned in DSM-IV manual (Hill & Frith 2003; Kanner 1943), is an aspect that can be quantified in the abnormal eye contact that people with autism make with others. Yet, the spatial and temporal characteristics of impaired eye gaze have not been characterized in detail, and their psychological basis remains elusive. People with ASD show a distinct gaze pattern when looking at faces and spend more time at the mouth and less into the eyes (Pelphrey et al., 2002; Klin et al., 2002), even though they can detect gaze direction normally (Baron-Cohen et al., 1999; Leekam et al., 1998; Neumann et al., 2006). Another research revealed that children of 2-5 years old with autism exhibited greater exploration and perseverative attention on object related to circumscribed interests than did typically developing children (Sasson et al. 2010). Although, they are also reported to have deficits in using information provided by another's person's change in eye gaze to look towards the same target in the periphery (Leekam et al., 1997; Goldberg et al. 2007)

On the other hand, MacPartland et al (2011) in contrast to their predictions revealed that children with ASD exhibited normative patterns of visual attention to human faces despite face recognition impairments and significant social deficits. These findings are consistent with other research investigating visual attention to static face stimuli in ASD (Sterling et al., 2008; Van der Geest et al., 2002). Dynamic

in vivo social interactions may be better able to characterize the variability in eye gaze among individuals with ASD (Klin et al., 2003; MacPartland, Webb, Keehn, & Dawson, 2011)

In conclusion, people with ASD have difficulties orienting to non-social visual events. However, the integrity of visual orienting is basic to various aspects of social as well as cognitive development, not the least of which is the ability to orient to the presence of others or to one's name when called. Thus, dysfunction in general, basic processes may well underlie some of the core deficits of autism (Landry & Bryson 2004).

1.5 Structured teaching & Visual Schedules

The Treatment and Education of Autistic and related Communication-handicapped CHildren (TEACCH; Mesibov, Shea & Schopler, 2002) is an educational program developed in the 1960s at the University of North Carolina. It was founded by Eric Schopler and has spread all over the world as a result of its theoretical framework, its extensive practical applications and multiple training activities It is one of the most frequently cited autism programs, broadly requested and implemented in public schools of several countries and considered one of the most widely-known, comprehensive intervention models. Comprehensive approaches attempt to address a range of developmental abilities, emphasizing early intervention, actively involving families and utilizing staff who are trained and specialized in autism spectrum conditions (Panerai, Simonetta, Oasi Maria SS 2012).

Social and vocational independence is an important curriculum goal for persons with autism spectrum disorder (ASD). Structured teaching developed by TEACCH is an effective instructional methodology facilitating independence and social amelioration for ASD (Virginia Department of Education – Review of Literature). Structuring the physical environment for persons with ASD is the first core component followed by the usage of visual support, in order to make the sequence of daily activities and individual tasks predictable and comprehensible. Last but not least, the TEACCH method utilizes the individualized schedules instead of using a standard curriculum. The addition of such visual information and visual supports to augment teaching of educational and vocational skills is one of the 24

recognized evidence-based practices with persons with ASD identified by National Professional Development Centre on ASD (Hatton & Odom, 2008). The work system designed by TEACCH is based on this visual support and works from start to finish using multistep tasks, organized in a simple left to right or up to bottom way (Schopler, Mesibov, & Hearsey 1995).

People with ASD are often capable of completing a variety of activities but often depend on prompts to do each one separately (McClannahan & Krantz, 2002). One form of empirically validated intervention that can promote greater independence and project completion is the activity schedule. These visual schedules usually consist of notebooks or placards depicting a series of pictures, symbols and/or words (Krantz & McClannahan, 1993; Lalli, Casey, Goh & Merlino, 1994) that are presented sequentially to cue a chain of responses from the person using the schedule (McClannahan & Krantz, 1999; Kimball, Kinney, Taylor & Stromer, 2004). In particular, picture-based systems have successfully cued persons with ASD to complete multi-step tasks including: daily living skills (Pierce & Schreibman, 1994); transitions (Bryan & Gast, 2000; Dettmer et al., 2000; Schmit et al., 2000); following a photographic schedule at home (Krantz et al., 1993); initiating and completing an activity following a photographic activity schedule (MacDuff et al., 1993); and food preparation tasks (Mechling & Gustafson, 2008).

Schedules may be used with persons of different ages and entry skills, in a variety of settings and across a variety of both discrete activities such as puzzles or worksheets and other open activities (Anderson, Sherman, Sheldon, & McAdam 1997; Bryan & Cast 2000; Copeland & Hughes 2000; Massey & Wheeler 2000; Schmit, Alper, Raschke, & Ryndak 2000). The chief reason for including conventional activity schedules in children's educational programs has been precisely to help them engage in habilitative routines in the absence of other people (Kimball, Kinney, Taylor & Stromer 2004).

Activity schedules have evolved in terms of both the ever more sophisticated media for their delivery and the resulting even broader range of independent skills they may support. Having noted the potential of activity schedules to facilitate social and communicational skills, researchers explicitly targeted them within the context of schedules (Dauphin et al. 2003; Krantz & McClannahan 1993, 1998). By combining activity schedules and computer technology, researchers have been able to teach new social skills to a similar degree of independence and observed that this independence

maintains when the instructional supports are faded to a simple notebook (Dauphin et al., 2003; Kalaigian et al., 2002; Kimball et al., 2002).

In conclusion, activity schedules originally were a means of promoting independent execution of previously learned responses by using pictures and words in notebooks or lists to cue a student's performance of sequence of activities. Integrating multimedia computer support with activity schedules can be an effective way to teach students to manage their work, play and skill-building activities independently (Stromer, Kimball, Kinney and Taylor 2006). The following part presents the concept of independent performance and the technological contribution to it.

1.6 Independent performance

It is important to utilize the criterion of ultimate functioning, which is defined as: "an ever changing, expanding, localized and personalized cluster of factors that each person must possess in order to function productively and independently as possible in socially, vocationally and domestically integrated adult community environments" (Brown, Nietupski, & Hamre-Nietupski 1976).

Self-monitoring, video modeling and visual support have been successfully applied to facilitate independent work performance and job related social skills (Virginia Department of Education). Several authors have offered clear descriptions of work systems, as developed in the TEACCH program, and the positive implementation of work systems to increase independent functioning in students with ASD (Carnahan et al. 2009; Hume & Odom 2007; Hume & Reynolds 2010). Focusing on the technological aspect, recent research has identified that individuals with ASD not only demonstrate significant skill acquisition when taught using mobile technologies, but also prefer instruction delivered through such devices (e.g., Shane & Albert 2008). In addition, many parents report their child's fascination with and propensity for learning from visually based media, such as computers (Nally, Houlton, & Ralph 2000; Ayers, Mechling, & Sansosti 2013).

It is apparent that technology can play an important role in supporting instruction to increase opportunities for employment and independent living for persons with ASD (Ayers, Mechling, & Sansosti 2013). In this section/part we present the means of technology that can assist towards independent performance for those

individuals. In particular, we examine mobile technology such as PDAs, smartphones, iPads, as well as computer-based methods like video modeling and virtual environments.

Mobile technologies

Wehmeyer (1996) described self-determination as acting as the primary causal agent in one's life and making choices and decisions regarding one's quality of life free from undue external influence of interference. High levels of self-determination correlate positively with enhanced quality of life for individuals with ASD (Wehmeyer & Schwartz, 1998). We present the evidence-based ways that mobile technology can help with improved skill development, as well as ways that it can lead to growth in some of the components of self-determination (Ayers, Mechling, & Sansosti 2013).

A study specified in the independent performance of persons with ASD was conducted with the usage of personal digital assistants or PDAs (Mechling, Gist, & Seid 2009), denoted that PDAs can be used as a self-prompting device for delivering antecedent cues as well as a permanent prompting system in demanding independent task performance. Krantz (2000) expressed the view that activity schedules may have special utility for social and communicational skills, adding video models to schedules promise to do so (Kimball et al. 2004). Additionally, on-board video cameras and add-on software applications of PDAs provide rich opportunities for the implementation of personalized vocational supports for persons with ASD on a workplace (Gentry, Lau, Molinelli, Fallen, & Kriner 2012). Last but not least, PDAs and smartphones have evident advantages such as their pocket-size, durability, ease of access and task organizational design that are appropriate for people with ASD, since research suggests that many of these people prefer instruction and support provided by computers to that offered directly by another person (Gentry, Lau, Molinelli, Fallen, & Kriner 2012).

Mobile technologies and add-on applications reflect on users in supporting the work efforts and transitions as well as in tracking or rewarding behavioral adaptation (Gentry et al, 2012). In other cases, games, songs and videos stored in the iPod Touch keep individuals occupied during long bus rides. An incident worth mentioning was that Lily's work performance suffered after her mobile device was lost; however she

quickly regained near-functional independence once the iPod Touch was replaced. (Gentry, 2012)

In general, mobile technology of any kind can be categorized by its roles on persons with ASD. First of all, it can be used as a skill instructor through video or photographic support to learners (Mechling 2011). Several researchers have used such a technique, in specific, Van Laarhoven, Johnson, Van Laarhoven-Myers and Grider (2009) used a video-prompting procedure on iPod to assist the instruction of a young woman with developmental disabilities to complete vocational tasks in a competitive work setting. Walser, Ayres and Foote (2012) used an iPhone and a video-modeling procedure to instruct a group of high school students with moderate intellectual disabilities to prepare food. A second usage is that it can provide valuable ways to promote self-management and self-instruction that lead to independent performance. In terms of self-management, four students with ASD demonstrated better performance with the support rather than without it, in the context of a withdrawal design (ABAB) (Cihak, Fahrenkrog, Ayres, & Smith 2010). On the self-instruction side, Bereznak, Ayres, Mechling and Alexander (2012a,b), building on work of Mechling et al. (2010), taught two high school students with autism how to operate an iPhone to prompt themselves through two daily living tasks and one vocational task (Ayers, Mechling, & Sansosti 2013).

Computer-based technologies

On the computer-side of technology, researchers have focused on video modeling, virtual environments and computer applications that include pictures, visual schedules and all kind of multimedia usage. Ploog, Scharf, Nelson and Brooks (2012) conducted a detailed application report, spanning over 40 years (1970 – 2011).

On the one hand, video modeling has been effective in teaching functional, social and behavioral skills to individuals with ASD (Ayres & Langone 2005; Bellini & Akullian 2007). Video instruction may be an effective intervention because it combines observational learning and imitation of observed behaviors (Clark et al. 1992). It also provides the opportunity for learners to repeatedly watch the model behavior and requires minimal staff training, as well as several learners can benefit at one time (Bidwell & Rehfeldt 2004; Bereznak, Ayres, Mechling, & Alexander 2012). Video instruction can include video modeling and/or video prompting is defined as

the viewing of a video of a peer or instructor successfully performing a chained task that participants are required to view at the beginning of a each training session (Legric & Blampied 1994; Bereznak, Ayres, Mechling, & Alexander 2012).

In specific, a study by Nikopoulos and Keenan (2007) confirmed that short video clips could successfully help children with ASD learn social behaviors and imitate social interactions. Later on, Sansosti and Powell-Smith (2008) conducted an investigation in the same field of study and found that all participants were able to maintain the learned social and communication skills through the combination of video modeling and computer-based instructions.

On the other hand, virtual environments, as Parsons and Mitchell (2002) suggest, could offer a platform for teaching social understanding to people with ASD. This virtual reality is a combination of technologies, allowing creation and exploration of virtual environments, which are 3D computer-generated representations of environments that have realistic appearance (Mitchell, Parsons, & Leonard 2006). Such environments allow authentic simulation of situations, potentially helping participants to perceive the relevance to the real world, which maximizes the likelihood of generalized learning (Strickland 1996, Strickland, Marcus, Mesibov, & Hogan 1996; Mitchell, Parsons, & Leonard 2006). According to Parsons and Mitchell (2002), any intervention capable of promoting role-play has tremendous potential, especially if it nurtures mental simulation. Virtual environments might satisfy this requirement in that they allow the user to discover conventions in a safe and supportive environment (Mitchell, Parsons, & Leonard 2006). To sum up, virtual environments and role-playing are abetting individuals with ASD to perform independently even in a virtual reality.

