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## Hands Deliverable 1.3.1 A: HANDS – final publishable summary report

*Final Project Report*

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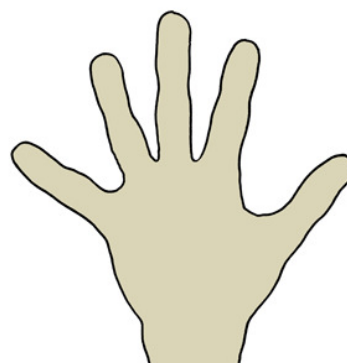
# PROJECT FINAL REPORT

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## **1 The HANDS Project – an executive summary**

The HANDS (Helping Autism-diagnosed teenagers Navigate and Develop Socially) research project involves the creation of an e-learning toolset that can be used to develop individualized tools to support the social development of teenagers with an autism diagnosis.

There are 10 partners in the HANDS project (3 universities, 3 software companies and 4 schools for teenagers with autism).

Two Prototypes of the HANDS toolset have been developed on a Microsoft platform. The HANDS toolset is based on ideas from persuasive technology. The tools are implemented on smart phones, which are in communication with the HANDS server. The HANDS toolset makes it possible for a teacher at one of the partner schools to tailor special and individual tools for his students. These tools are supposed to help the users in their daily life.

In addition to the two Microsoft Prototypes the HANDS partners have developed a Prototype for an Android platform.

The HANDS prototypes have been tested from three different perspectives (cognitive psychology, educational studies and persuasive technology studies). It has been demonstrated evidence that there is a potential in the HANDS toolset for being helpful for young people with autism.

One of the advantages of the HANDS toolset compared to other products, is that the use of the HANDS server from where the tools can be downloaded by the teachers and the students and on which all HANDS activity on the smart phones is logged. Clearly, this means that a certain degree of surveillance is involved in the use of the HANDS tools. This obviously gives rise to some ethical problems. The partners have studied this and other ethical problems related to HANDS. A special Ethical Board (EB) was been formed from the very beginning of the project. The members of the EB are independent and qualified persons not directly involved in the HANDS research. All experiments in the HANDS project had to be approved by the EB before they were carried out.

## 2. The HANDS Project – summary description of project context and objectives

The HANDS Project is defined in the DoW (Annex 1) as an agreement between the European Commission and the 10 partners in the HANDS consortium. It is the aim of the HANDS project to

- study the psychological, educational and social potential of persuasive technology as a tool for helping young people with an autism diagnosis
- develop mobile ICT solutions that will help young people with autism to become better integrated in society.

### 2.1 Activities in the HANDS Project

During the project period two prototypes of the so-called HANDS toolset were planned, designed, implemented and tested within a Microsoft environment. In addition, a third version of the tools was developed and implemented in an Android environment. The HANDS toolset is designed to be used by two closely related user groups:

- teenagers with an autism diagnoses and with normal or high IQ
- teachers at schools for young people with autism.

In fact the teenagers in question are supposed to work together with their teachers in order to make individually tailored tools, which may function as a support tool for the teenager in their daily life in school and elsewhere. The toolset is made available on the HANDS server and all interaction with the HANDS tools will in fact be stored (logged) on the HANDS server.

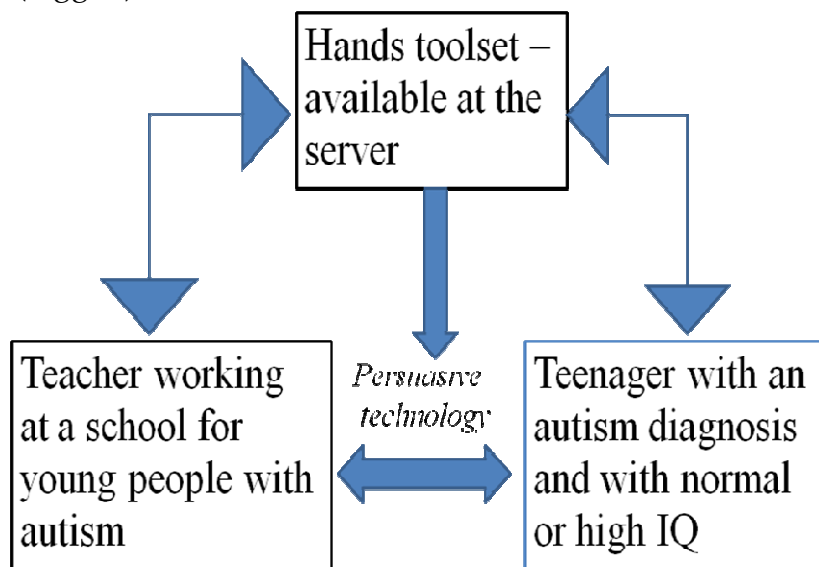
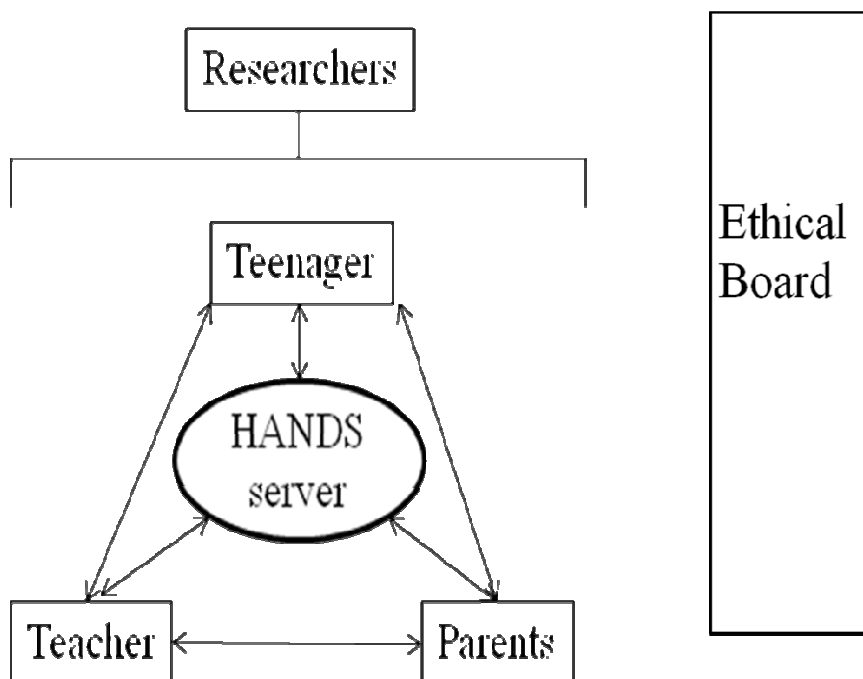


Figure 1. Using the HANDS toolset available from the HANDS server the teacher and the teenager can in fact co-operate in developing individually tailored tools, that may be helpful for the teenager in his daily life.

The toolset include the following functionalities:

1. The Handy Interactive Persuasive Diary (HIPD).
2. The Simple-Safe-Success Instructor (SSSI).
3. The Personal Trainer (TT)
4. The Individualiser (TIn)
5. The Sharing Point (SPo)
6. The Credibility-o-Meter (CoMe)

HIPD is designed to facilitate the temporal organization which is essential for the teenager. SSSI and TT offer strategies for dealing with the individual teenager’s problems. TIn makes it possible for the teacher and the teenager in co-operation to tailor the tools in an individual manner. SPo is an attempt at introducing social media to teenagers with autism in a safe manner. CoMe offers various ways for the teacher to follow the activities of the teenager in order to learn more about his interaction with the tools and his relations to them – the ultimate goal being a possibility of measuring how credible the teenager finds the tool.



*Fig. 2. The organisational setup in HANDS. Experiments etc. have had to be approved by the Ethical Board before they were carried out.*

Clearly, there are many ethical questions involved in this. First of all, HANDS involves a lot of surveillance in the sense that all activities using the HANDS tools will in principle be logged on the HANDS server. The data on the server will be accessed by the student himself, by the teachers and the researchers, and to some extent also by the parents. This clearly means that there is a need for ethical

discussions of the use of and the access to such person-sensitive data. Which data should be treated as private? In order to deal with these and other ethical questions related to the HANDS project in a qualified manner, an Ethical Board has been established as an important part of the research setup. All experiments and pilot studies in HANDS were approved by the Ethical Board before they were carried out. The members of the Ethical Board are independent in the sense that they participate neither in the research at the schools, nor in the testing procedures. However, the members of the Ethical Board have been invited to take part in the discussions at the general meetings in HANDS in order to strengthen the ethical and value-oriented dimensions of the work carried out within the HANDS project.

### **Two Prototypes on a Microsoft Platform and One Android Application**

During the project period two prototypes of the HANDS software were developed and tested at the partner schools. These prototypes were developed on a Microsoft Platform. Prototype 1 was released in October 2009 and tested until May 2010. Three very different kinds of tests were carried out by researchers from the three partner universities. The tests were carried out from three perspectives: cognitive psychology, educational studies, and persuasive design studies. The test results were discussed among all partners. These discussions were not only based on scientific principles, but also on the values and principles of the partner schools. The results of these discussions were the formulation of system requirements for Prototype 2. Again the second prototype was tested at the partner schools by the three university teams. The test results were again discussed among all partners mainly involving the user participatory design group (UPDG), which may in fact be seen as a way of operationalizing a participatory and value sensitive design approach.

The discussions among the partners in UPDG inspired yet another prototype development of the HANDS toolset, this time on an Android platform, *Handroid*, also recommended by The European Commission. A brief test program of this third version of the HANDS toolset was carried out at Egebakken in Aalborg, Denmark.

### **The test results**

The motivation behind the HANDS project is the fact that the behavioural and cognitive characteristics of people with ASD put them into a high risk of social marginalisation. The HANDS toolset tests show evidence of the importance of teachers' potential ability to identify needs that can, in many cases, be formulated as interventions on HANDS in a successful and appropriate way, and that these interventions may be very helpful for the students in their everyday life. For this reason it is also concluded that the positioning of social and life skills development, particularly in terms of the overall school curriculum and approach at schools for



young people with autism, is a significant factor in order to ensure the effectiveness of solutions like the HANDS toolset.

It should be emphasized that these potential beneficial effects all seem to depend on

- the individual's specific needs, strengths, weaknesses, motivations and attitudes;
- the pedagogical approach and expertise of the teacher;
- the institutional and professional culture of the school;
- and most probably on several other factors related to the socio-emotional context of the pedagogical intervention.

The notion of credibility turns out to be essential when dealing with persuasive technology. The literature on persuasive technology indicates (Fogg 2003, 2002) that in some instances computers can be regarded as more credible sources for persuasive messages than human actors (Gerdes & Øhrstrøm 2011). From the HANDS studies there are also some indications from interview responses for Prototype 1 that some children may actually prefer to receive persuasive messages from HANDS than from their teacher.

Various observations indicate that the HANDS toolset (or something very similar) may be relevant for a larger user group than teenagers with autism.

### **Organisation of the work in the HANDS project**

The work in HANDS has been carried out by the partners in close co-operation with Aalborg University as the co-ordinating partner. The work has been led by Peter Øhrstrøm as co-ordinator of HANDS. Henrik Schärfe has acted as assisting co-ordinator, and Morten Aagaard has been the chairman of the partner forum, UPDG. Joan Vuust Milborg has served as secretary for the project, and she has together with Morten Aagaard taken care of the internal communication among the participants in HANDS using a Moodle platform.

The software development and implementation has been carried out by Wirtek Rumania, Wirtek Denmark, and Edvantage Group. The HANDS server is placed at Aalborg University. Each of the teachers at the partner schools as well as all researchers involved in the project, have had access to the server. This means that the teachers have been able to develop tools for their students and check the interactions between the server and the smart phones belonging to their students as well as sharing experiences with each other and also to use ideas and already existing components from other users for the construction of tools for their own students. The access to the server also means that the teacher may obtain information concerning the HANDS activities performed by their students. Obviously, this information can also be used by the teacher in his teaching.

### 3 The HANDS Project – a description of the main S & T results

The HANDS team at London South Bank University has developed an explanatory model which can be used in order to obtain a clear understanding of the most important relations in settings studied in the HANDS project. The model claims that the explanatory relationships essential for the understanding of the use of the HANDS tools can be introduced in terms of this visual model. The model represents the key meta-concepts/explanatory themes identified in the thematic analysis as having a mediating factor on the engagement with HANDS.

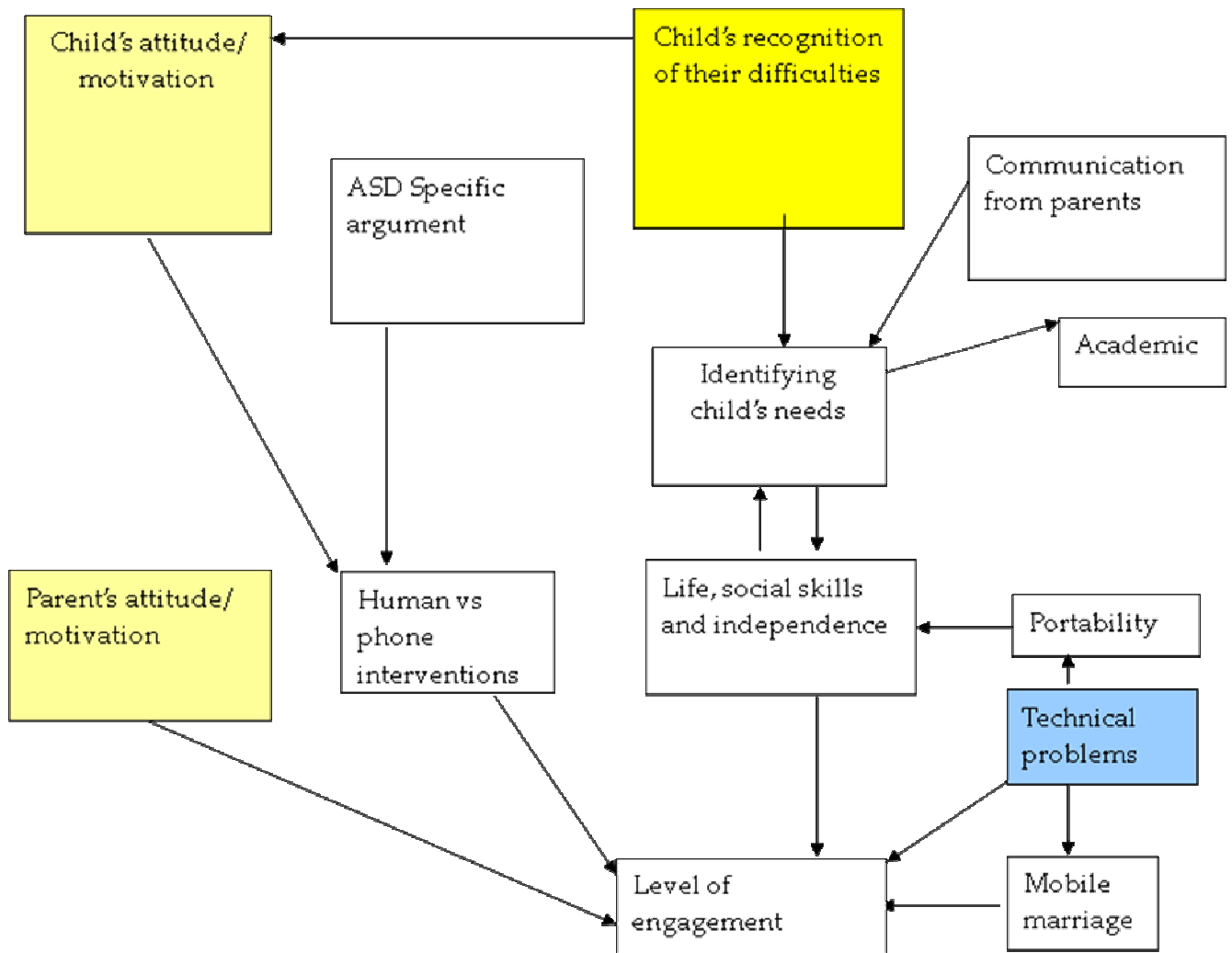


Figure 3. The model illustrates the types and strengths of interactions between the meta-concepts present in the HANDS setting. The yellow boxes highlight positive influences on engagement, whilst the blue box demonstrates a negative influence on engagement. In addition the boxes are graded in strength of impact with the smallest boxes having a relatively weak impact on the model and larger boxes having increasingly more importance.

The working assumption is that where there is a greater and more positive engagement, this is very likely to be associated with greater positive response to behavioural interventions. We expect to undertake cross analysis with the Cognitive

Psychology data set in order to validate this particular outcome more clearly for the explanatory model.

Of course the actual intensity of each meta-concept in the model will vary from case to case, thus the model shows the potential interrelationship. Clearly the model also provides a conceptual basis for the further investigations of the problems related to the use of the HANDS tools.

In the following we shall outline the results of the attempt to profiling HANDS from the viewpoints of psychology and pedagogy of ASD, succeeded by a presentation of the main results of the HANDS testing from the three perspectives used in the project.

### **3.1 Profiling HANDS from the viewpoints of psychology and pedagogy of ASD**

The HANDS tools have been designed, developed and tested with a special population in mind. In the following we shall characterise the present target group of the HANDS project keeping the possibility of a future extension of the target group in mind.

#### **3.1.1 The target group**

All effective and evidence-based interventions for people living with autism spectrum disorders are based on a comprehensive understanding of these conditions. Thus, while developing the HANDS toolset we had to consider all the specific behaviour and cognitive patterns characterizing young people with ASD. However, this profiling of the target group of the HANDS project has key importance on the perspectives of the system created, and on the future research agenda implied by all the results, products and limitations of the HANDS project. Therefore, the target group of the HANDS project will be characterised shortly.

Following the key **behavioural features** of autism spectrum conditions, all adolescent with ASD – the specific target group of the HANDS intervention - have market and qualitative developmental impairments in three fields of behaviour. They have deficits in *verbal and non-verbal communication*, including use of stereotyped, repetitive and idiosyncratic language, poor conversational and verbal comprehension skills, and difficulties in identifying and understanding gestures, facial expressions or body language. They have difficulties in developing and maintaining *reciprocal social interactions*, including forming friendships, understanding hidden social rules or sharing experiences and enjoyment. The *flexible regulation of behaviours* also show limitations, including organizing daily living activities, carrying out age appropriate leisure activities, adapting to minor changes in their environment. Above these core impairments, in many cases, *sensory*

*abnormalities, uneven cognitive profile, emotion regulation and motor coordination problems* also occur.

On the one hand, these behavioural characteristics are caused by an atypical pattern of underlying *cognitive functionings*. In recent decades, a systematic and massive body of research has proven that an ASD-specific cognitive profile is able to explain this set of co-occurring symptoms. Three main cognitive impairments have emerged as candidates for explaining the specific ASD behaviours (for summary reviews, see, e.g., [Frith, 2003], [Gyori, 2006], etc.). (1) Impairment in the *theory of mind ability* [Baron-Cohen & Frith, 1985] prevents people with autism to flexibly attribute independent mental states to self and others to predict and explain actions. (2) Impairment in *executive functions* ([Ozonoff, Pennington, Rogers, 1991], [Russell, 1997a]) leads difficulties in flexible attention shifting, inhibiting prepotente response, generating goal-directed behaviour and solving problems adaptively. (3) Impairment in the so-called *central coherence* ([Frith, 1989], [Frith, 2003]) causes problems in organizing and integrating information into coherent content and meaning.

On the other hand, these behavioural and cognitive characteristics put people with ASD into a high risk of *social marginalisation*. As we highlighted in a previous deliverable (Gyori et al, 2008, D2.2.1, p 19):

“The impairment in reciprocal social behaviours directly prevents the affected individual from participating everyday social interactions smoothly. Moreover, the oddness of social behaviours often leads to rejection by others in the social environment, and also anxiety in the affected person. The massive naïve theory of mind impairment underlying inadequate social interactions prevents the individual from handling these problems in an insight-driven way.

Similarly, the impairment in reciprocal communicative behaviours prevents the affected individual from being a natural part of usual everyday communicative transactions. This again leads to social isolation, and, in turn, anxiety in the individual. Again, massive impairment in naïve theory of mind does not make it possible to handle these problems via insight.

The strong tendency for repetitive and stereotypic activities and actions as well as the obsessively narrow interest make the affected individual strange and often even bizarre in the eyes of others in the social environment, seriously preventing her/him from social participation and inclusion. Underlying executive functions problems are too fundamental to be overcome by insight or therapeutic intervention.