Valuable information about the usage of virtual environments by individuals with ASD can be found on Mitchell's (2006) research. Participants' experience with the VEs led to improvements in their judgment and reasoning about where to sit in some of the videos of real cafes and real buses. These improvements coincided with the timing of the VE intervention. Typically, individuals with low verbal IQ show the most severe social impairment, therefore such high needs of those individuals might be met via the use of a suitable VE. Primarily, VEs might be useful in that they create a forum for the teacher to communicate in an optimal and contingent manner with the person with ASD.

Technology on the Horizon

The utility of computers and mobile technologies in research and treatment of autism has been recognized in the last decades (e.g., Colby 1973; see Ploog et. al. 2013). However, in recent years there have been quantum leaps in the development of computer-based audio-visual (multimedia) technology. Approaches that were simply impossible a few years ago are now well within reach for the general public. Some of this evolution will capitalize on hardware advances. For example, the usage of GPS and covert audio, game consoles such as Kinect by Microsoft and Wii by Nintendo (Ploog, Scharf, Nelson, & Brooks 2012). In addition, Project Glass by Google with its new visual features as well as all new applications that can be downloaded and used on such devices (Ayers, Mechling, & Sansosti 2013). This technical and economic trend has further potentiated the utility of computers in the treatment of individuals with ASD. As a result, all the diagnostics and treatment of mental and mobility disorders are going to evolve in order to take advantage of new technologies, resulting in differing procedures and applications for educators.

Overall, researchers and technology engineers have addressed the unique needs of persons with disabilities as they relate to the independent access of various assistive technologies (Stock et al. 2006). Tablets and corresponding software with activity schedules offer a new perspective of technology usage for persons with ASD worth searching for, in order to enhance independence on social, vocational and everyday life. Even though research has not kept up with the dazzling pace of product development over the past few years – in which we have seen the rapid appearance of smartphones, iPod Touches, iPads and Android tablets, among others – the potential for the use of these devices as assistive technology is readily apparent (Gentry, Lau, Molinelli, Fallen, & Kriner 2012). Technology in general is no different from any other tool, however the power comes not from what it is but how it is used. It has to be noted though, that skills in engaging with modern technologies may have to be taught specifically to individuals with ASD (Kagohara, 2011; Ploog, Scharf, Nelson, & Brooks, 2012).

Conclusion

Successful integration of technology into the everyday routine and educational program of individuals requires understanding of their cognitive characteristics, knowledge of personal needs, and familiarization with available technology. It is likely that the literature on evidence-based practices will always lag behind the newest innovations, unless those innovations are based on evidence-based practices. The major challenge will be to date with technology being available and the existing evidence for supporting the use of technology with persons with ASD. To this end, no new teaching procedure or technology should be implemented without a sound plan for evaluating and monitoring its effectiveness. Documenting failures, as well as successes, and conducting rigorous research are important for ensuring that technology can assist in coping with the individuals' unique needs (Ayres, Mechling, & Sansosti, 2013).

2 Mobile Applications on Autism

The former part of the dissertation has already presented the autistic spectrum disorder and ended on how technology is already used in helping individuals with unique needs. This chapter makes a further analysis on mobile technologies and in detail demonstration of applications that were developed for persons with ASD. Finally, an introduction on our application encloses the chapter and triggers the beginning of others that follow.

2.1 Apps for Autism Spectrum Disorders around the Globe

On this section we demonstrate some of the worlds most famous applications for people with ASD. The selection of the presented material was made based on the impact that these apps have on children or adults with autism. Some of them are well advertised on the media while others are not. However, the information that we index into our dissertation is based on each developers site, the Apple Store, and finally on other websites that make comparisons on such software. Worth mentioning is the fact that the majority of the applications are for the iPad, while others mentioned are both for the iPad and for Android / Windows tablets. To sum up this introductive section we have to notify the potential reader that the majority of the applications cost a respective amount of money that their developer have already set on the Apple Store. Also, we have chosen to depict the key features of the applications below that distinguishes them from others, however they do have additional features that we have not presented but are available on the developers website to which we have a full reference guide on the corresponding section of our dissertation.

My Autism Day – By Little App Helpers

My Autism Day is compatible with iOS devices and specifically with the iPad and it's free of charge. As the developers describe on their website, My Autism Day replaces your daily planner, address book, progress reports, baby sitter notes and therapy recommendations. It not only keeps all these notes in one place, caregivers can use the graphs and daily comparison options to better understand what's working and what strategy should be scrapped. This app puts everything you do in perspective. Compare days of the week. Recognize what food intake leads to more focus and faster learning. Notice how much sleep leads to a brighter day at school. Even better, the more you learn, the more you can share with others. This app allows you to quickly post your ideas on social media or share with your friends who also have kids with special needs (iTunes, Little App Helpers).

The user interface of the app:

Picture 1 – My Autism Day by Little App Helpers

In conclusion, the app was introduced in the media with the following feedback:

"This is a good choice for a parent wanting a comprehensive view of their child's daily life (multiple children can be tracked too!)"

- Special Apps, Special Kids

Autism / Special Needs Daily Organizer – By Brooke Twine & EdwayApps

The app is designed for the iPad (costs 3,59 $) and was developed by Edway Apps with the cooperation of Brooke Twine, a "mother/teacher who understands the depth of planning and preparation that goes into just a regular day in the life of a child on the Autism Spectrum or even the constant on the go lifestyle that any child brings" as she describes (iTunes, EdwayApps, AutismSeriously) on the website. The app allows you to:

- Profile: you can create an individual profile of each children
- Daily Routine: create your own daily routine by adding written prompts and uploading your own photographs to create step-by-step visual of a particular activity.
- Food: create your own food board by uploading your own pictures of food.
- I Feel: create your own feelings board by using the built in animation s to communicate feelings.
- Play: create your own play board by uploading pictures of toys or games.

The user interface of the app, as presented in the developer's website (Edwayapps.com.au):

Picture 2 – Autism / Special Needs Daily Organizer

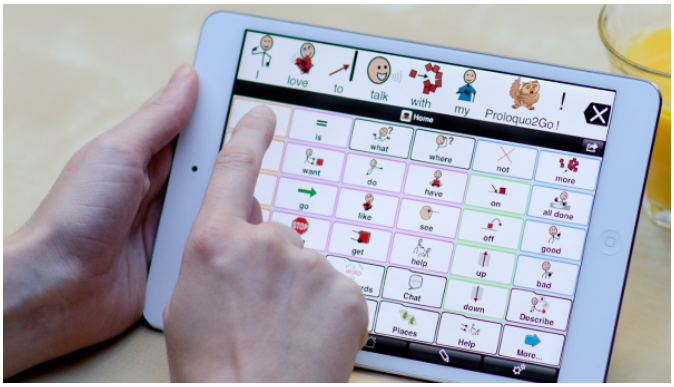
Proloquo2Go – By AssistiveWare

Proloquo2Go is a symbol-supported communication app providing a voice to over 75.000 individuals around the world who are unable to speak. It was first released in 2009 and featured research-based vocabularies, natural sounding voices that make it a solution for children and adults with autism, cerebral palsy, Down syndrome, developmental disabilities, apraxia, stroke, or traumatic brain injury. It is designed for iOS devices such as iPhones and iPads and costs 219 $ (iTunes, AssistiveWare).

Its main features are:

- Communicate with ease
- Choose vocabulary that fits
- Grow along with the user
- Customize to fit
- Edit with ease
- Access for users with motor impairments
- Speak with a natural voice
- Explore learning and community resources

The user interface of the app, as presented in the developer's website (assistiveware.com):



Picture 3 – Proloquo2Go by AssistiveWare

First Then Visual Schedule – By Good Karma Applications, Inc

First-Then visual schedule application is designed for caregivers to provide positive behavior support. For individuals with communication needs, developmental delays, Autism / Down syndrome or those who benefit from a structured environment, visual schedules serve to increase independence and lower anxiety during transitions through different activities. Additionally, can be beneficial for populations like, typically developing children, those learning English as a second language, individuals with dyslexia or others affected by aphasia after a stroke. This app is designed for use for the iPhone, iPod and iPad and costs 9.99 $.

The user can record their own voice, add their own images from their computer or simply use images from the application's stock library to create a schedule (iTunes, GoodKarmaApplications).

The user interface of the app, as presented in the developer's website (goodkarmaapplicaitons.com):

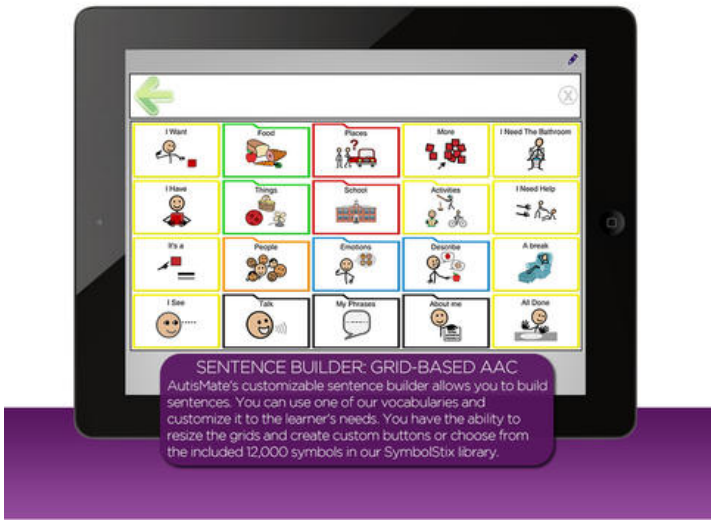
Picture 4 – First Then Visual Schedule by Good Karma Applications, Inc.

AutisMate – By SpecialNeedsWare

AutisMate is an application that can be personalized to each user and progresses with the changing needs of the individual. This enables users to develop communication and life skills simultaneously, allowing each skill to build on the other. It allows you to create contextual environments that are perfect for all ages and accommodate a wide range of ability levels, from individuals that are just beginning to communicate to those that are verbal and using virtual supports to promote independence. It is targeted for the iPad and costs 149.99 $.

AutisMate features a user interface that you can create visual supports in seconds, or download need from the developers' content library to get the app running. It uses visual supports like Visual Scene Displays, Full Sentence Builder, Video Modeling, Visual Schedules, Visual Stories, Content Library, and GPS (iTunes, SpecialNeedsWare).

The user interface of the app, as presented in the developer's website (autismate.com):



Picture 5 – AutisMate by SpecialNeedsWare

aacorn AAC – By aacorn

aacorn is a revolutionary next generation assistive communications solution providing realistic speech and language skills to children and young adults who have either limited or no ability to communicate verbally. The AAC is designed especially for children of all ages and abilities up to those who cannot type or spell. It introduces a 'word tree' where words present themselves automatically when the child needs them. There is no need to use a keyboard.

It is designed for children with Autism, Cerebral Palsy, Downs, MS, Apraxia, and developmental delays or difficulty in learning language. It is targeted for the iPad and costs 189.99 $ (iTunes, AccornApp).