Similarly, such additional symptoms as impulse control problems and emotional tantrums, or strong insistence on non-functional routines, difficulties with daily life management and self-care make these individuals, even if they are in the high-functioning segment of autism spectrum conditions, generally they are social partners hard to cooperate with, socialize with, build partnership with – without specific expertise.”

These fundamental features of Autism Spectrum Disorders have been important to recapitulate - here partly to state that the difficulties in the cognition and behaviours of individuals with these conditions have remained essential over the years since the beginning of the HANDS project: neither neural, nor other medical or psycho-behavioural interventions that are able to eliminate these difficulties have been developed. Similarly, the underlying (impaired) mechanisms have remained too complex to be replaced by any prosthetic technology. That is, *the overall psychological and psycho-educational context of the HANDS project has remained relevant*. Likewise the design and functional principles forming the basis of the requirements for the HANDS system remained relevant. (For recent, extensive reviews on various aspects of ASD, see, e.g.: Matson and Sturmey, 2011).

### **3.1.2 Overlapping aspects with other conditions: further potential target groups**

Another reason to summarise the key behavioural and cognitive features of ASD has been to point out other human conditions to some extent showing analogous, partly overlapping characteristics to/with ASD. It is important to highlight these characteristics, as the conditions represent potential future target groups for further development of the HANDS system. Considering the *potential extension of HANDS to novel target groups* naturally form a part of a future research agenda.

It must be emphasised that even though the behavioural features of ASD are highly variable, together they still form a unique pattern. That is, although several elements of the behavioural patterns of ASD do occasionally occur in other conditions, solutions elaborated for individuals with ASD cannot, most of the time, be transferred to other groups without an appropriate adaptation procedure.

With this important reservation, **Table 1** below offers a short overview of a few important conditions that have overlapping features with ASD, and seem worth to bring into consideration as novel target groups of further developments of the HANDS system.

	<b>Nature and origin of condition</b>	<b>Estimated prevalence in societies</b>	<b>Most affected part of lifetime &amp; course of development</b>	<b>Key analogies to behavioural/cognitive phenotype of ASD</b>	<b>Tentative specific subgroup(s)</b>
<b>Attention Deficit / Hyperactivity Disorder</b>	Neurodevelopmental disorder with heterogeneous causal background, often with strong genetic loading	3-5 % of people under the age of 19, with considerable geographical / local variability	Childhood and adolescence (in 30-50% it persists to adulthood)	Overlapping cases and limitations in attention and impulse control, adaptive flexibility	Relatively mild cases from late childhood to adulthood
<b>Developmental Intellectual Disabilities</b>	Developmental condition due to heterogeneous causes, often with strong genetic loading	2-3 %	Whole lifetime affected	Overlapping cases and limitations in adaptive behaviours & social understanding	Adults
<b>Alzheimer Disorder</b>	The most common form of progressive dementia - strong but heterogeneous genetic loading	0.4 %	Age > 65 years, progressive	Limitations in: - adaptive behaviours - social understanding - communication	Early-phase and mild cases
<b>Frontal/prefrontal brain injuries</b>	Acquired brain injuries, due to heterogeneous causes	0,3-1 %	Can occur at any age, more frequently in adolescents and young adults, though growing prevalence towards/in old age	Limitations in: - adaptive behaviours - social understanding - communication	Relatively mild cases

*Table 1. Some neurocognitive conditions showing cognitive-behavioural difficulties, to some extent analogous to those in ASD.*

## 3.2 Test Results and Recommendations

Some of the evaluations of the HANDS tools carried out in the project are quantitative and some are qualitative. The quantitative methods have mainly been used in connection with the psychological approach, whereas the methods used for the tests based on educational and persuasive technology studies are mainly qualitative. In the following, the test results will be outlined. It should be said that the efficiency testing mainly exists as a separate stream (focus on specific ASD outcomes) to the participatory user design approach (focus on development and fit to practice and field of use), but aspects of efficiency testing in places (e.g. eye tracking) also inform the user design approach.

### 3.2.1. The Evaluation Result in HANDS seen from the psychological perspective

In the *Report on test methodology and research protocols* (D2.1.1; Gyori et al, 2008) it was emphasised that there is a strong need for systematic efficiency research regarding psychosocial intervention for people with ASD to prove that they can be considered as *evidence based practice* (EBP). In the recent years several different reviews of evidence-based practices of treatments for young children with autism were published but there is little evidence for the relative effectiveness of these treatment options (e.g. Reichow et al, 2008; Seida et al, 2009).

In order to give an effective answer to this problem, a new method for the evaluation of empirical evidence was developed by Reichow et al (2008, 2011) to identify the practices that could be considered EBPs for children with ASDs.

In the threefold system, the rigour and strength of a research report can be determined, as well as criteria for determining whether an intervention is EBP.

To be able to evaluate a research report *rigor* (i.e. the methodological quality of the research report) differ, but similar criteria were developed for group research method and single case design. Several primary quality indicators (e.g. participant characteristics, independent variables, comparison conditions, dependent variables, baseline condition, link between research question and data analysis, visual analysis, statistical analysis, experimental control) and secondary quality indicators (such as random assignment, inter-observer agreement, blind raters, fidelity, attrition, generalization or maintenance, social validity, effect size) were identified. The research report is evaluated against all these quality indicators one by one and can be awarded as high quality (H), acceptable quality (A) and unacceptable quality (U).

The second instrument rates the *strength of the research report* by summarizing the results of quality indicators above. Three levels of the research report strength were identified: strong, adequate, and weak.

The third instrument provides a criteria for determining whether a practice has amassed enough *empirical support to be classified as an EBP*. Two levels of EBP can be achieved: established and promising.

It would seem a highly useful endeavour to evaluate the efficiency testing of HANDS against these criteria – though they have been published after the beginning of HANDS. However, some further analysis of data from HANDS is clearly needed to make such an evaluation with the due precision – too little time has been available since the completion of our data sets from Prototype 2 testing. This is clearly a task for the future, but it is worth noting that while in some respects HANDS certainly cannot fulfil all the most stringent criteria, our efficiency testing still belongs to the rather small set of relatively large-scale and successful efficiency studies on interventions in ASD.

As it was explained in D2.4.2, the overall design of the psychological efficiency testing in the HANDS project has been based on the scheme of a *Randomized Controlled Trial (RCT)*, an ideal way of measuring effects of an intervention technique. However, for both practical and ethical reasons, it has been impossible to carry out a *bona fide* RCT on the efficiency of such a psycho-behavioural intervention methodology, as HANDS-aided interventions are. Therefore, our testing methodology attempted to approach the model of an RCT as much as possible, but at the same time took all the relevant ethical and practical considerations and limitations into account (hence we called it a *quasi-RCT*).

With all its necessary limitations and modifications ‘on-the-fly’, this methodology represents a *rare and valuable attempt* of controlling intervention effects quantitatively - both, more narrowly, in the field of assistive technology for people with autism spectrum condition, and, more broadly, in the field of psycho-educational intervention techniques for the same group of people (see the previous part of this document).

Our overall methodology comprises of two more specific methodologies. *Psychometric-behavioural methods* served as the backbone of psychological efficiency testing. In the HANDS Project deliverables, D2.1.1 and D2.4.2, we conceptualised the possible effects of using the the HANDS toolset, to be measured by these psychometric-behavioural methods, on three levels (for more detail, please refer to the documents mentioned above):

- *general effects*, measured by standard, comprehensive tools
- *skill- or ability-level effects*, measured by more focused tools
- *specific effects*, measured by HANDS-specific tools.



As the testing of HANDS Prototype 1 had no significant effect on the medium level (see D2.4.2, Gyori et al., 2010 for details), a general level of inquiry has been omitted for Prototype 2 testing and, instead, log-data-related analysis of psychometric data has been introduced (see D2.5.1, Gyori et al. 2011 for details).

The RCT, based on psychometric-behavioural methods, has been complemented by eye-tracking studies in order to test whether the user interface of a software guides adaptively the user's attention. Eye-tracking measurements were not involved in the quasi-RCT design described above. Instead, at the end of the testing periods of both Prototype 1 and 2 a series of eye-tracking measurements were administered to be able to control the adaptivity of the graphical design of the HANDS Mobile user interface.

In the following, we will summarize the key findings and conclusions, largely on the basis of deliverable D2.5.1 (Gyori et al., 2010).

### **3.2.1.1 Skill-level findings**

Analyses of data gained by the Social Responsiveness Scale brought relatively univocal, though largely negative, results. Though, in many ways, SRS ratings have proven to be sensitive tools to measure changes in some ASD-related skill-level difficulties and gains, some significant findings quoted above seem to have shown, that HANDS-assisted pedagogical intervention has not brought robust specific effects. This last proposition is true regarding both potential positive and negative effects.

Putting it briefly, testing the efficiency of the HANDS Prototype 2 toolset by psychometric tools – Social Responsiveness Scale and HANDS Follow-up Questionnaire – has not brought any *robust* effects *on group level*. Neither strong positive effects, nor strong negative effects were found, although both kinds of effects would have had some plausibility. Strong positive effects could have arisen from the HANDS toolset being highly advantageous above traditional forms of psycho-educational support; while negative effects could have easily arisen from the mere fact that children in the test group necessarily had to get acquainted with a novel form of support, and learn related new skills.

Instead of such massive effects, an apparently relatively noisy data set was collected. This is demonstrated by, at least, two kinds of findings:

- weak correlations between parents' and teachers' ratings; and
- quite sporadic and mixed positive and negative effects found.

There are several possible reasons which, in various patterns, could explain the noisy nature of the data set and the lack of massive group-level effects:

- *Very short testing period*: three months of testing is quite short to gain robust improvement effects – necessarily tight timing of the project, however, could not allow for a longer testing.
- *Initial and/or ‘inherited’ instability issues/bugs in the software*: although, according to users’ judgements, Prototype 2 of the HANDS software showed significant improvements in terms of stability and overall quality (see D3.5.1), as compared to Prototype 1, still there were some minor instability issues at the beginning of Prototype 2 testing period.
- *Strong and mixed expectations* from the children, their parents and teachers could all influence the data set; and this is true of negative expectations as well as positive ones (expecting ‘breakthrough’ effects from Prototype 2). Qualitative research has shown that both kinds of expectations were present among children and teachers (see D3.4.1 and D3.5.1 by ALE research group at London South Bank University).
- *Less pervasive and continuous usage* than expected arose at the beginning. It seems from qualitative research, and largely from the above factors, that this could also contribute to the lack of massive group level effects set of data.
- Finally, *clearly diverse institutional cultures and pedagogical practices* across the four test sites (see deliverables referred to above) certainly contributed to ambiguities and relative poverty of group level effects.

It is certainly relaxing that no massive negative effects arose in the Prototype 2 testing, as measured by SRS and HFQ. As noted above, such effects could have arisen due to (1) introducing a radically novel way of support, (2) the necessity to learn novel skills, and, (3) to some extent, withdrawing the well-established traditional modes of support. Lack of robust negative effects, in this context, speaks, in a way, for the relative ‘strengths’ of HANDS-assisted pedagogical intervention. However, the fact that there is not robust positive effect *on group level*, does *not* exclude that there *are* positive effects, revealed by alternative ways of analysis – see later in this document.

### 3.2.1.2 Specific effects

*Our overall question* in measurements by Experimental Task Analysis (ExTA) has been whether the visual algorithm given by Prototype 2 of the HANDS software works at least as well as the ‘traditional’ paper-based visual support. This overall question has been broken down into 2 more specific questions that could be approached by statistical methods:

- (1) Is there significant improvement in task performance when using support (visual algorithms)?
- (2) Are there differences in the extent of improvements between the two groups (HANDS user test pupils & paper-based support user control pupils)?

In the test group, we have found strong significant improvements (lesser deep prompts were needed) after the introduction of the HANDS-based visual support. In the control group, our results show the same direction of effects, but with less strong significances in two variables and only tendency-level probability in the third one. Moreover, in the HANDS-user test group the *number of necessary prompts decreased to a significantly larger extent* than in the control group, while in the test group the *depth of necessary prompts decreased to a tendentiously larger extent* than in non-HANDS user group. *This shows the potential efficacy of HANDS-like approaches to the development of social and life skills functions in young people with ASD.*

The overall conclusions from ExTA measurements in HANDS Prototype 2 testing are the following:

- in case of *specific, much-focused psycho-educational interventions*, such as supporting adolescents with ASD in performing specific challenging social or daily-life activities, the HANDS Mobile toolset has proven to be a *highly efficient medium of intervention* in the short run.
- In such situations, HANDS-assisted interventions *can be significantly more effective* than traditional ('paper and pencil') support tools.

These conclusions assume that the decision to use the HANDS toolset is made on the basis of careful consideration of the individual user's specific needs for support, and the actual focus and content of the intervention is set and designed on the basis of such considerations *and* a professional understanding of principles of psycho-educational intervention and support in ASD. In terms of the LSBU causal model (Figure 3 above) it may be said that the qualitative data give useful info on what the specific factors resulting in successful use will be.

### **3.2.1.3 Findings from log-data-related re-analysis of skill-level data**

These analyses were motivated primarily by two interrelated facts: first, testing was moved from possible overall, general effects (see section 1.1.1 of D2.1.1) towards potential skill-level and specific effects based on findings from the HANDS Prototype 1 testing focusing on psychological efficiency. Linking individual usage with individual effects is a methodological movement into the same direction. Second, skill-level investigations of effects of HANDS Prototype 2 did not bring particularly robust evidence for any (positive or negative) massive effect.

Although findings from log-data-dependent re-analysis of effect measures are somewhat heterogeneous and data set is obviously noisy, the *overall, dominating tendency is that more intensive usage of the HANDS Prototype 2 toolset gives more positive effects.*

However, an important cautionary note must be made. The facts that we calculated correlations and that our (positive) findings are correlative findings, imply that

actual cause-effect relationships remain, strictly speaking, undisclosed. It comes from the nature of correlative studies that we *cannot* say with certainty that it is the more intensive usage of the HANDS toolset that *specifically caused* the more positive effects. Actual causal links can be quite complex. For example, potential effects of more cognitively flexible children using the toolset with a higher probability and frequency, and the possibility that these children are more prone to show significant development in a relatively short run. But again, as we must remain agnostic about specific causal patterns, we cannot know if such a chain of causation indeed played a role in giving rise to the correlations we found. Usage frequency can easily be a mediating factor between several relevant causal aspects (related to individual kids' characteristics, teachers' attitudes and proficiencies, schools' institutional cultures, individual and institutional histories, and so on, and so on) and individual gains in skills as an effect. Unfolding these intricate causal patterns would require a study on a significantly higher order of magnitude (in terms of sample size, testing time, test methodologies, and so on) than testing the HANDS toolset has been. However, the correlation is still suggestive of impact. It suggests need and potential benefit for longer in depth trial of the usage of a HANDS-like technology.

On the other hand, direct comparisons did not reveal any significant negative effect either and, apart from one massive but highly specific example, no negative correlations between usage frequency and developments have been found. From these facts we can safely conclude that using HANDS Mobile Pt2 as an assistive tool have not caused any significant harm – it is *not a less effective medium* of psychopedagogical interventions than the traditional (largely 'paper and pencil' ones). Taken into account that its introduction clearly required effort from the part of both teachers and subjects, and occasionally and initially lead to frustrations, we can render it probable that the above-found positive correlations between usage frequencies and behavioural gains (to some extent) *do indeed mirror positive causal effects* of applying HANDS Prototype 2.

It seems worth returning to the issue, why correlations (probably) implying positive effects have been found here, and, at the same time, no positive effects were found in direct comparisons. This seems to be due to the fact that the direct comparisons involved all valid cases in our sample – irrespective of how much they used the toolset. In these analyses, therefore, the test subjects, who used the toolset just to a minimal extent, were part of the analyses with the same 'weights' as those who used it on a regular basis. The presence of the former set of cases in the data set seems to have masked the gains shown by the latter set of cases. Correlative analyses by their very nature target precisely these differences.

#### 3.2.1.4 Findings from eye-tracking

Analysis of eye-tracking data has brought quite clear-cut and positive results. Our dynamic-interactive methodology showed largely similar patterns of visual scanning behaviours in the ASD group and in the non-autistic control group. This overall finding, together with the fact that in both groups all subjects solved all tasks in an errorless way, suggest that, generally speaking, the visual user interface of the Prototype 2 of the HANDS Mobile software, and especially its Persuasive Trainer functionality has an adaptive design, well-suited for the needs of the target group – though a cautionary note will follow below.

We believe that the above conclusion can tentatively be generalised to the Handy Interactive Persuasive Diary functionality, too. It has not been *directly* investigated in the present analysis, as HIPD-related data were far too ambiguous to be brought into the analyses. However, successful task behaviour necessarily relied heavily on this functionality, too. As both groups were equally successful in solving the tasks and as significant differences in visual scanning can be attributed to very specific aspects of the Persuasive Trainer interface (see next paragraph), we seem to be on safe grounds when concluding that the visual design of HIPD appears to be adaptive, too. Finally, as the reward surface and overall control surface of the HANDS Mobile have been successfully tested in the Prototype 1 testing, with positive results, , we can generalise the positive outcomes to the overall visual design of the HANDS Mobile system.

We must remind the reader, however, that some differences have also been found between the attentive behaviours of ASD and control groups. Overall, ASD subjects needed more time and fixations to solve the tasks with the same success as the control groups. This difference can be attributed to autistic subjects' *relative difficulties with processing written instructions*. This is, on the one hand, in line with our previous findings from Prototype 1 testing, but on the other hand, it seems to be related to autistic subjects' relative difficulties with linguistic/written information, and therefore it cannot be seen as a problem related to the graphical design of the HANDS Mobile user interface.

Overall, in our view, eye-tacking data convincingly suggest that the HANDS Mobile graphical user interface has been adaptively designed to support teenagers with ASD in problematic situations. It also indicates, that the feedback, based on eye tracking, which led into the design review process from the evaluation of Prototype 1, was beneficial.

### 3.2.1.5 Conclusions on the efficiency of the HANDS toolset

On the basis of the above-summarised main results of our quantitative studies, the following general conclusions can be drawn on the effectiveness and visual design of the HANDS Mobile toolset:

- The visual user interface of the HANDS Mobile toolset has been designed adaptively, that is, in accordance with the specific needs of adolescents with Autism Spectrum Disorders. This conclusion assumes that the actual visual settings of the user interface are set carefully according to the specific needs of the individual user. These are pre-requisites of any successful intervention, and, therefore, for the further conclusions below, too.
- In case of *specific, much-focused psycho-educational interventions*, such as supporting adolescents with ASD in performing specific social or daily-life behaviours that are problematic for them, the HANDS Mobile toolset has proven to be a *highly efficient medium of intervention*, at least in a very short term. In such situations, HANDS-assisted interventions *can be significantly more effective* than traditional ('paper and pencil') support tools. Again, this conclusion assumes that the decision to use the HANDS toolset is made on the basis of careful consideration of the individual user's specific support needs, and the actual focus and content of the intervention is set and designed on the basis of such considerations *and* a professional understanding of principles of psycho-educational intervention and support in ASD.
- Appropriately used on a regular basis in a longer run (months), the HANDS toolset seems to have more general positive effects on developing social and daily life skills in teenagers with ASD. From our studies we cannot (yet) positively tell whether these effects may be significantly stronger than those of applying traditional means of psycho-educational intervention, but our results suggest that they are at least on par with them. Again, these longer-run positive effects pre-assume a careful consideration if applying HANDS-based mobile cognitive support is appropriate in case of the given individual, and also a careful composition and continuous monitoring of the specific details and content of the interventions, based on expertise in evidence-based psycho-educational approaches to autism.
- It should further be emphasised that these potential beneficial effects all seem to depend on
  - a. the individual's specific needs, strengths, weaknesses, motivations and attitudes;
  - b. the pedagogical approach and expertise of the teacher;
  - c. the institutional and professional culture of the school;
  - d. and, most probably on several further factors, related to the socio-emotional context of the pedagogical intervention.

Although these factors were not quantitatively investigated, but qualitative research findings from other research streams, these streams strongly suggest their relevance.

Though our quantitative studies could not aim directly at the effects of the HANDS toolset specifically on social inclusion versus marginalisation, the implication of the above-summarised findings is that the HANDS toolset in its present or further-developed form can be an important element in the complex methodological toolkit used in the education and support of people with autism, leading to a lower chance of social marginalisation.