The user interface of the app, as presented in the developer's website (accornapp.com):

Picture 6 – aacorn AAC by aacorn

In conclusion, the app was introduced in the media with the following feedback:

"aacorn signals a revolution in the way we provide AAC support to children. . The first to really capitalize on the strengths of the iPad"

- Professor Sue Fletcher-Watson (University of Edinburgh)

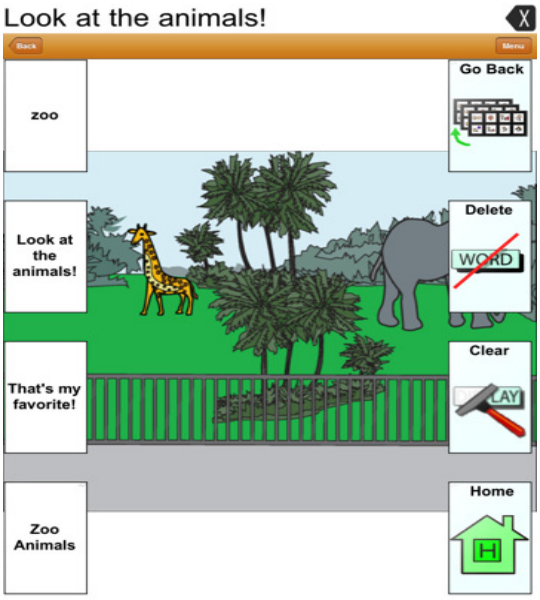
"aacorn is the first solution that will help to unlock a child's real potential to communicate"

- Professor Sheena Reilly (Murdoch Children's Research Institute).

TouchChat HD AAC – By Silver Kite

TouchChat HD is a full-featured communication solution for individuals who have difficulty using their natural voice such as, Autism, Down Syndrome, ALS, apraxia, stroke, or other conditions that affect a person's ability to use natural speech. It fits into the category of assistive technology known as Augmentative and Alternative Communication (AAC). Words, phrases and messages are spoken with the built-in voice synthesizer or by playing recorded messages. TouchChat also has a feature whereby one can simply tilt the device to make the message expand to fill the screen in large letters. This feature allows a person to communicate silently on in a noisy environment. Finally, it gives an individual the ability to navigate through page sets and speak messages. Each page set targets individuals with different communication needs. The application is available in English, Spanish and Hebrew and is targeted for the iPhone, iPod and iPad and costs 149.99 $ (iTunes, TouchChat, Silver Kite).

The user interface of the app, as presented in the developer's website (touchchatapp.com):

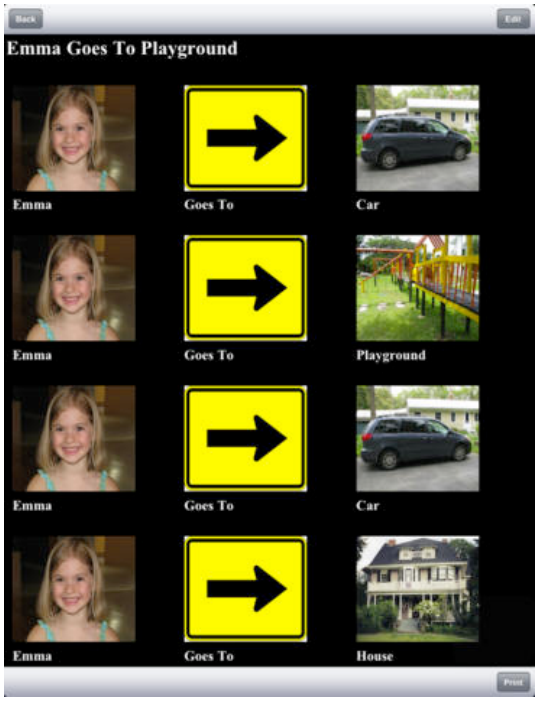


Picture 7 – TouchChat HD AAC by Silver Kite

iCommunicate – By Grembe Inc.

iCommunicate lets you design visual schedules, storyboards, communication boards, routines, flash cards, choice boards, speech cards, and more. It is customizable to the users needs. It features internet voices like: Australian, Canadian, Dutch, French, German, Italian, Norwegian, Swedish, UK English, US English, and US Spanish. Finally it is designed both for the iPhone and iPad and costs 29.99 $.

The user interface of the app, as presented in the developer's website (grambe.com/icommunicate):



Picture 8 - iCommunicate by Grembe Inc.

2.2 The “Autonomic” application

Nowadays, developers follow a much more innovative path towards persons with ASD, Down syndrome, and developmental disorders in general. This kind of innovation and creativity is expressed through applications for smartphones and tablets. Such a similar path we have also adopted in order to accomplish the design and development of our application that is called “Autonomic”.

Autonomic

Autonomic comes from the Greek word autonomous and is the individual’s right for self-determination, or in other words is the potential capability of a person to make decisions under the lack of external influence and while being fully informed. That definition of the word autonomous made us use such a meaningful and sentimentally powerful name for our application.

The application addresses individuals with autistic spectrum disorders that are considered as medium to high functioning people. An effective user that will take advantage of all features that the app has to offer might need the assistance of another person such as a friend, a parent or a teacher. Nevertheless, the level of assistance that each person needs depend on the capabilities of the user as well as how familiarized with the use of mobile technologies will be. Meanwhile, parents and teachers have their own modification of the app in order to have the pledge of using it for their children respectively.

The central feature of autonomic is the creation, modification, and storage of a visual schedule through the selection of multiple pictures of activities that lead to the creation of a chronological sequence that a person with ASD has to follow. That development was based on the literature and the evidence-based practices of structured teaching as well as visual schedules that were depicted on the previous chapter. Special consideration was made on the educational program that was developed by University of North Carolina known as TEACCH and was well presented in advance.

In conclusion, autonomic is an application for Apple’s iPad device and all the design, development, users manual and the apps interface will be presented on the chapters to come.

3 Design & Development of Autonomic

On this chapter we present an analysis of all stages of the software development. The software requirements are considered to be the first stage, the applications design is the second and the final one is the development of the application for iPad devices. Good programming practices and a friendly user interface were taken into consideration in order to create an invaluable app for the potential user.

3.1 Software Requirements

In general, the software requirements are divided in two main categories, the user and the system ones. Each scope requires different features from the created application. A potential user judges the services and the functionality that the application features in order to decide whether it meets their expectations or not. On the other hand, the necessity in mobile technologies, programming language, and in supportive development software is the systems requirements.

3.1.1 User Requirements

Persons with ASD

The first category of users is individuals with autistic spectrum disorders that are considered as medium to high functioning people. Specific requirements from that target group of users might be:

- Clear, specific, and well-organized user interface.
- Easy conceivable pictures of activities and in general usage.
- Prompts and messages in case of asking for help.
- Unequivocal sounds and alert messages in case of misuse.
- Chronological sequence of activities with a timer.
- Storage of old visual schedules on a users profile.

Parents of a child with ASD

The second category of users is parents of a child with autistic spectrum disorders. Specific requirements from that target group of users might be:

- Profile creation of their child with photo and name.
- Multiple visual schedules for every time of the day.
- Administrator privileges on the application.

Teacher of children with ASD

The last category of users is teachers in schools for children with special needs and specifically with autistic spectrum disorders. Specific requirements from that target group of users might be:

- Multiple profiles for children in a class.
- Visual representation of a class.
- Multiple creations of visual schedules for every child in the class.
- Administrator privileges on the application.
- Supervision of previously stored schedules.
- Clear and effective usage of prompts with pictures and sounds.
- Extra category of activities that can be done by the child with the teacher or with other children.

3.1.2 System Requirements

The application is designed for iPad devices, which support the operating system iOS 7.0. The development was made in two Macintosh laptops with specifications such as MacBook (late 2008) with the operating system Mac OS X 10.7.5 and MacBook Pro (mid 2012) with the operating system Mac OS X 10.9.3. The development kit used, was downloaded from the Apple Store, and is Xcode 4.8 and Xcode 5.0 on the two laptops respectively. The testing procedure of the application was made on a iSimulator 7.0 program and finally but most important on a 4th generation iPad with Retina display. Buing a developers license that costs 99$ was an essential requirement in order to test the application on the iPad. The application will be available for download on the Apple Store.

3.2 Design of Autonomic

The design of the application was conducted under the influence of two main aspects. The visual graphics part that consists of pictures, icons, and background pictures, and secondly the viewing part that is shown on iPad each time the user interacts with the device. On the first part, the interference of a graphics designer was inevitable; as a result we established cooperation with Joanne Dertili in order to come up with the essential elements for the application. In addition, a sound and speech configuration was designed in all use cases to support the audio effects of the application. Meanwhile, individuals with autism spectrum disorders were the targeted users and as a result, all parts of the design were created and finally embedded on the app taking that precondition in consideration.

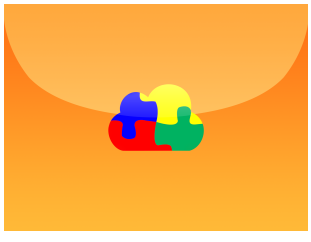
3.2.1 Graphics Design

The application has an app icon, pictures for activities, pictures for using the app like buttons and titles, sounds on buttons and activities, and finally background pictures that all considered to be the graphical design of our app. We also used high resolution on all graphics contents in order to match the specifications of the retina display of the iPad. The sounds were recorded and applied on the app with the suffix .caf as being smaller in document size while maintaining a high quality of sound. As for labels and text, the font called chalkdaster was selected to meet the needs of the backgrounds visual effect.

Application icon

The icons design was based on the usage of puzzle as a symbol for autism. We combined that with a cloud to demonstrate the mobility of the application on devices like iPad that can be taken everywhere at any given time. The icon was also used as a starting view when the app first launches.

Picture 9 - App Icon



Picture 10 - Launching view

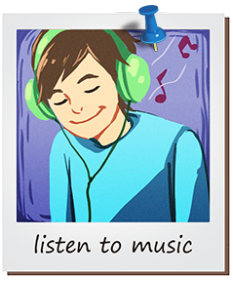
Activities pictures

For the selection of activities, we focused on things that people with ASD can do on their everyday life. This can be either at school with their teacher and other children, or at home with their parents or even on their own. Worth mentioning is the fact that all pictures have titles of what they show; this can help children improve their reading abilities. The design of pictures and fonts was based on definition clarity and prominent meaning. All the activities names and some representative pictures of them can be seen below:

Ball, Basketball, Be quiet, Blocks, Break, Brush my teeth, Car ride, Computer, Cycling, Do your work, Drawing, Drawing lines, Dress myself, Eat, Emotions, Football, Go to sleep, Hands on table, Help, Ice cream, Listen to music, Listen to the teacher, Magazine, Math, Play cards, Play music, Play nice with your friends, Play with animals, Play with toys, Prepare a meal, Puzzle, Shopping, Swim at the pool, Swing, Television, Tidy up my room, Toilet, Trampoline, Walk in the park, Wash my hands, Writing.

Picture 11 – Football

Picture 12 – Go to sleep



Picture 13 – Listen to music

General categories pictures

As mentioned before the three general categories of activities was based on things that children can do with their parents, their teacher or with other kids.

Picture 14 – On my own

Picture 15 – With my teacher

Picture 16 – With other kids

Applications buttons, titles and background

To begin with, a corkboard was used as a background on all views of the application as well as thumbtacks in order to pin pictures, titles and buttons on that board. All titles are shown as torn paper from a notebook while buttons are designed as a rectangle paper with a thumbtack on them. The prominent meaning of buttons was supported by the insertion of signs on them in order to clarify what they trigger on a users push. Some samples are shown below.

Picture 17 - The background

Picture 18 - Buttons

Picture 19 - Titles

User interaction

A potential user can be an individual with ASD, a parent or a teacher each of them have different functionality on the app that is triggered by these three pictures.