### **3.2.1.7 Key products of efficiency testing beyond findings**

In our view, the efficiency testing of the HANDS toolset has brought at least two important methodological innovations, as important ‘products’ beyond findings.

- (1) The newly-developed Experimental Task Analysis (ExTA) seems to be appropriate to measure effects of intervention techniques aiming at individually relevant goal-behaviours, which could be strong on a linear algorithm. This suggests that ExTA could be useful not only for autism-professionals, but for researchers and practical professionals, too, who work for and with people with special needs, especially with individuals with Autism Spectrum Conditions, and who try to evaluate the success of an individualised training/education/therapy/etc., as objectively as it is possible.
- (2) Our dynamic-interactive eye-tracking methodology developed to test the visual layout of the HANDS Mobile system appears to be unparalleled in the field of eye-tracking studies on Autism Spectrum Conditions. It may serve not only as a model for testing mobile assistive applications in safe but ecologically valid settings for this target group, but may also be a useful framework for basic cognitive/psychological research on the psychological background of ASD. This is the case as the methodology uniquely combines active control of relevant instruction with active task solution in a well-defined (virtual) work-space, all integrated in a computer screen as a surface of gaze-tracking, too.

Moreover, now beyond these products, our research findings show that the methodologically mixed and complex research strategy characterizing the HANDS quantitative efficiency testing, narrowly, and the HANDS testing, more broadly, has proven to be a highly useful and productive methodological approach.

## **1.2.2 The Evaluation of the use of the HANDS Tools seen in the context of the co-operation between the students and their teachers – based on educational and persuasive technology studies**

The applicability in the learning environment evaluation focused on:

- the applicability of the ICT tool to the learning environment – i.e. how it fits with existing practices of teaching and learning *and* what impact it has on such practices;
- gaining feedback on the development, improvement and overall technical assessment of the ICT tool and elucidating recommendations for functional changes for the future development of the tool, and similar mobile technology.

In persuasive technology studies the emphasis is on:

- designing interactive technology, the use of which will lead to a changed attitude or behaviour without using deception or manipulation (or other unethical strategies);
- investigating the qualities of technological solutions, which may cause people to actually use such solutions.

The educational evaluation involved detailed respondent feedback mainly from teachers, but also from children and parents. Classroom observations provided relevant triangulation data on teacher responses from the Helen Allison School, Autism Foundation and Svedenskolan test sites.

A thematic analysis of the full data set was undertaken. A coding structure was developed, adapted from the Prototype 1 coding scheme and mapping back to the key research questions. Following the initial descriptive coding exercise, an axial or thematic coding was undertaken, which identified key potential mediating factors affecting the use of the HANDS tool.

Interview transcripts, questionnaire responses, and observational narrative records (forming the data set) were uploaded to the Nvivo qualitative data analysis software package and the data set was coded against the coding structure within Nvivo. An analysis was also undertaken of the CoMe Log File data for specific children.

The persuasive design evaluation has focused on the use of the HANDS tools in order to support the teenagers with autism to function better in social settings. The main question in this context has been to what extent the use of the tools has led to the changes in behaviour or attitudes, setup by the teenagers and the teachers in co-operation and to which the teenager has given his or her consent. All participating teenagers at the four partner schools have been individually interviewed in order to



obtain information concerning the use of the tools and the experienced effects. In addition, information regarding the persuasive effects has been gathered from meetings with the teachers involved in HANDS at the partner schools.

### **3.2.2.1 The Identified Data Themes**

The axial/thematic coding of the data, following the initial descriptive coding exercise, resulted in the development of a series of meta-codes, which have been referenced against all of the data samples (across Prototype 1 and 2 use) including parent, child and teacher interviews, questionnaires and observations. The meta-codes represent a systematic identification of themes or potential causal relationships within and between the data sources.

In analysing the data, our focus was on a series of cases, defining cases as a teacher-child dyad. Thus, if one teacher worked with three children using HANDS, then this would be analysed as three teacher-child cases. In total we identified 27 teacher-child cases in the data.

These teacher-child cases represent, of course, the same test subjects as used in the Cognitive Psychology and Persuasive Technology testing. Cross referencing between the data sets has been relevant and useful. In particular, the cognitive profile – child age, IQ, VQ, comorbid diagnosis, has been relevant to the interpretation of the qualitative data.

The key themes identified were:

1. Students' awareness of their difficulties
  - a. A key finding during Prototype 1 and included in D3.4.1 was that: "most instances of effective use of HANDS by children in the test group were predicated on the individual child recognizing that an issue existed with a particular behavior and having some level of motivation to engage with change". We also made a connection with "age and cognitive appropriateness" in arguing that for some children cognitive ability may mediate their ability to recognize that they have an issue or difficulty. The recommendation in D3.4.1 arising from this analysis was that teachers and students should focus more clearly on identifying clear goals when working on behavioral changes in HANDS. The Prototype 2 data provides further evidence to support this recommendation.
2. Accurate identification of children's needs and associated formulation of interventions
  - a. During the Prototype 2 implementation we have had evidence that the accurate identification of the children's needs by teachers, followed by the formulation of well-bounded and clearly defined interventions on

HANDS, are likely to lead to higher levels of engagement and response to behavioral interventions.

- b. We also identify, from our evaluation of Prototype 2, that where such accurate identification is undertaken, it needs then to be expressed in a clearly formulated intervention on HANDS. Thus some interventions will, by their nature and the functional ability of HANDS, lend themselves to clear formulation in HANDS, and some will not. The evaluation indicates that teacher awareness of such distinctions is an important factor in mediating the appropriateness of interventions developed on HANDS, and subsequent engagement with the intervention by the children.
3. General Identification of Need: Teacher Expertise and Teacher Guidance based on the Persuasive Design technique called “tunnels” (see Fogg 2003; Øhrstrøm 2011).
    - a. In response to recommendations from the Prototype 2 evaluation, the HANDS consortium developed a set of “tunnels”, which were linked to the web server software and guided teachers in developing interventions for individual children as well as facilitating the exchange of templates and best practice examples.
    - b. However, our evaluation indicates that in Prototype 2 teachers still often found it difficult to identify the appropriate pedagogic use of the HANDS mobile tool. However, in some cases, teachers did find the tunnels to be beneficial and made significant use of them.
    - c. Thus we assert that there is potential in the use of adjunct tunnels and best practice ideas exchange systems such as the Prototype 2 tunnels, and that their use for mobile persuasive systems such as HANDS can usefully be explored further.
  4. Portability
    - a. In Prototype 1 we noted that “extending the reach” outside the classroom was a significant aspect of the HANDS software and that emphasis should be given to the portability of HANDS in selecting behavioral interventions, particularly with regards to interventions focused on locations outside of the school (D3.4.1, Recommendation 3). The evaluation of Prototype 2 indicated slightly less emphasis on out of school uses of HANDS than in Prototype 1. However, there was evidence that teachers did set up interventions for outside the classroom, particularly in the home environment.
    - a. Our evaluation also indicates 1) teacher assessment of the capabilities of their students will at times restrict and guide their thinking on how independent a student can be outside of the school domain, and 2) a linked lack of emphasis on use outside of school in some cases at Svedenskolan and Autism Foundation Schools. At Svedenskolan, some teachers found it difficult to identify and formulate interventions

for use outside of school. At Autism Foundation, there was, in some cases, a reluctance to allow the children to take the HANDS mobile out of school due to capability and safety/security concerns. However, in both schools there were instances of successful use of HANDS outside of school during Prototype 2

5. Learning social and life skills (positioning of social and life skills development)
  - a. School settings focusing on social and life skills can give teachers an increased opportunity to support the child's development of these skills. In particular our evaluation across Prototypes 1 and 2 indicates that there is a qualitative difference in emphasis on the balance between school focus on academic versus social/life skills between the test site schools. Thus, in our analysis we classified Helen Allison School as having a greater emphasis on pure academic development, and Autism Foundation and Egebakken schools as having more emphasis on social and life skills development. Note that we attach no negative connotation to this difference in emphasis, which is based on legitimate structural policy approaches.
  - b. There is evidence that of the potential ability of teachers to successfully and appropriately identify needs that can in many cases be formulated as interventions on HANDS, which may be very helpful for the students in their daily life. Hence, it is concluded that the positioning of social and life skills development, particularly in terms of the overall school curriculum and approach, is a significant factor in order for the use of solutions like the HANDS toolset to be effective.
6. Persuasion and credibility; Human vs HANDS interventions
  - a. The literature on persuasive technology indicates (Fogg 2003, 2002) that in some instances computers can be regarded as more credible sources for persuasive messages than human actors (Gerdes & Øhrstrøm 2011). We also had some indications from interview responses for Prototype 1 that some children may actually prefer to receive persuasive messages from HANDS compared to their teacher.
  - b. The evaluation indicates that for some children with ASD, they have a preference for receiving persuasive interventions from a mobile device in comparison to their teacher in some contexts. In some cases, this is because children do not perceive the mobile device as having the overbearing or "nagging" quality of their teacher. This could be considered having resonance with our meta-concept of students' awareness of need. In that case, a greater focus on the child's own identification of their own needs can be regarded as an expression of their own autonomy. Similarly, children may regard the device as a removal from the perceived authority of their teacher, and thus may feel that their sense of autonomy is better preserved when they receive

messages from the mobile device as compared to their teacher. In other cases, there is a mode preference for the reception of sequential instructions, as on the mobile device, particularly with the Personal Trainer function in Prototype 2, the child can control the flow of information.

7. Persuasion and credibility - Mobile Marriage
  - a. Mobile marriage is the development of an intensive positive relationship between the user and the device, based on repeated interactions over a period of time. These repeated interactions will typically involve other mobile phone functions such as the use of SMS, Internet, Social Media etc. The development of this positive relationship increases the perceived credibility of the mobile device and thus increases the likelihood that the user will respond positively to persuasive messages delivered via a specific persuasive mobile system such as HANDS.
  - b. Based on evidence from the Prototype 1 evaluation, we postulated that the process of mobile marriage both increased usage and the likelihood of successful interventions is increased.
  - c. In our evaluation of Prototype 2, again we have seen evidence to support the potential influence of mobile marriage as a factor mediating a positive engagement with the HANDS mobile tool.
8. Student Awareness of and Preference for Other Phone Models
  - a. The potential influence of mobile marriage can also be seen, albeit indirectly, in the reporting by a number of children of their preference for later Smartphone models. All the students in the HANDS test group have been using HTC 2009 models for the duration of Prototype 1 and 2. However, there has been some debate amongst the users and teachers about other Smartphone models that are available on the market, for example the iPhone.
  - b. The data provides strong, albeit indirect, evidence to support the contention that mobile marriage is a significant factor in mediating the child's engagement with HANDS and their response to behavioral interventions. If they don't view the phone itself as having credibility (because it is viewed as an "old phone"), they are less likely to want to engage with it, and in the perception of students, parents and teachers, less likely to respond positively to persuasive messages from HANDS.
9. Influence of the ASD diagnosis
  - a. Our evaluation of Prototype 2 has identified some instances in which mobile persuasive technology is potentially effective in promoting behavior change with children and young people with ASD because it aligns itself with certain cognitive or social features typical of people with an ASD diagnosis. For example, for some children with impaired executive functioning, the ability to receive step by step instructions

from a mobile device at a rate that they can control may result in better performance when compared to instructions given orally by an adult.

#### 10. Communication with parents

- a. Our evaluation indicates that in some instances teachers felt that they needed to have greater liaison with the child's family when using HANDS. Parental input can facilitate out of school use, thus maximizing the portability potential of HANDS, and the potential to fully exploit opportunities for social and life skills development outside of the school.
- b. Practically, it is important that teachers communicate with parents when planning interventions timed to activate when the child is at home with their parents. Furthermore, parents can contribute with vital pieces of information about overall social and life skills which teachers may otherwise be unaware of. Our evaluation of Prototype 2 indicated that where there has been effective liaison with teachers, this has been associated with the successful development of out of school interventions.
- c. In one case at least the introduction of HANDS has facilitated increased communication between home and school.

#### 11. Platform reliability and the effect on: a) credibility, and b) portability

- a. Although major technical problems have not been as widespread or as detrimental to PT1 compared to PT2, these issues have not been fully eliminated. Having said that, teachers have felt that technical problems have decreased and, as a result, are more positive about the technical quality of HANDS.
- b. The technical stability of the software and also the perceived reliability by teachers and pupils will affect how credible the device is thought to be for use outside of the school. This is a particularly important factor for use outside rather than inside the school, as within the school there are alternative support structures more readily available such as pen and paper forms of support as well as staff such as teaching assistants, who can provide on the spot support if the technology fails or does not quite match the needs of a particular situation. If the child is using the phone independently, an adult may not be there to support them. In such circumstances, the reliability of HANDS has more relevance.

#### 12. Platform flexibility, credibility and portability

- a. In addition to platform reliability, our evaluation of Prototype 2 has also indicated that platform flexibility is a significant factor mediating, in particular, the potential use of HANDS in out of school settings. Specifically, our evaluation indicates that in order for more out of school use to take place, greater flexibility is also needed between the mobile device and the web based CoMe programme.

- b. Teachers at AF have noted that it is easier for them to use HANDS in school, where they can be sure that if they need to change something suddenly they have alternative strategies which can be employed easily or they have a computer at hand in order to change the scenario.

Thus, can be concluded, that the individual's specific needs, strengths, weaknesses, motivations and attitudes, the pedagogical approach and expertise of the teacher, and the institutional and professional culture of the school, all play significant parts in determining the extent of engagement with HANDS, and the consideration from the efficiency testing results is clearly borne out by the qualitative analysis. Further, the correlation data on the usage level of HANDS is given contextual support by the identification of multiple engagement patterns varying across students and teachers, again as identified in the qualitative data.

### **3.2.2.2 Overall Conclusions and Recommendations Regarding HANDS Prototype 2 Arising from the Qualitative Analysis**

Persuasive Mobile Technology for Children and Young People with ASD is mediated by a) the child's awareness of a difficulty/issue; b) their motivation to achieve behavioural change; c) teachers' identification of needs and d) formulation of well-specified interventions.

Our evaluation indicates that in line with the general literature on persuasive technology, mobile persuasive interventions for children and young people with ASD are more likely to be effective if the child is both a) aware of difficulty/issue and recognised as such, and b) motivated to achieve positive behaviour change. Concomitantly, such awareness and internal motivation on the part of the child needs to be coupled with teacher ability and orientation towards identifying social and life skill issues that can be programmed on a mobile persuasive system such as HANDS. Teachers must have the necessary understanding of the potential pedagogic uses of HANDS allowing them to define well-formulated behavioural interventions on HANDS or a similar system.

Our recommendations for further development of mobile persuasive tools for ASD are:

- a) The tunnels system developed for Prototype 2, or a similar system, should be further refined and developed. The usage of such systems should relate to the existing best practice examples developed during HANDS and available on the HANDS system.
- b) Teachers should develop interventions for HANDS and similar systems based on recognition of the fact that student awareness of needs and internal motivation for behaviour change is a key mediating factor. Rather than starting

from a position of “teacher knows best”, they should work collaboratively with children and young people to identify interventions that the child or young person themselves assents to.

c) Strong consideration should be given, in school based implementations, of such systems, to increasing the autonomy of the child or young person in terms of their level of control over the interventions that are developed for them on HANDS-like systems. Although some level of adult supervision and facilitation will always be required in school based implementations, the balance should be “tipped” further towards the child’s own control of the development of interventions.

### *Platform Flexibility*

There is strong evidence from the data analysis suggesting that teachers require greater levels of flexibility in order to change and amend and add interventions at the device level and that this will support their ability to use HANDS in out of school settings. In particular, effective use in out of school situations requires greater flexibility in being able to rapidly amend and vary interventions. Currently this can only be done via the HANDS web based CoMe server application.

Our recommendations for further development of mobile persuasive tools for ASD are:

HANDS-like systems should include a specific Smartphone application that allows easy access to the COME server application via a well-designed “app” interface on the Smartphone itself. This will facilitate the ability to more rapidly update interventions on HANDS or similar systems, leading to greater flexibility.

### *Wider Phone Functions – “Mobile Marriage”*

Experience across three of the test school sites provides further evidence that students’ relationship with HANDS is shaped by their identification with the Smartphone and the other phone features. A logical extension of this argument is that students are likely to wanting HANDS-like systems instantiated on their own mobile phone. If student identification with their mobile device leads to increased credibility and responsiveness to persuasive messages, it makes sense to install mobile persuasive applications on the child’s own mobile device.

Our recommendation for systems similar to HANDS is that developers should aim at accommodating the use of the child’s own mobile device for the mobile persuasive application. An inescapable corollary of this, given the current diversity in Smartphone operating platforms, is that any future HANDS-like system should be developed on a cross platform basis.

### *Collaboration with Parents; Positioning of Social and Life Skills*

Our experience across all schools demonstrated that high levels of the involvement of parents fostered a greater emphasis on the use of the HANDS tool outside of school, in areas such as home use, travel use, and use within the local community. As one of the aims of the HANDS project is to enable young people to become more independent in their life and social skills, we feel that encouraging use outside of school is an important factor in being able to achieve this. Where parents were more involved in the planning stage of HANDS, i.e. deciding what, how and when to put scenarios and interventions onto the HANDS tool, teachers felt more informed and confident in their decisions about what to put on HANDS. Where parents were involved in implementing and supporting their child's use of HANDS together with the teacher, the child had someone outside of school to turn to when they had technical or otherwise difficulties using the HANDS tool and phone.

The data also suggests that the schools perspective on teaching social and life skills to its students can be a limiting factor for developing the use of support tools outside of school, with the eventual aim of student autonomy. For example, at Helen Allison a number of teachers felt that the school system did not allow them the opportunity to teach their students social and life skills. Their duties consisted mainly of teaching students academic lessons. In contrast, at both the FE College at Helen Allison School and at Autism Foundation we saw a greater focus on developing student autonomy in these skills. Where this happened, the HANDS tool could be implemented more successfully and teachers found it a more useful tool to fit in with their pedagogy.

The experience with the out of school use, and in the Further Education setting, strongly suggests that there are potential for the effective use of mobile persuasive technology with children and young people with ASD in additional settings apart from schools. Our recommendation is that consideration should be given to implementing and testing HANDS-like technology within Further Education and post the age of 16 environments. This could be extended to Higher Education and workplace settings where there would be an equivalent focus on life skills, although this would depend on the status and function of intermediaries such as Higher Education support staff in mediating the use of HANDS-like technology with young people with ASD.

Furthermore, consideration should also be given to placing greater emphasis on the role of parents in mediating the use of a HANDS-like technology. The evaluation strongly supports the contention that implementations could reasonably be undertaken where the main focus of use is on the home setting and the main intermediaries mediating the use of HANDS-like technology are the parents, although this would not and should not preclude the involvement of school services and teachers, working in collaboration with parents and the young people.



### *Technical Reliability*

There is good evidence from the data analysis that technical problems affected the user perception of HANDS as an ICT innovation and the level of engagement with HANDS. Thus, the evaluation lends further weight to the recommendation from Prototype 1 that platform reliability is particularly crucial for our target population. A diagnosis of autism is often associated with issues with attention and concentration. Thus, what might be regarded as relatively minor problems with reliability and speed, which may be more readily tolerated by other user groups, pose a significant risk of disaffection and non-engagement with children with autism. The software must a) load rapidly, b) react to user inputs rapidly and c) function highly reliable. Furthermore, technical factors such as battery length and charging the phone remain problematic. Clearly achieving these reliability parameters will be depend on a combination of hardware and software factors.

Our recommendation is that one crucial way of achieving this is to ensure that the software specification and development function **is very tightly aligned** to the user perspective. Although there was a good degree of matching within this area in the development of Prototypes 1 and 2, our evaluation indicates that typical industry standard levels of user-function specification matching can, in fact, be insufficient.

### *Influence or Relevance of the ASD Diagnosis*

Our analysis successfully allowed us to develop a working model of the factors, which are likely to be influential in mediating engagement with HANDS by teachers and young people with ASD in school settings. When implementing both Prototype 2 and Prototype 1, we also identified examples of highly effective use of HANDS in helping young people with ASD in the areas of social and life skills, associated with significant potential to promote social and educational inclusion. Our model does not, however, allow us to identify, thoroughly enough, which young people are most likely to benefit from the use of a HANDS-like technology. We clearly identified some highly relevant and crucial factors, such as the self awareness of the child as well as awareness of need and motivation for behavioural change, the importance of technical reliability, and the primacy of teacher potential to engage with technology innovation both at the individual and at the school level. Yet the evaluation indicates that the use of such technology in schools, as well as in other settings, is likely to be maximally efficient if we can more clearly specify the individual profile of the child, who is most likely to benefit from its use.