Picture 20 – Me

Picture 21 – Parents

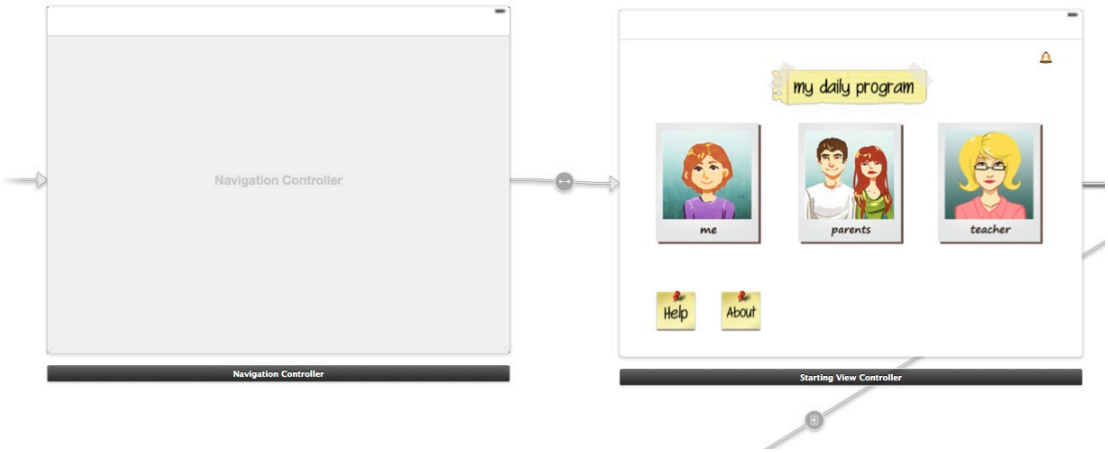
Picture 22 – Teacher

3.2.2 Application Views Design

The programming procedure in Xcode 5 consists of the actual code divided in files as well as the storyboard that is the visual representation of the app. In other words we use a combination of UIViews, UITableViews, and UIContainerViews that make the apps storyboard. The creation, handling and usage of core data (an pbject oriented database structure that the IDE offers) were uniquely imported to the design process in order to support a persistent storage of the users data. On this subchapter, samples of the aforementioned views are depicted to demonstrate step by step the design procedure. The pictures that follow are elements from the applications storyboard.

UIView

The usage of UIViews is a mainstream procedure in creating applications for iOS devices. Elements such as buttons, pictures, and backgrounds, that a user sees and interacts with by applying gestures on the iPad, can be imported into an app through the use of UIViews. That kind of visual representation was used in all phases of our development. A sample of a UIView from our app is the one that follows.

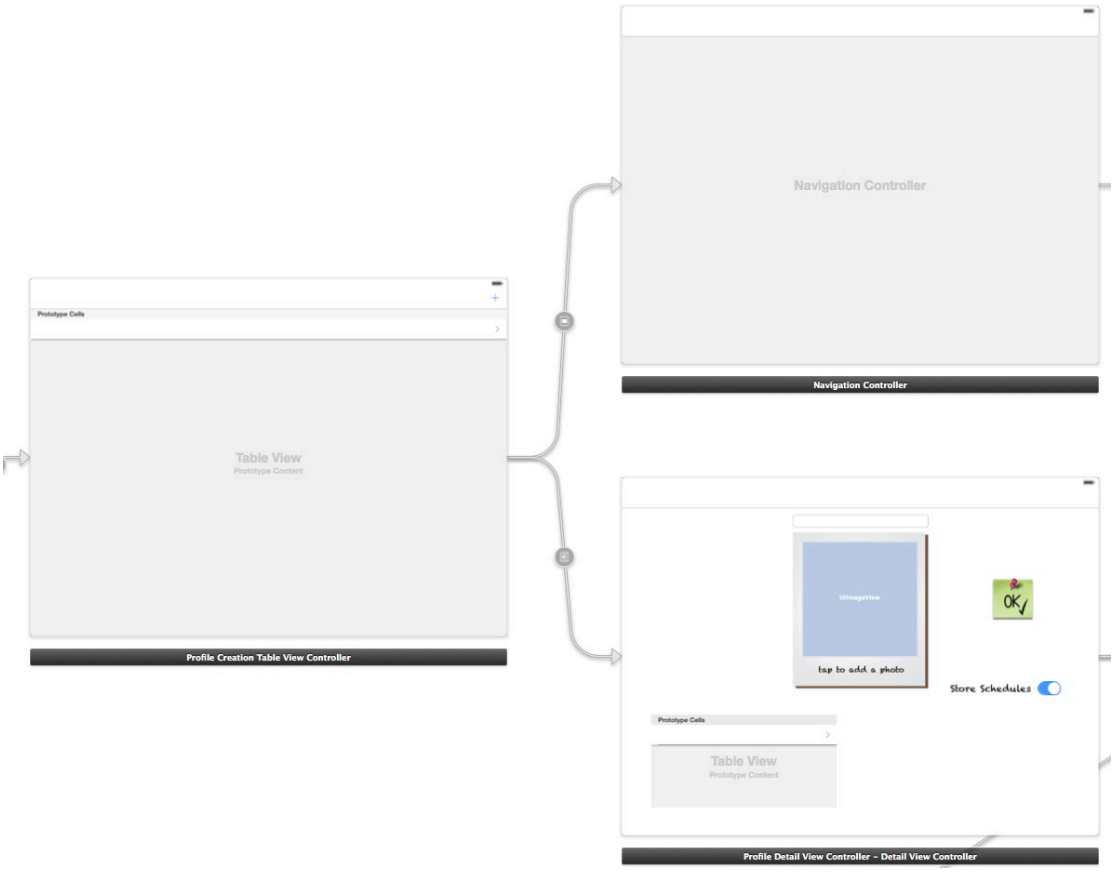


Picture 23 – The starting UIView on the right.

UITableView

A table view is a visual representation like the UIView, however it is designed to present to the user lots of information in a clear and easy to manage format. The table view was used in two cases in our app, on the creation of a profile to support

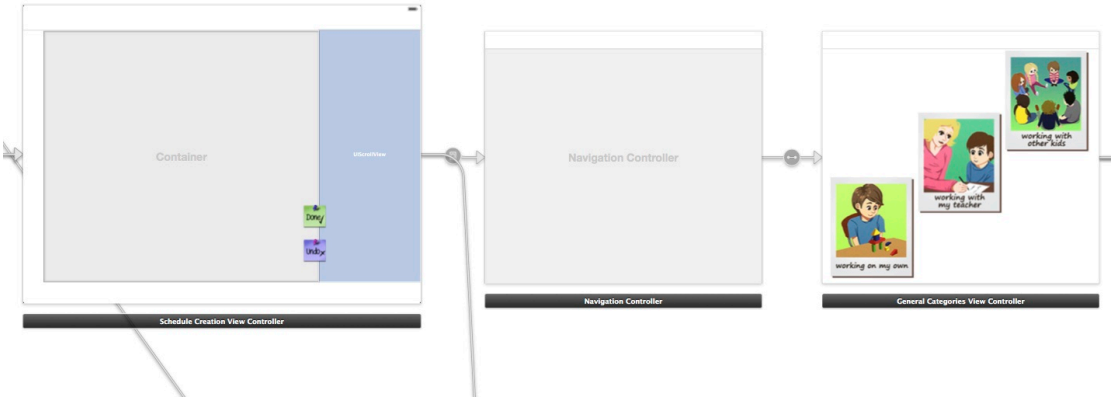
multiple profiles by different users and on the detailed profile view to demonstrate all schedules previously created be a specific user. A sample of a UITableView depicts the profiling procedure and all previously created schedules on the left and right respectively.



Picture 24 – The profiling UITableView on the left & old schedules on the bottom right.

UIContainerView

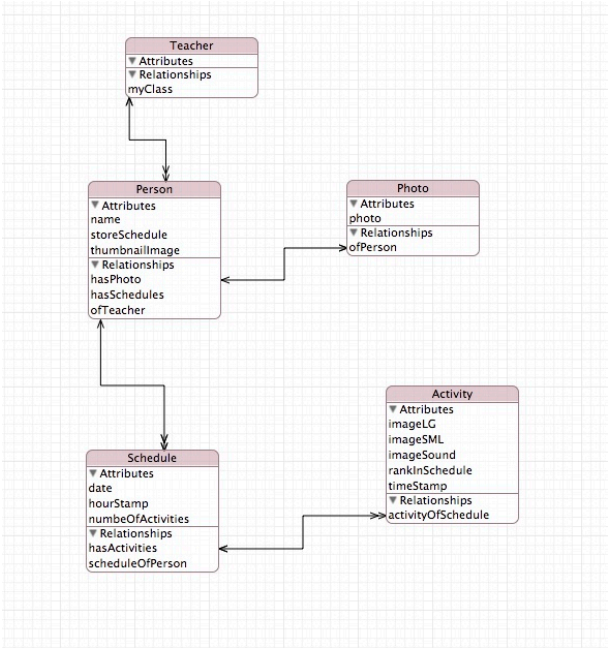
A container view is a means of embedding UIViews inside another UIView and manipulating them programmatically. We imported a container into our app in order to manage the large number of activities and give the user an easy way to make a selection through multiple pictures. At first, we had to distribute the activities into general categories and then present them to the user. Secondly, the schedule creation procedure was designed to have all activities on the left of the view and the generated visual schedule on the right. In addition, a scroll view was inserted to support a multiple input of activities on schedule as well as a capability of scrolling around them on an upper-down way. A sample of the container view follows.



Picture 25 – The UIContainerView on the left and the embedded UIViews on the right.

Core Data

The Core Data framework provides generalized and automated solutions to common tasks associated with object life cycle and object graph management, including persistence. In other words, it is an easy, well-organized, and efficient way of manipulating data that need to be persistently stored on an application. On our app, core data were used to perform the storage, editing, and creation of profiles, schedules, names and finally photos. In specific, five entities were created to withhold all data with the corresponding attributes and proper relationships (one to one, one to many) between them as shown on the sample that follows.



Picture 26 – Core Data with five entities. Inside are the attributes and relationships.

3.3 Development of Autonomic

On this subchapter we present the development of the application that implements the functionality of the app as designed on the previous section. The programming language used is Objective-C that Apple imposes in creating applications with Xcode. Some good programming principles were followed in order to achieve well-structured and efficient code. Firstly, the pair programming practice in writing and testing the code and secondly the algorithmic rule of divides and conquers on the significant problems that we had to tackle during the development. In detail, we divided the project in two main components, one was the profiling procedure and the other was the creation of a schedule. Finally, we unified the two components into one final application called "Autonomic".

3.3.1 Profiling Component

The profiling component was designed to manage all inputs of the user into the database, such as personal information (name & photo) and multiple schedules that were previously created. All the data manipulation was achieved through the combination of core data and a table view. For the tables' data, we programmed each cell in a way that it fetches and loads all existing profiles of the database in a preordained way. Worth mentioning is the fact that each of the programming files is considered to be a controller that implements the features of a view. On the following lines we index these programming files with the corresponding code to achieve the desirable utility.

profileCreationTableViewController

This view controller gets the database through the managedObjectContext that was passed by a previous view controller of the app. The methods that are implemented on this file along with the corresponding utility are the following.

- **fetchedResultsController**: Makes a fetch request on the managedObjectContext to get the database.
- **numberOfSectionsInTableView:** Sets the sections of the table.
- **numberOfRowsInTableView:** Sets the rows of the table.
- **cellForRowAtIndexPath:** DE queues a selected cell from a specific row.

- **configureCell:** It is called from the cellForRowAtIndexPath in order to configure the cell. It fetches a person from the database and calls the profileTableViewCell to configure the view of each cell.
- **controller:** It manages the insertion, deletion, and update of a row in the table view controller.
- **prepareForSegue:** Manipulates the segue to another view and passes the corresponding data depending on the segues id.
- **addPersonViewController:** Loads a modal view controller to add the name of a new profile and then continue to the profileDetailViewController.

profileTableViewCell

Into this file we get a person from the database and set the visual effects on each cell of the table. The orientation of the presented data is the photo of the person on the left with the name on the right next to the photo. The methods that are implemented on this file along with the corresponding utility are the following.

- **imageFrame:** Create a rectangle with preordained dimensions to withhold the persons photo.
- **nameLabelFrame:** Create the frame for the persons name.
- **layoutSubviews:** Set the above sub views on the cell view.
- **setPerson:** Set the entity Person with all its attributes.
- **initWithCoder:** Initialize a row of the table to show the persons photo and name.

addPersonViewController

It creates a new profile and triggers a modal view to get the name from the user. The manipulation of the name is done by delegation on the text field. The methods that are implemented on this file along with the corresponding utility are the following.