Further theoretical development on the internal motivation of children with ASD and their likely response, in particular to persuasive interventions, is needed in order to facilitate this. Persuasion profiling is being developed for general persuasive technologies, and it is likely that a specific ASD persuasion profile will need to be developed to allow for even more appropriate targeting of mobile persuasive interventions for young people with ASD.

Our recommendation is that wider field testing of HANDS-like technologies with young people with ASD should be undertaken in conjunction with further theoretical development of an ASD persuasion profile. This will most likely be facilitated best by further trials which, rather than being fully randomized, make use of the existing mediating factors identified in our model above. Thus, the selection for participation should be based, for example, on prior identification of young people who have the potential to be aware of their own difficulties and the ability to set goal-orientated targets for behavioural change. Integration of cognitive psychology results with qualitative ALE results from HANDS will be important in the development of such persuasion profile.

#### *Battery Life and Charging*

Evaluation of Prototype 2 indicates that battery life and charging are potentially significant issues. With current smartphone technology, battery life is typically one day, and thus a regular charging routine is crucial if HANDS-like technologies are to be effective with young people with ASD. Our evaluation indicated that as many children and young people with ASD have problems with organisation skills, it is very easy for them to forget to charge their smartphone.

Our recommendation is that any HANDS-like technology should come pre-loaded with personal trainer-like functions which are set to remind the user to charge their phone. Furthermore, a charging protocol should be implemented by the key intermediary working with the child with ASD, focusing on ensuring that they regularly charge their device.

Additionally, HANDS-like technology should be specified to minimize battery drain, thus maximising the charging life span for the user.

## 4. The Potential Impact of HANDS

The aim of HANDS has been to explore the possibilities of helping autism-diagnosed teenagers navigate and develop socially. This has been done by the creation of an e-learning toolset that can be used to develop individualized tools to support the social development of teenagers with an autism diagnosis. As it has been explained above it has been documented that the toolset can in fact serve this purpose. This means that HANDS has provided a way of supporting young people in their learning situations and also in their everyday life in society. Clearly, this may be very important from an educational as well as from a social point of view. For this reason, further considerations on dissemination and exploitation become very important. In the following, we shall present the main dissemination activities of HANDS as well as the plans for the further exploitation of the research results.

### The main dissemination activities of HANDS

In order to obtain the socio-economic impact, which the results of HANDS deserve, the HANDS partners put particular emphasis on the publication of the research results in scientific papers and books. In addition, the results of the HANDS project have been presented at several conferences and research seminars.

The HANDS partners have presented their research results in well established scientific journals and books. In fact, a number of peer reviewed articles and book chapters have been published. The following is the complete list of these publications:

No	Title	Main author	Title of the periodical or the series	Number, date or frequency	Publisher & Place of publication	Year of publication	Pages	Permanent identifier	Is/will open access provided?
1	The Role of Credibility in the Design of Mobile Solutions to Enhance the Social Skill-Set of Teenagers Diagnosed with Autism.	Anne Gerdes	Journal of Information, Communication & Ethics in Society	4	Emerald, United Kingdom	2011	1477-996X	ISSN: 1477-996X	No
2	Helping Autism-Diagnosed Teenagers Navigate and Develop Socially Using E-Learning Based on Mobile Persuasion	Peter Øhrstrøm	International Review of Research in Open and Distance Learning	Vol.12.4	Canadian Institute of Distance Education Research Canada	May 2011	p. 54-71	1492-3831	No
3	A tekintet-követés módszerének alkalmazása a neurokognitív fejlődési zavarok diagnosztikájában: alapok és	Miklos Gyori	K. Radványi, ed., <i>A diagnosztika aktuális kérdései.</i> [Current	(in press) Budapest:	Eötvös Kiadó., Hungary				No

	perspektívák. [Applying gaze-tracking technique in the diagnosis of neurocognitive developmental disorders. Foundations and perspectives.]		<i>issues in diagnostics.</i> ]						
4	Key Factors Mediating the Use of a Mobile Technology Tool Designed to Develop Social and Self Management Skills in Children with Autistic Spectrum Disorders	Joseph Mintz		. 0360-1315		Accepted Manuscript			
5	Branching Time as a Conceptual Structure	Peter Øhrstrøm	<a href="#">Conceptual structures: from information to intelligence</a>	Volume 6208/2010	ICCS 2010, Springer Press, BRD	2010	125-138	10.1007/978-3-642-14197-3_14	No
6	The application of persuasive technology to educational settings	Mintz, Joseph	Educational Technology Research & Development	accepted	Springer, Learning & Instructions, BRD		na	na	No

Table 1: A list of peer reviewed publications on HANDS

There is a list of abstract of the papers in D8.3, "A List of papers and conference presentations". In addition, it should be mentioned that several other papers based on the HANDS results can be expected to appear in the near future. In fact, the partners have also decided to publish a book on the HANDS research results.

However, the publication of scientific papers and books is not the only kind of dissemination activity in which the HANDS partners have been involved. The partners have also made presentations at a number of conferences, seminars, workshops etc. Furthermore, the partners have, from time to time, presented aspects of the project for the public in the media. The following is a list of this kind of dissemination activities:

LIST OF DISSEMINATION ACTIVITIES								
N O.	Type of activities <sup>15</sup>	Main leader	Title	Date	Place	Type of audience <sup>16</sup>	Size of audience	Countries addressed
1	TV Clip	Morten Aagaard	Presentation of the HANDS project including visit to Egebakken	27-11-2008	DR.dk	Medias	< 5 mill	DK
2	Conferenc	Aagaard,	It might be Kairos	2-4 of June,	N. A.	Conference	<400	All

	e paper	Morten		2008				
3	Conference paper	Albrechtslund, Anders	Surveillance in Mixed Spaces : Persuasion and resistance	, 15. oktober 2008 - 18. oktober 2008	N. A.	Conference	<400	All
4	Conference	Gyori, M	Mobile Digital Technology As A Helping Hand - The 'Hands' Project	9th May, 2009.	N. A.	Conference	<300	HU
5	Conference paper	Balázs, A	Psychiatry Meets Mobile Digital Technology For High Functioning Autism: The HANDS Project	22-26 August, 2009	N. A.	Conference	<400	European countries
6	Presentation	Devecchi, M.C	The HANDS project: a mobile phone solution for children on the autistic spectrum. The Evaluation and Implementation Guide	March 2009	NA	Conference	<50	UK
7	Conference paper	Devecchi, M.C.	The HANDS project: evaluating the use of smartphone applied technology for children with autism, or the case of overcoming contrasting capabilities and irreducible difference.	29 May 2009	Conference	Conference	<100	HU
8	Conference paper	Devecchi, M.C	Supporting user participation in developing mobile technology to help young people with autism: The HANDS smartphone project	9-11 July 2009	Conference	Conference	<300	EU
9	Conference paper	Mintz, J.	A mobile phone solution for young people with autism: Introducing the HANDS project	2-6 September, 2009	Conference	Conference	<300	UK
10	Conference paper	Pertou, Maria Elisabeth	Adaptive Persuasive Scripts	2009	Conference	Conference	<300	All
11	Conference paper	Ranfelt, Anja M	Towards a Handy Interactive Persuasive Diary for Teenagers with a Diagnosis of Autism	26-29 April 2009	NA	Conference	<300	EU
12	Conference paper	Henrik Scharfe	A Conceptual Analysis of Difficult Situations - developing systems for teenagers with ASD	2009	NA	Conference	<300	All
13	Conference presentation	Kanizsai-Nagy	HANDS from a strictly autism-specific point of view	April 23, 2010. Budapest	Conference	Conference	<100	HU
14	Conference	Søren Madsen	Presentasjon av prototype "Hands"	25 June 2010		Scientific Community	<200	NO
15	Conference	Michael Sørensen	Teorien bak og første evalueringer av utprøvingerne i "HANDS" prosjektet [Theories behind and first evaluations of the tests in "HANDS"]	25 June 2010		Scientific Community	<200	NO
16	TV Clip	Henrik Schärfe	Lecture on persuasive design and HANDS on Danish national broadcast	25 March 2010	DR.dk	Medias	< 5 mill	DK
17	Conference article	Bertel, Lykke Brogaard	The Use of Rewards in Persuasive Design	2010	Proceedings of Poster Papers, p25-28	Research paper		All
18		Anne Gerdes	Issues of credibility in developing mobile solutions for autism-diagnosed teenagers	2010	Proceedings of Poster Papers, p37-40	Research paper		All

19	Workshop presentation	Gyori, Miklos	Introduction to HANDS-in-action: goals, plans and a brief midway summary.	April 23, 2010. Budapest	N.A.	Conference	<300	HU
20	Conference paper	Gyori, M	In the garden of Hungarian minds': an exploratory eye-tracking study on sentence integration in Hungarian readers	25-26 October 2010	NA	Conference	<300	HU
21	Conference paper	Gyori, M	Mobil digitális gyógypedagógia: fókuszban az autizmus. A HANDS projekt és első eredményei. [Mobile digital special education: autism in focus. The HANDS Project and its first results.]	22-23 January 2010	NA	Conference	<300	HU
22	Conference paper	Gyori, M	Testing a mobile digital cognitive support system for high functioning adolescents with ASD: Prototype I of the HANDS system	8-10 October, 2010	NA	Conference	<1000	EU
23	Conference paper	Mintz, J	How Easy is it to Introduce Something New? Issues Associated with Introducing a New Technology Tool (the HANDS Mobile Solution) to Develop Social Skills with Children with Autism	2010	NA	Conference	<1000	EU
24		Mintz, J.	The Application of Persuasive Technology to educational settings: Some theoretical from the HANDS Project	June 4-6 <sup>th</sup> , 2010	NA	Conference	<300	EU
25	Conference paper	Scharfe, H	Tracing Concepts in Designing for Change		NA	Conference	<300	EU
26	Conference paper	Stefanik, K	A HANDS kognitív támogató rendszer autizmussal élők számára I.: tesztelés Kísérleti Feladatelemzéssel. [The HANDS cognitive support system for people living with autism I: testing by Experimental Task Analysis.]	27-29 May 2010	NA	Conference	<300	HU
27	Conference paper	Várnagy, Z	A HANDS kognitív támogató rendszer autizmussal élők számára II.: tesztelés szemmozgáskövetéses (eye-tracking) módszerekkel. [The HANDS cognitive support system for people living with autism II: testing by eye-tracking.]	Hungary, 27-29 May 2010	NA	Conference	<300	HU
28	Conference talk	Miklos Gyori	Innovatív technikai lehetőségek a neurokognitív fejlődési zavarok diagnosztikájában: a tekintet-követés (eye-tracking) technika. [Innovative technological perspectives in the diagnosis of neurocognitive developmental disorders: the eye-tracking technique.]	25 September 2010. Budapest	NA	Conference	<300	HU
29		Peter Øhrstrøm	Helping Autism-diagnosed Teenagers Navigate and Develop Socially Using E-learning	27-29 January 2010	NA	Conference	<200	EU
30	Conference talk	Várnagy, Zsombor	A HANDS kognitív támogató rendszer autizmussal élők számára.: tesztelés interaktív tekintetkövetéses módszerekkel.	25-27 May 2011, Budapest	NA	Conference	<200	HU
31	Conference talk	Gyori, Miklos;	A mondatintegráció és a mondatintegráció/tudatelmélet kölcsönhatás vizsgálata magyar nyelven, tekintetkövetéses	25-27 May 2011, Budapest	NA	Conference	<200	HU