- **save:** Gets the name from a text field, creates a person on the database and assigns the imported name to it. An alert message is shown in case of wrong input.
- **cancel:** Undoes the operation of adding a new person and returns to the previous view.

profileDetailViewController

This file manages the view of the detailed information of a profile. Firstly, it shows the newly inserted profile and edits the name, the photo of the person, and the potential volition of the user to store future schedules. The unification of the two main components of the app takes place on this view. Another table view is created to import all the stored schedules of a specific user that exist into the database. The schedules are presented on a descending manner by the time they were originally created. The functionality of the schedules' table is identical to that of the profile. The methods that are implemented on this file along with the corresponding utility are the following.

- **photoSelection:** If the view is on editing mode, the user is able to click on the photo to select and import one to the profile. This button pops up an action sheet where the user can choose to import a photo from the library or to take a photo using the camera of the device.
- **actionSheet:** Manipulates the selection of the user on the pop up menu.
- **imagePickerController:** It creates a new Photo entity and stores the selection from the user in it by creating a thumbnail image with specific dimensions. It also establishes the relationship between the Person and the new Photo entity as shown in the core data.
- **setEditing:** It recognizes if the user has pushed the edit button and gives them the chance to change or delete the photo, name, and all stored schedules.
- **UITableViewDataSource:** This section presents the implementation of the table configuration methods. The key difference from the one before is that we have a schedule management here and a presentation to the user through their date / time.
- **commitEditingStyle:** Gives the user two types of editing style of the table, one by clicking the edit button and another by a swipe gesture to the left on each row.
- **controller:** It manages the insertion, deletion, and update of a row in the table view controller.
- **prepareForSegue:** Manipulates the segue to another view and passes the corresponding data depending on the segues id. A key difference than before is that here the user can either create a new schedule or load a previously created through the table view.

3.3.2 Schedule Creation Component

Given a specific entity of a Person from the database, this component creates an activity schedule along with the appropriate relationships in the core data. As mentioned in the design section, a container was used to present to the user all the available activities. Passing the activity that the user has chosen to the parent view controller was a milestone for the functionality of the component. Another significant operation was the deletion of unwanted activities on schedule. Meanwhile, in all the prementioned features, a proper update of the database took place to avoid data inadequacy in a future use of the app by the same user. On the following lines we depict these programming files with the corresponding code to achieve the desirable utility.

scheduleCreationViewController

Initializes the procedure of creating a visual schedule. At first, it fetches all objects that the database contains and then creates "children" views to support the large number of activities. As a "parent" view controller it receives the selected activities and stores them into the already created schedule. In case of deletion, a reverse procedure is followed. The methods that are implemented on this file along with the corresponding utility are the following.

- **fetchedResultsController**: Makes a fetch request on the persons managedObjectContext to get the schedule database.
- **animateSelectedActivitiesOnScrollView:** Creates the visual effects and animation when activities are being added or deleted on the schedule.
- **longPress:** It implements the feature of a long press gesture on each activity of the schedule in order to set the its' duration.
- **pickerView:** It pops up a picker selector after a long press on an activity in order to offer the preselected time limit for each activity.
- **undoButton:** Deletes the last selection of activity and updates the database.
- **generalCategoriesViewController:** A method that triggers the functionality of the container view by creating child views. Each child view passes back the arguments like the selected activity into this method in order to animate them on the scroll view.

- **prepareForSegue:** Manipulates the segue to another view and passes the corresponding data depending on the segues id. It also passes arguments on the children views that are created in container mode.

generalCategoriesViewController

It is the first child view of the container mode. In here, a classification on the activities was made according to the design from the previous subchapter. Then, all data were passed on the next child view that manages the activity selection.

activitySelectionViewController & manyActivitiesToSelectViewController

These are the last children of the container mode sequence. Into these two files the user selects the activities for the current schedule. The methods that are implemented on this file along with the corresponding utility are the following.

- **activityButton:** Creates a new object for the Activity entity and stores all the attributes in the core data as shown in the design section.
- **moreActivities:** Loads more than 12 activities to select from.

3.3.3 Final App – Autonomic

The final application was created by the combination of the previous two components. The consolidation procedure took place on the profileDetailViewController where we fetch all previously created schedules by the specific user. The sequence of a Person, with a Photo, has many Schedules, with many Activities was achieved on the final project through different views. At first, the user creates a profile and edits it, then creates an activity schedule, and finally stores it on the profile. When the app is reloaded, the user has the chance to load the whole database of previously created schedules. A detailed and unambiguous user interface as well as some use cases are presented on the chapter that follows. In addition, all phases of the design and development procedure become more comprehensible on the next chapter where the functionality of the app is being thoroughly presented.

4 User Interface and Use Cases

On this chapter we present the main features of the application along with an in depth view on how different users (children, parents and teacher) can use it. Firstly we make a brief presentation of the user interface with all its views and functionality. Then we demonstrate some use cases of the application that are separated in the following categories: create and manage profile, activity selection, perform activity schedule, teacher mode and parent mode.

4.1 User Interface

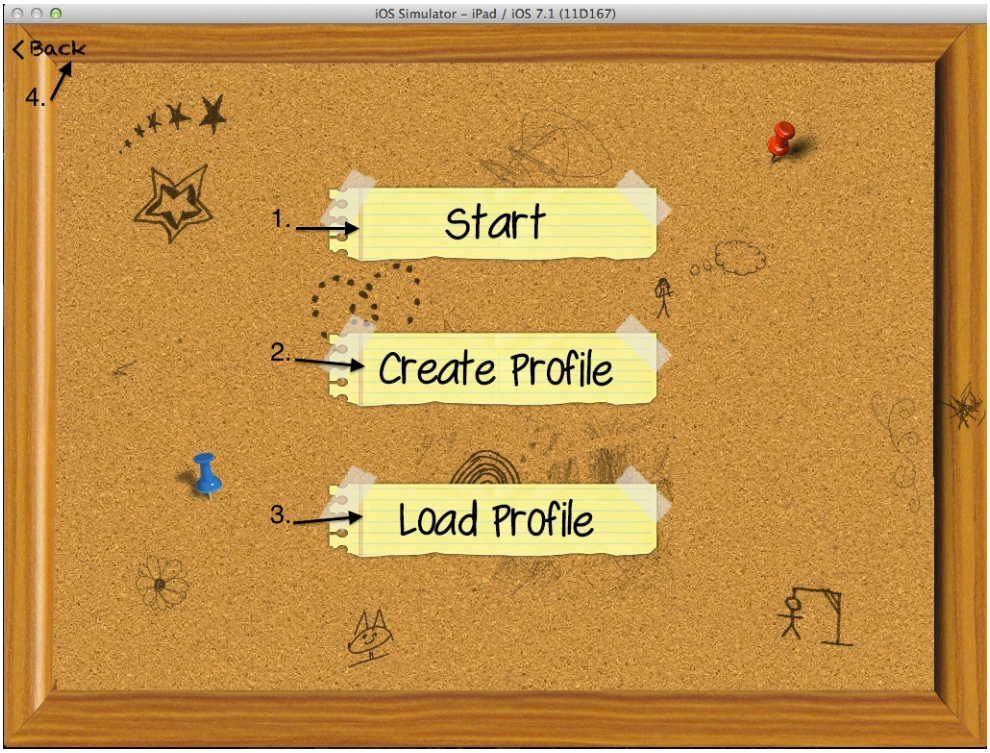
Welcome Screen

Picture 27 - Welcome screen

1. Button that the child itself is going to use in order to create a schedule (child mode).

2. Button that it is going to be used by the parents to create an all day schedule for their child (parent mode).
3. Button that the teacher is going to use in order to create personalized activity schedules for each child of the class (teacher mode).
4. Button that shows information concerning the application, the developers and the people that were involved in the whole process.
5. Button that shows brief instructions on how to use the application.

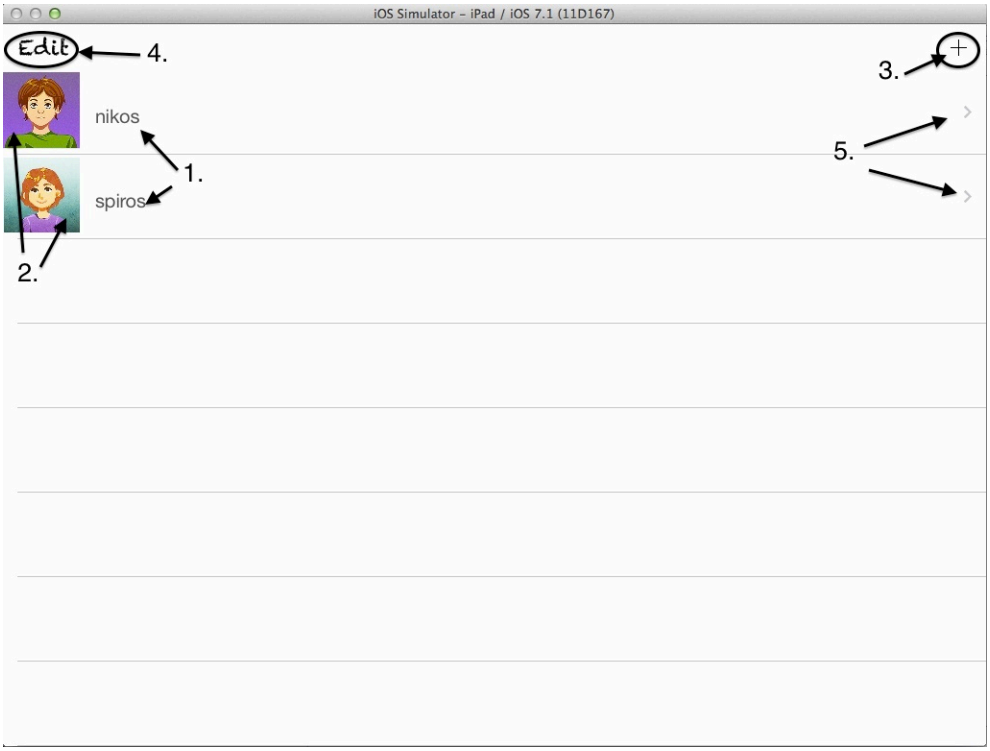
Child Mode



Picture 28 - Main menu in child mode.

1. Button that loads the latest activity schedule that was created from the user.
2. Button for creating a new profile.
3. Button for loading an existing profile.
4. Button that navigates the user to the previous view (picture 27, welcome screen).

Profile Browser

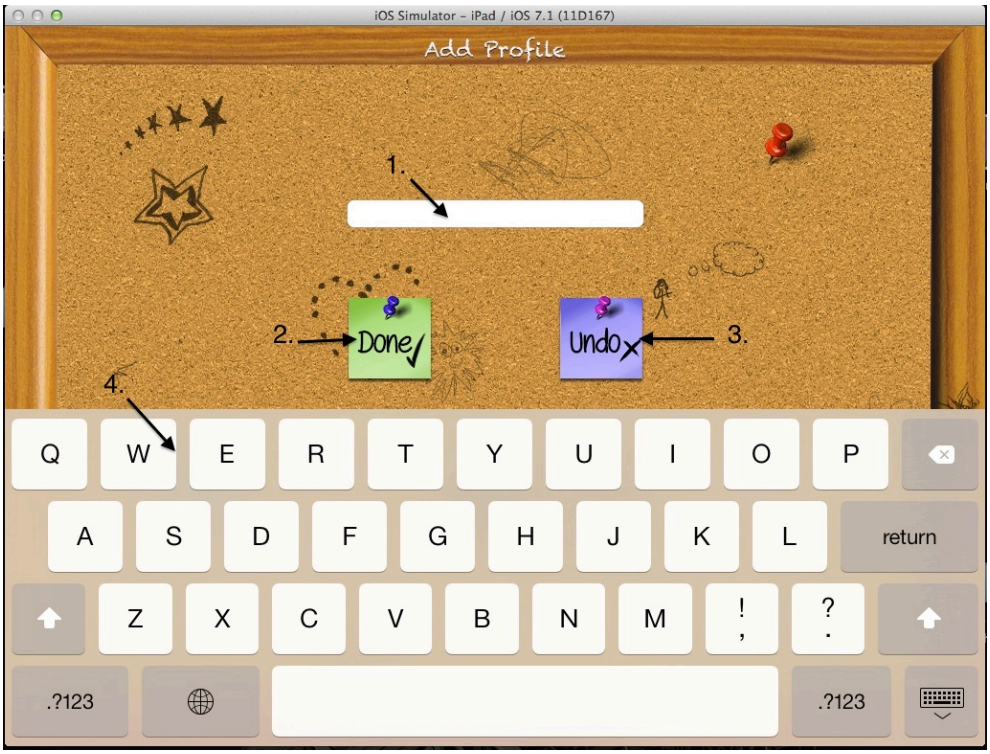


Picture 29 - Profile browser

When the view appears on screen it loads all the profiles from the database.

1. Text field that presents the name of the user.
2. User's thumbnail image.
3. Button for adding a new profile, triggers the add profile mode (picture 30).
4. Button that enables deletion of the table entries.
5. Select a specific row from the table.
   a. By selecting a table entry the program loads the specific profile.
   b. On a swipe gesture to the left on a profile row you can delete that specific profile as you can do by pushing the edit button.

Add Profile



Picture 30 - Add profile

This view is loaded by clicking the + button in the previous one (picture 29) and it creates a new entry to the table of profiles as well as in the database.

1. Text field for typing the name of the user's profile.
2. Button to create the profile.
3. Button to cancel the procedure.
4. Pop up keyboard appears on screen as soon as the view appears because the text field is the first responder so that the user can type the name immediately and create a new profile.

Detailed Profile

Picture 31 - Profile creation / editing

This view loads when the done button is pressed in the previous one (picture 30) and the name of the new profile is already put in the database.

1. Label with the name of the user.
2. Polaroid with the photo of the user.
3. A table that contains previously stored schedules.
4. Switch that enables or disables the storing of an activity schedule.
5. Button that navigates the user to the next view, in order to create a new activity schedule.
6. Button that enables the editing option, so the user can delete stored programs, change the profile photo or change the name.
7. Button that navigates the user to the previous view (picture 29, profile browser).

Parent Mode

Picture 32 - Parent mode

The view loads from the welcome screen (picture 27).

1. Switch that enables the creation of an activity schedule for a specific time of the day (morning, noon, afternoon, night).
2. Labels that present different periods of time during the day.
3. Button that pushes the next view on the screen for activity selection.
4. Old schedules on a table view.
    a. Table that presents previously stored programs that the user can choose to load.
    b. On a swipe gesture to the left the user is able to delete the specific row from the table of schedules.
5. Button that navigates the user to the previous view (picture 27, welcome screen).
6. Button that enables the edit option to manage the schedules in table view (delete or not).

Teacher Mode

Picture 33 - Teacher mode

The view loads from the welcome screen (picture 27).

1. Buttons that present the pictures of the children that constitute the class, by tapping on the photos the program loads the latest activity schedule of the specific user.
2. The name of the specific children.
3. Button that navigates the user to the previous view (picture 27, welcome screen).

Categories of Activities

Picture 34 - Categories

The schedule creation procedure starts from this view with the general categories of activities.

1. Button that contains activities that the child can do on its own.
2. Button that contains activities that the child can do with the assistance of the teacher.
3. Button that contains activities that the child can do with other kids.
4. Button that navigates the user to the previous view depending on the mode that the application is currently running (e.g. teacher mode, parent mode & child mode).

Activity Selection

Picture 35 - Activity selection

1. Buttons that depict various activities.
2. Button that loads more activities.
3. Button that finalizes the schedule and pushes to the screen the next view (picture 36, final view).
4. Button that deletes the last activity of the schedule.
5. List of the activities that the user has added to his schedule in a scroll view appearance that the user can navigate in an upper-down way. The user can perform a long press gesture on a picture of the schedule to set the timer of the specific activity.
6. Button that navigates the user to previous view (picture 34, categories).
7. Button that navigates the user two views back depending on the mode that the app is running (e.g. teacher mode, parent mode & child mode).

Perform a Schedule

Picture 36 - Final view / Perform a Schedule.

1. Button that shows various prompts that the teacher or parent can use (picture 37).
2. Label that shows the name of the users' profile.
3. Picture that shows the current activity.
4. Button that can be used from the children to ask for help in an activity from the teacher or a parent.
5. Button that loads the previous activity.
6. Button that loads the next activity.
7. Progress bar that shows the time that has been left for the activity to be completed. On the left is the time in which the activity should be completed and on the right the progress bar becomes red as the time passes. This timer was previously set on each activity on the schedule creation mode (picture 35).
8. It depicts a list with all the activities of the schedule; the faded pictures indicate activities that have been already completed while the highlighted ones are left to be done.

Prompts

Picture 37 - Prompts

1. This screen contains various prompts or rewards that the teacher or the parents can use towards the child. As soon as a prompt button is pressed, the corresponding sound is been heard.

4.2 Use Cases

4.2.1 Create and Manage Profile

In order to use the application and start making activity schedules the user must create a new profile. The reason is that the profile is going to store the name, the photo and all previously created schedules of the user. Firstly the user must tap on the "Me" button (picture 27) where the starting view controller is going to redirect him to the next view (picture 28). This view controller contains three buttons that give the user the option to create a new profile, load an existing one or load the most recently created schedule (start button). If the user taps on the "Create profile" button the application is going to redirect him to a new view controller (picture 29), which is a table that loads all the profiles from the database and shows them into each row by the profiles' photo and name. If there is not any profile stored in the database then all fields will be empty.

Next by tapping the plus button that is located in the upper right corner of the table the user has the opportunity to add a new profile. The plus button triggers a modal view on screen (picture 30) where the user can type his / her name. Then by tapping on the done button the modal view disappears from the screen and the table updates its content with the new profile entry. Simultaneously, the user is redirected to the detailed profile view (picture 31). Moreover the user can delete an entry of the table, thus deleting the specific profile, simply by pressing the "edit" button located in the upper left corner or by performing a swipe gesture from the right to the left on the each row. This edit procedure is demonstrated in the picture below (picture 38).

The next view is the detailed profile view (picture 31) in which the user is been redirected either by selecting his / her profile in the table view (picture 29) or by creating a new profile with a new name (picture 30) as mentioned above. In this view the user has the opportunity to set or overview his personal information (image, name and previous schedules) and by tapping the "ok" button he can immediately start planning an activity schedule. Moreover in this view the user has the ability to enable the editing option, as seen in the picture below (picture 39), by tapping the "edit" button that is located in the upper right corner of the screen. While the editing option is enabled the user can change his name, delete previously stored schedules (this

procedure can also be done by performing a swipe gesture from right to the left on a specific table row) and lastly load a photo as an avatar for his profile.

Picture 38 - Table editing

Picture 39 - Profile editing

When the editing option is enabled and the user taps on the empty photo button (avatar), then a popup message appears on screen that informs the user about the possible options on how to import a photo to the profile. The selection can be made through a variety of either to take a photo using the camera of the iPad or choose an existing one from the camera roll. After the user has chosen a photo, the application stores it as the avatar of his profile. If the user has finished editing his profile he then can tap the "Done" button that is located in the upper right corner of the screen to store the changes that he had already made. All this editing photo procedure is shown on the picture that follows (picture 40).

Picture 40 - Choose photo

4.2.2 Activity Selection

The next step in the application, after the user has finished creating the profile, is the activity selection. There the user has the opportunity to build a visual schedule with various activities that can be selected from three main categories (picture 34). The categories depict the ways that an individual with ASD can perform the selected activity, as a result some activities can be done only with the teacher, or with other kids, or finally on his / her own. The user firstly selects a category in order to browse the variety of activities that are on his / her disposal. Then taps on the picture that wants to add to the schedule. The application adds the selected activity to the current schedule that is located in the right section of the screen (picture 35). The user can delete the last activity of the schedule simply by tapping the "Undo" button, if there is no activity in the schedule and the button is tapped an alert message pops up to inform the user (picture 42). Moreover the application gives the ability to the user to navigate through the three categories of activities using the "Back" buttons that are located in the upper left corner of the screen. He can also inspect his schedule by performing a swipe gesture, along the right section of the screen on an upper-down format.

Apart from the schedule creation procedure the user has the ability to set a timer for each activity. Performing a long pressure gesture on a selected activity can do this feature. Consequently, a timer pops up with a picker selection of preselected durations of time as seen in the picture that follows (picture 41). Lastly by tapping the "Done" button the user finishes the schedule creation procedure and the application redirects to the next screen that is the final one (picture 36).

In conclusion, in all the phases of a schedule creation and activity selection the database is been updated to withhold the current version of data. In case of misuse of the program, alert messages inform the user for the situation and all the data are protected from inconsistence. Those alert messages consist of a pop up message on the center of the screen and an audio message according to the misuse that had occurred. To contribute to that cause, some buttons become hidden in order to prevent such a misuse of the application. This can be seen on the picture that follows (picture 42) where the "ok" and "undo" buttons are hidden from the user due to the fact that there is no activity selected so neither a deletion can occur nor a redirection to the next view to perform the schedule.

Picture 41 - Setting timer to a specific activity.

Picture 42 - Alert message in case of deletion of a non-existing activity.

4.2.3 Perform Activity Schedule

In this section we present the main functionality of the application, how a user can perform an activity schedule that has already created or loaded from the table of the stored schedules. As seen in a previous picture (picture 36), in the middle there is the current activity that the user has to perform. The “previous” and “next” buttons can be used to navigate to the previous or the next activity of the schedule. Also, the activity schedule is located on the right section of the screen where the faded pictures show activities that have been performed and the colored ones show activities that haven not.

If an activity has a time limit then the time bar that is located just below the main picture indicates the time that is left for the activity to be completed. Also on the upper right corner of the main activity is a “Help” button that the user can tap on to ask for assistance. Additionally, a “Prompts” button, located on the upper left corner shows on screen some prompts (picture 37) that the teacher or parent can use to address some issues to the child. As soon as the user finishes the schedule, an alert message pops up on the screen as shown below (picture 43). Finally, the user can use the “Back” button to go to the previous view (picture 35) if he / she wants to change the activities of the schedule.

Picture 43 - Alert message in case of a finished schedule.

4.2.4 Teacher Mode

In this section we present how a teacher could use the application in order to create different activity schedule personalized for each child inside a classroom. First of all the teacher has to create a profile for each child in the classroom in order to take the advantage of the loading different schedules feature. The teacher has to follow the procedure that is described in the "create and manage profile" section and the one that is described in the "activity selection" section in order to create a program for each child. By following this procedure a teacher has the change to create a database of children in a class and add a variety of schedules on each one separately.

As soon as this process is been done, the teacher is able to tap on the teachers mode into the welcome screen (picture 27) and the application redirects to the next view (picture 33). From that point and on the application is running under the teacher mode, this view offers the opportunity to the teacher to view the profile pictures and the names of the children that constitute the class. Consequently, by tapping on a photo of a specific child the application will load the latest schedule that was created for that profile and then it pushes to the final view (picture 36) in order to perform the schedule. Moreover by tapping the "Back" button into the final view the teacher can go back to the previous view of the class and reload a different schedule for another child.

In conclusion, a teacher is considered to be an administrator of the application in a way that he / she can manage the profiling database and at the same time load a class of children with a preselected schedule for each one. Also, the app gives the teacher a capability of loading instantly a variety of schedules according to the different profiles.

4.2.5 Parent Mode

In this last section we present how a parent could use the application to make activity schedules for their child. The parents do not necessarily have to follow the procedure of creating a profile for the child even if they could do so in order to help their child to use the app. By selecting the parent mode on the welcome screen (picture 27), the application redirects into their mode (picture 32).