			technikával: előzetes eredmények [Investigating sentence integration and sentence integration / naive theory of mind interactions in the Hungarian language, by gaze-tracking technique. Preliminary findings.]					
32	Conferenc e talk	Gyóri, Miklós	Miért nélkülözhetetlen a komplex empirikus kutatómódszertan? Integrált eredmények és érvek a HANDS projektből [Why complex empirical research methodology is indispensable].	November, 2011, Budapest	NA	Conference	<200	HU
33	Conferenc e talk	Stefanik, Krisztina	Egyéni támogatási szükségletek és kvantitatív hatásmérés: a Kísérleti Feladatanalízis módszertana és eredményei [Individual support needs and quantitative testing of effectiveness: the Experimental Task Analysis and its results].	, 3-5 November, 2011, Budapest	NA	Conference	<200	HU
34	Conferenc e talk.	Várnagy, Zsombor	Speciális nevelési igények, innovatív kutatási eszközök: a tekintetkövetéses módszertan alkalmazása a HANDS projektben. [Special educational needs, innovative research techniques: using gaze-tracking technique in the HANDS Project.]	3-5 November, 2011, Budapest	NA	Conference	<200	HU
35	Conferenc e talk	Kanizsai- Nagy	Autizmus, speciális nevelési igények, infokommunikációs támogatás: a HANDS projekt kontextusa és módszertanai. [Autism, special educational needs, info-communication assistance: the context and methodologies of the HANDS Project.]	3-5 November, 2011, Budapest	NA	Conference	<200	HU
36	Conferenc e talk	Gyori, Miklos	Innovatív IKT, speciális (oktatási) szükségletek: biztos távlatok, váratlan csapdák. A 'HANDS' mobil kognitív támogató rendszer első tesztjének tanulságai. [Inovative ICT, special (educational) needs: firm perspectives, unexpected traps. Lessons from first testing of the 'HANDS' mobile cognitive support system.]	14-15 January 2011. Budapest	NA	Conference	<200	HU
37	Conferenc e poster	Gyori, Miklos	Sentence integration / social cognition interaction in the Hungarian language: preliminary findings.	21-25 August, 2011.	N. A.	Conference	<300	Europea n countries
38	Conferenc e Poster	Gyori, Miklos	Testing a mobile cognitive support system for teenagers with autism by a dynamic-interactive eye-tracking methodology.	21-25 August, 2011.	N. A.	Conference	<300	Europea n countries

*Table 2: A list of dissemination activities*

### **Plans for the further exploitation of the research results**

The HANDS partners certainly find it very important that the results of the project will actually be used at many schools for young people with autism and also more privately by the young people in their daily life. Some of the analyses made during

the project even suggest that the HANDS toolset and similar procedures may also be used in relation to other target groups than young people with autism.

In fact the partners have decided to continue their co-operation after the end of the HANDS project. For this purpose, they have formed the HANDS Open organisation.

The background for the formation of HANDS Open is a common understanding of the intellectual property rights (IPR) related to HANDS. Since all partners have contributed to the establishment of the scientific results and development of the HANDS tools, all partners have some IPR related to the overall HANDS product. However, since the co-operation in HANDS has been rather close, it makes no sense to make statements deciding precisely which partners should be entitled to which intellectual property rights. For all practical purposes, it makes more sense just to place the rights in question in the fellowship of all partners. The idea is that HANDS Open for all practical purposes should function as the joined owner of the HANDS results and the HANDS software.

#### *The formation of HANDS Open*

All HANDS partners have been invited to join the HANDS Open organization, and all partners have in fact agreed to join. HANDS Open will be led by a board. The agreement is that all partners can appoint one member of the board. The partners have also elected Morten Aagaard, Aalborg University, as the chairman of a working group for HANDS Open. The chairman is going to lead HANDS Open in its first period. The partners agree that one of the first obligations for the working group will be to have proper and formal regulations for the HANDS Open organization formulated. The office for legal matters at Aalborg University has promised to assist.

#### *New members of HANDS Open*

It should be possible to include new members in HANDS Open by unanimous decisions in the board. Such new members could be schools for young people with autism or research units with the ambition to develop the HANDS ideas and techniques further. It could also be companies wanting to market the HANDS products (the software, the courses etc.).

#### *The purpose of HANDS Open*

HANDS Open is supposed to deal with a number of rather different challenges. The work carried out within the organization will include activities regarding the present HANDS software and activities and also the further development of the software and the further development of the use of the HANDS ideas and techniques.



One major task to be carried out within the HANDS Open cooperation has to do with the HANDS server. It is very essential for the use of the HANDS software that the HANDS server is active and constantly under supervision and maintenance. During the project period this work has been carried out at Aalborg University where the server is presently placed. This will continue after the end of the project period. If Aalborg University, at some future time, should wish to stop this activity, it will be the obligation of the board of HANDS Open to find an acceptable solution regarding the server. (In fact, the present leaders of the computer department of Aalborg Municipality have already indicated that they may be ready to accept the obligation of hosting and maintaining the HANDS server, if it turns out to be needed at some later time.)

It will also be an important task for HANDS Open to develop the HANDS tools and the techniques further. In particular, the educational perspectives will be important. The HANDS tools should be seen in an e-learning context. It is essential that the teachers are trained in the use of the HANDS tools and the use of the data stored on the HANDS server. For this reason, one very important challenge for HANDS Open will be to establish a certified education for experienced practitioners employed at schools for young people with autism (see below).

It should also be mentioned that it will be an important challenge within HANDS Open to investigate the potential extension of HANDS or its spin-offs to other groups in need for cognitive support, especially groups with needs somewhat analogous to those of people with ASD.

Furthermore, it will be important for HANDS Open to establish more research in order to develop new ICT tools, which can be relevant alongside the HANDS tools which have already been developed. One such project could be that of "Human sensing", which has already been preliminary discussed among the HANDS partners (see <http://www.humansensing.blogspot.com> and Rosalind Picard's paper on sensor use and individuals with autism, "Future Affective Technology for Autism and Emotion Communication", [www.media.mit.edu/affect/pdfs/09.Picard-PhilTranRoyalSocB.pdf](http://www.media.mit.edu/affect/pdfs/09.Picard-PhilTranRoyalSocB.pdf)).

In addition, it is essential that the HANDS Open cooperation pay due regard to the ethical issues involved in the HANDS techniques. In particular, it is important that the procedures involved in the treatment of person sensitive data is constantly monitored in order to make sure that no personal right and no personal integrity is being violated.

Finally, it will be important for the co-operation within HANDS Open to establish further relevant business contacts in order to explore the commercial potential in the HANDS software and the HANDS techniques. In the present situation, the

companies already related to the HANDS project do not want to invest in the further development of the HANDS software and the HANDS techniques etc. However, this might have to do with the general financial climate. It is conceivable, that things may be different in a better financial situation which hopefully will occur soon again.

#### *Financial issues*

The HANDS partners do not have to pay anything in order to become and to stay members of the HANDS Open organization. It is expected that the activities in HANDS Open, to a large extent, can be treated without a common economy. In cases when extra/special funding is obtained one option is to make special decisions on how this funding is used. Likewise special arrangements may be needed whenever various costs related to HANDS Open should be covered. It may be decided that companies, schools, or other organizations have to pay a certain amount in order to become members of the HANDS Open organization. The board will have to decide how income of this kind should be used. More details on the business oriented perspectives of HANDS Open can be found in D8.5.

#### *Towards a certified education for experienced practitioners employed at schools for young people with autism*

The main idea in HANDS is that the individual teacher at a school for young people with autism should tailor individual tools for each of her or his students, and that the teacher, in supervising her or his students, should then benefit from the fact that the use of the tools are monitored at the HANDS server. Given that this is the case, it is obvious that the training of the teachers at the school is essential for the success of the HANDS ideas. It is one of the conclusions in the HANDS project that too little emphasis has been put on the training of the teachers in the use of the HANDS software and techniques. For this reason, it will obviously be a good idea to establish a certified HANDS education for experienced practitioners employed at schools for young people with autism. This education should obviously equip the teachers with sufficient knowledge and sufficient technical skills in order to use the HANDS toolbox to tailor individual tools and in order to make use of the data stored on the HANDS server. Furthermore, it should be a substantial part of this education to make the participants aware of the ethical problems and challenges involved in treating person sensitive data carefully and respectfully.

Clearly, this kind of certified education has to be established on a national basis – at least for language reasons. On the other hand, it is obvious that much material in the national educations will be shared across borders. In fact, this educational activity can, to a large extent, be organized and supported from the Hand Open organization, although this is an international organization.

The HANDS Partners find that the establishment of this kind of certified HANDS education for teachers and other practitioners employed at schools for young people with autism will be the first major step towards making the HANDS software more known and used for the purpose it was actually designed for. It is also strongly believed that if more teachers etc. are involved, it will also speed up the development of practical HANDS tools tailored by the teachers using the HANDS toolset. This way it may be possible to establish an online library of practical tools made by using the HANDS toolset.

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