From that point and on, the application runs under the parent mode, in which the main feature for parents is that they can make different schedules for different periods of time during the day. This feature is triggered by a variety of switches that are next to the labels and can be enabled accordingly (one switch at a time). As a result, the parent first enables a switch according to the desired time of the day and then taps on the "start" button to create the schedule. A time label identifies that schedule and the child can load it in order to perform the preselected activities (picture 32). A table view that is located in the middle of the screen and below the labels is used to present to the parent all previously stored schedules. As mentioned before, the parent could delete a schedule either by tapping on the "Edit" button or by performing a swipe gesture from the right to the left (picture 44).

Picture 44 - Editing option in parent mode.

5 Evaluation

The evaluation process of a scientific product is considered to be essential and vital due to the invaluable information that brings to the creators. Whether this product is an application or not, extremely useful results can be drawn only by offering it to the potential users in order to make comments and evaluate it through their own perspective. However, a well-formed and integrated questionnaire is necessary to be given to the evaluators in order for the procedure to be as much objective as possible.

When it comes to evaluating an application, various specifications should be taken into consideration, which are based on the value and the features that the app brings to the user. Furthermore, if the application is considered educational and at the same time targeted for persons with autism spectrum disorders, then the whole evaluation process should be treated with great respect, scientific knowledge, and carefulness. These characteristics are vital if the developer really wants to create software that will be useful, flexible, and with great value for the potential users.

5.1 Evaluation Objectives & Methodology

Objectives

The main objective from the developers' point of view on the evaluation procedure is to find out what impact his creation might have on people. Firstly, what visual impact might have, meaning whether a user really liked the visual content and effects of the app or did not. Secondly, whether the applications' features met the users expectations for the app or they fall way beyond. Thirdly, if the user found the application easy to use and how much time did they spend on learning the users' interface. At last, did the user enjoyed using the application or was frustrated at some points?

From the users point of view, an evaluation process gives him a powerful means of expressing what he really needs from a product. The most valuable objective of the user is that he can actually influence the final appearance of an app as well as he can change the features of it towards a more convenient and useful way that the developer might have not comprehended.

Methodology

Following the needs of people with ASD, the evaluation process was based on a questionnaire with twelve questions concerning not only the application but also the impact that it might have on children with ASD. The design of this tool was to be answered by teachers that are currently working on the scientific field of autism and are familiar with the educational technique of visual schedules and structured teaching in general. The most desirable audience of evaluators is the one that has plenty of experience on the field and at the same time mobile technologies and applications are familiar tools to them. The evaluation of teachers is supposed to be the basis of the evaluation process into this dissertation, although a future prospect might be to evaluate the application into a classroom with children with ASD. This would broaden our horizons but at the same time it necessitates plenty of resources that currently are not available.

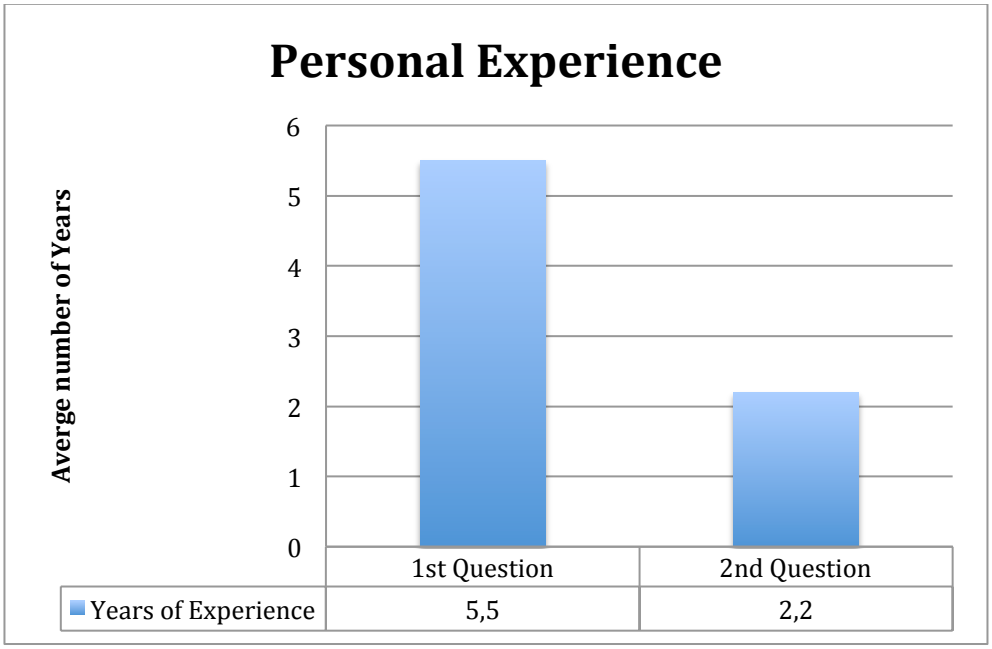
The autism specialist group that answered the questionnaire enumerated fourteen (14) people that were teachers in the educational sector of special needs and particularly in autism. The people that constitute that group teach in schools that are located in a variety of regions around Greece, also the group varies not only in age but also in the educational experience that its participants have. These facts have contributed to the whole process by making the evaluator's sample to vary and most importantly to become more objective. In specific, the locations that the evaluation took place were Volos, Larisa, Chania, and Alexandria. Additionally, the schools were "1st Kindergarten for Special Needs in Larisa", "Kindergarten for Pervasive Developmental Disorders in Larisa", "Primary School for Pervasive Developmental Disorders in Larisa", "3rd Kindergarten for Special Needs in Chania", "Autism & Special Needs Center in Alexandria", and "1st Primary School for Special Needs in Volos". Finally, we would like to express our sincere gratitude to all these teachers that contributed significantly to our dissertation and application.

5.2 Evaluation of Autonomic

The questionnaire consists of twelve questions concerning the quality of the application as well as two questions regarding the teachers experience on the field. These criteria can be answered on a suitability of five-scale scoring such as 1-Strongly disagree, 2-Disagree, 3-Neither agree nor disagree, 4-Agree, 5-Strongly agree. Meanwhile, at the end of the questionnaire is situated an empty space in order for the teachers to write comments and observations if they wish to do so. These comments are further analyzed into the next paragraph in order to come up with qualitative results.

Quantitative Results

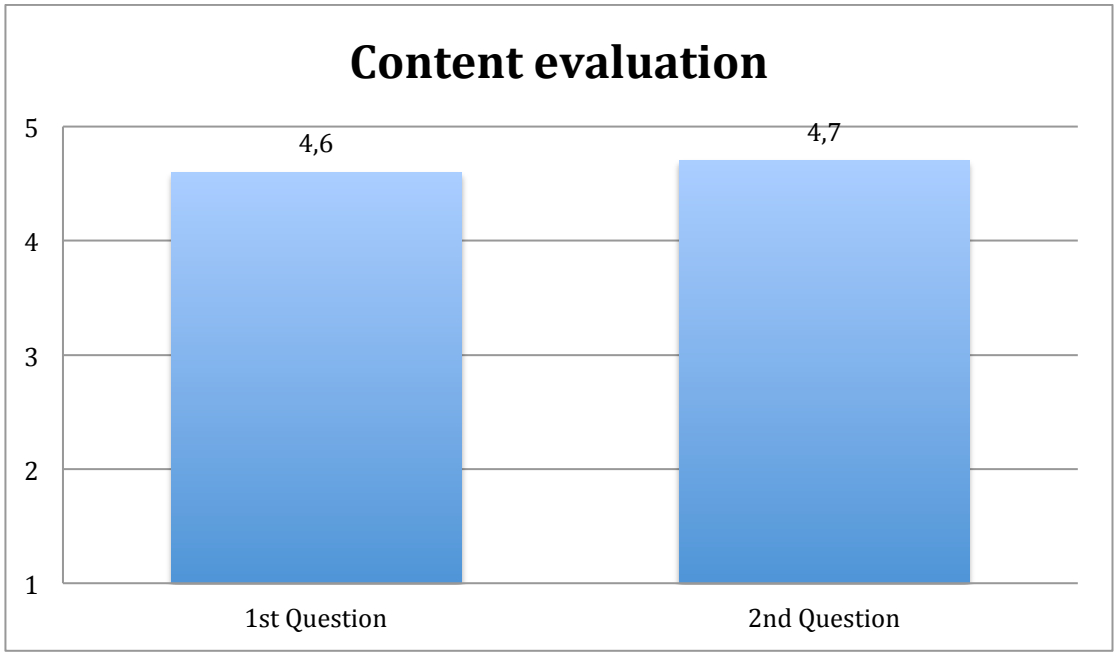
The 14 participants of our survey have an average of 5.5 years of working experience in the field of autism and an average of 2.2 years of practicing educational software in the same field. The twelve questions have been classified in three categories, the first regards the evaluation of the applications' content (vocabulary and activities), the second concerns the design factors while the latter the usable and helpful could the application be for children with ASD based on the teachers' perspective. On the charts below we present the average score (from a scale 1 to 5) that each question took in our questionnaire.



Graph 1 – Personal Experience

1st Question: How many years have you been teaching to children with autism?

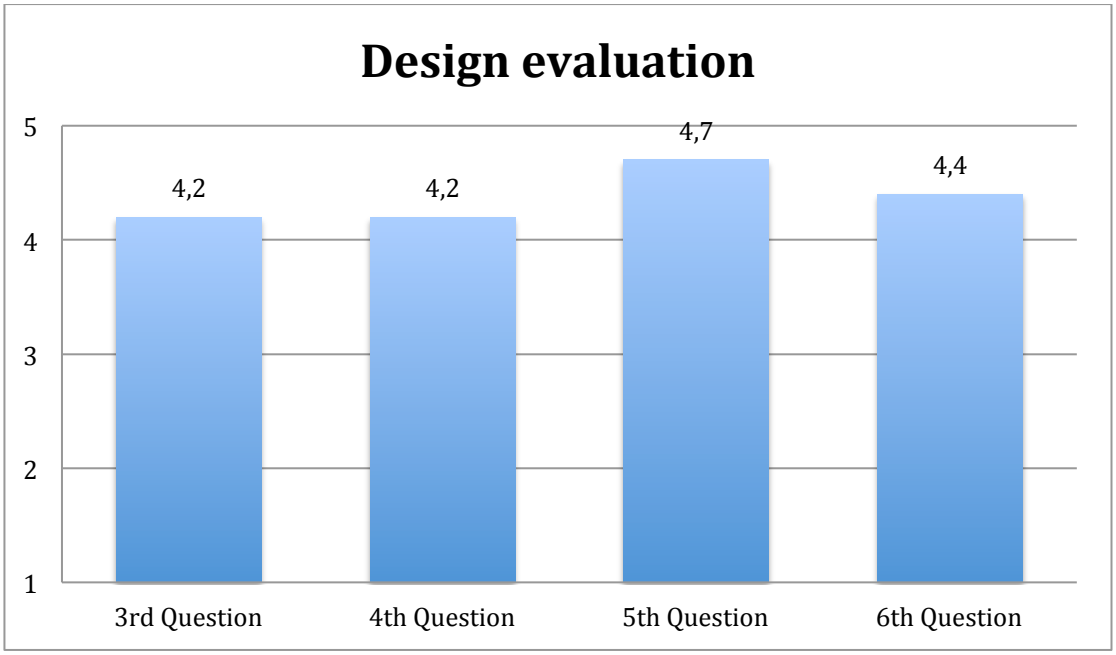
2nd Question: How many years have you been using educational software in teaching children with autism?



Graph 2 – Content Evaluation

1st Question: Does the application contain concepts and vocabulary that is suitable to the abilities of children with autism?

2nd Question: Does the application contain activities that cover those that children with autism perform in their every day life?



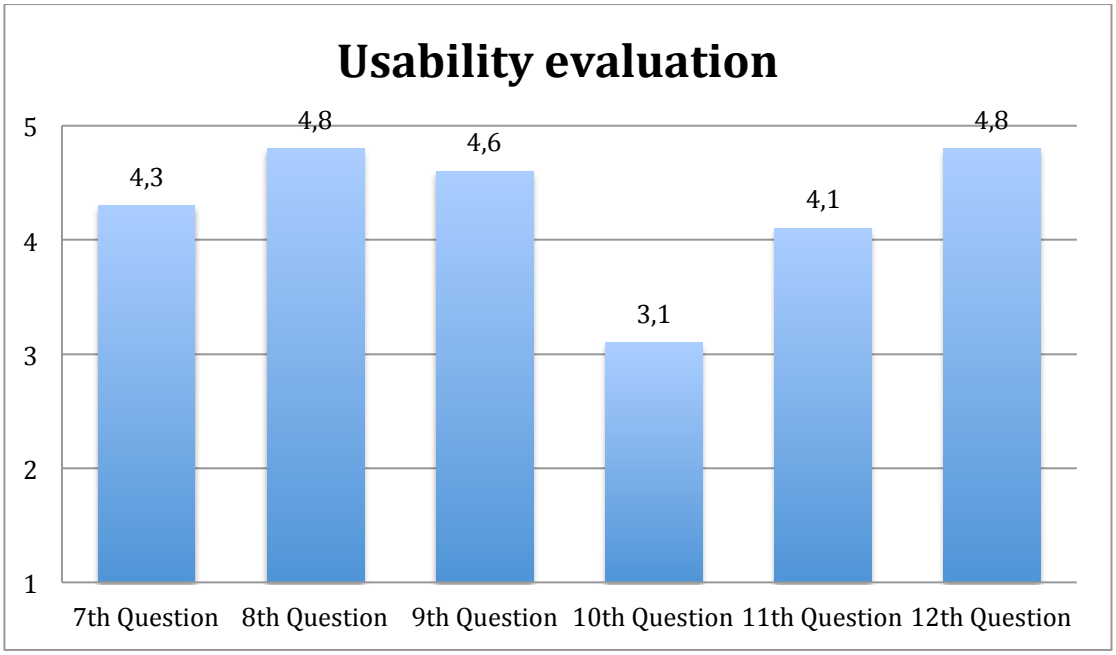
Graph 3 – Design Evaluation

3rd Question: Does the application feature interaction that is suitable to the cognitive and mobility characteristics of children with autism?

4th Question: Is the content of the application easily conceivable by the user (pictures, buttons, sounds)?

5th Question: Are the views of the application designed with visual clarity?

6th Question: Does the application offer sufficient feedback (alarm messages, prompts etc.)?



Graph 4 – Usability Evaluation

7th Question: Is the application easily usable?

8th Question: Is the application pleasant to use?

9th Question: Does the application engage the users' interest?

10th Question: How much effort is it necessary in order to learn how to use the application?

11th Question: How easily could a child with autism learn how to use the application?

12th Question: Does the application facilitate the teaching process in classroom based on the fact that it is designed for mobile devices?

Qualitative Results

Along with the questions, teachers had also the chance to express their personal opinion concerning the application in the remarks section of the questionnaire. The majority of the remarks that have been made were positive, while most of them focused on the software design and the appearance of the application. Nonetheless there were some negative comments, which in the future may prove to be valuable towards the further evolution of the application. In addition, all the qualitative results can be also drawn by the comments that teachers made either by

writing them down as mentioned before or by making a sincere and beneficial conversation with us. The facts listed below are based on both conclusions but mainly and most important on the written ones.

To start with the positive comments, the majority of the evaluators mentioned the beautiful and unambiguous visual design as well as the mobility of the device that can be taken everywhere at every time. These advantages were also compared with a computer that the teachers have already used in the educational process, and finally decided that mobile devices will be a step forward towards autism.

Secondly, teachers strongly believed that such an app would ease their way of teaching and organizing their classes, especially through the feature of multiple profiles with plenty of visual schedules on each of them. Also they were particularly interested in applying the software into a classroom with children with ASD as well as in altering their educational methods in order to incorporate such an application.

Another result was that the application could easily be used by other users aside those with autistic spectrum disorders. Some of them could be children with Down syndrome, Asperger, or even with Attention Deficit Hyperkinetic Disorder. Some of the teachers also believed that children with normal cognition and development that attend a nursery school or in case of an English lesson could also use it in order to exploit the audio and visual effects of the application.

Finally, an ardent problem that all teachers have to tackle is that children with ASD do not attend school during the summer or holiday periods in Greece. As a result all the educational contribution to the child's development is interrupted, leaving children on its own. Consequently, the teachers believe that our application would help in dealing with that issue by having all the visual schedules that were created and used into a class, stored in the device all the time. So the child would face a much desirable continuity on their every day life.

On the other hand, there were negative comments too that will be the basic updates of the second edition of the application. The main observation that everyone out of the 14 participants noticed is that the application is more suitable for children with medium to high functioning autism. They significantly pointed that children with low functioning autism are going to use both the device (iPad) and the application in a stereotypical way and it probably won't of any assistance to them. The task of training children with those characteristics is considered ardently difficult as well as challenging enough for the teachers. As a result, teachers strongly believe that the

application will not make any difference to them. Furthermore, this category of children are hardly going to use the application in a meaningful and constructive for them manner.

Another important remark was that although the application is implemented for a portable device with a touch screen that offers many advantages in the teaching process, the drawback is the device is highly priced. Consequently, it will be an excellent prospect to implement the application for other software platforms and devices other than iOS, in order to expand the number of potential users.

The last remark that the evaluators made is that the application should have a greater variety of activities. This is due to the fact that children with autism spectrum disorders occupy themselves with various activities and some times get bored by an unchanging feature. Thus it will be a good practice to enrich the application with more activities in order to cover a big part of their every day schedule. Even further, we could give them the opportunity to make their own activities in a way that they would have the chance to create even more personalized schedules.

6 Conclusions

In recent years, applications on smartphones and tablets have become innovative and creative means of informing and entertaining people. They also constitute a new way of communicating with friends and family. As a result, they consider to be a blooming and instantly available to the public industry. These figures of technology we have tried to apply to the potential users of our application. On the other hand it is clearly believed that visual schedules can assist individuals with autism spectrum disorders, however the use of mobile technology to apply such schedules into a classroom is considered extremely rear. Consequently, we concentrated our efforts in implementing software for tablets that combines the helpful effects of a visual schedule with the excessive growth of applications for mobile devices.

By analyzing the impact that tablets have on people with autism we found out that it can become a unique source of assistance for their everyday life. A large number of studies on that field show that people with ASD are good responders in mobile technologies, especially in tablets. The evaluating procedure of our application revealed that tablets could effectively be used on children with autism and the majority of the teachers would happily welcome such an addition to their lessons.

As we embark to the end of this dissertation we have to mention that all teacher were thrilled and filled with enthusiasm by the fact that an application could actually implement an every day ritual of people with ASD as well as a vital part of the lesson on every school that treats such individuals. Although, the evaluation has shown that only medium to high functioning persons could effectively use the application with or without the need of assistance. In addition to that, all categories of the potential users should spend quite some time to familiarize themselves with the application and get to know how it is properly used.

A future prospect of the application could be the addition of a larger number of activities as well as administrator privileges to the teacher or parent to edit these activities. Another perspective could be to add process-based lessons for people with ASD on a daily routine, such as a lesson on how to brush my teeth step by step. Also, the expectations of parents and teachers towards the application would probably change due to the variation of each person's needs into a class or at home, however

the basic features would always meet those needs. We could add features like recording your own sounds or printing the activities of the app. In conclusion, it is fully acceptable that the users' needs might constantly change, that will trigger our motive to implement more recent versions of the application in order to meet those needs and tackle with the problems that users have to face.

To sum up, helping children and adults with autism spectrum disorders can be an ardent motive in every ones life. By combining that motive with a complete cognition of mobile technologies can easily bring fully functional, essential, and innovative products to society.

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Appendix

A - Questionnaire

Greek edition

Εκπαιδευτική Εμπειρία	Έτη	Μήνες			
1. Για πόσο χρονικό διάστημα διδάσκετε παιδιά με αυτισμό;					
2. Για πόσο χρονικό διάστημα χρησιμοποιείτε εκπαιδευτικά λογισμικά για τη διδασκαλία παιδιών με αυτισμό;					
Αξιολόγηση Λογισμικού	1	2	3	4	5
1. Το λογισμικό περιέχει έννοιες και λεξιλόγιο που ανταποκρίνονται στις ικανότητες των παιδιών με αυτισμό					
2. Οι δραστηριότητες που περιέχονται στο λογισμικό καλύπτουν αυτές τις οποίες το άτομο με αυτισμό ακολουθεί στην καθημερινότητα του. (σχολείο, σπίτι κτλ.).					
3. Το λογισμικό παρέχει αλληλεπίδραση σύμφωνη με το κινητικό και γνωστικό επίπεδο των παιδιών με αυτισμό, δεδομένου ότι γίνεται μέσω μίας οθόνης αφής.					
4. Η πληροφορία που παρουσιάζεται στο λογισμικό γίνεται εύκολα κατανοητή από τον χρήστη (εικόνες, κουμπιά, ήχος κτλ.).					
5. Οι οθόνες είναι σχεδιασμένες με σαφή τρόπο					
6. Η χρήση του λογισμικού είναι απλή.					
7. Το λογισμικό είναι ευχάριστο στην χρήση του.					
8. Το λογισμικό συνολικά είναι ενδιαφέρον για τον χρήστη					
9. Απαιτείται ιδιαίτερη προσπάθεια για την εκμάθηση του λογισμικού.					
10. Ο μαθητής μπορεί να μάθει να χειρίζεται το λογισμικό με ευκολία.					
11. Το γεγονός ότι το λογισμικό χρησιμοποιείται μέσω φορητής συσκευής μπορεί να διευκολύνει την διδασκαλία μέσα στην τάξη.					
12. Η ανατροφοδότηση του λογισμικού είναι επαρκής (μηνύματα λάθους, προτροπές κτλ.).					

Παρατηρήσεις:

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Σας παρακαλούμε να απαντήσετε σε όλες τις ερωτήσεις βαθμολογώντας με βάση την παρακάτω κλίμακα:

1. Καθόλου
2. Ελάχιστα
3. Μέτρια
4. Αρκετά
5. Πάρα πολύ

Σας ευχαριστούμε πολύ για την βοήθεια!

Γούλιας Νικόλαος: nigoulia@inf.uth.gr
Χατζηκωτούλας Σπυρίδων: sphatzik@inf.uth.gr

English edition

Teaching Experience	Years	Months			
1. How many years have you been teaching to children with autism					
2. How many years have you been using educational software in teaching children with autism?					
Evaluation of the application	1	2	3	4	5
13. Does the application contain concepts and vocabulary that is suitable to the abilities of children with autism?					
14. Does the application contain activities that cover those that children with autism perform in their every day life?					
15. Does the application feature interaction that is suitable to the cognitive and mobility characteristics of children with autism?					
16. Is the content of the application easily conceivable by the user (pictures, buttons, sounds)?					
17. Are the views of the application designed with visual clarity?					
18. Does the application offer sufficient feedback (alarm messages, prompts etc.)?					
19. Is the application easily usable?					
20. Is the application pleasant to use?					
21. Does the application engage the users' interest?					
22. How much effort is it necessary in order to learn how to use the application?					
23. How easily could a child with autism learn how to use the application?					
24. Does the application facilitate the teaching process in classroom based on the fact that it is designed for mobile devices?					

Remarks:

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Please answer all the above questions according to the following scoring-scale:

1. Strongly disagree
2. Disagree
3. Neither agree nor disagree
4. Agree
5. Strongly agree

Thank you for your contribution!

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B – Index of pictures

UNIVERSITY OF THESSALY

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

2014