RiE 2015

6th International Conference on Robotics in Education

Yverdon-les-Bains, Switzerland, 20 - 23 May 2015

Jean-Daniel Dessimoz, Richard Balogh, David Obdržálek, editors

heig-vd

Hes·so

sgaico

IEEE

VAUD

RÉGION
YVERDON LES BAINS
JURA-LAC

ISBN: re proceedings

Technology and Art – Solving Interdisciplinary Problems

Igor Zubrycki and Grzegorz Granosik
Institute of Automatic Control
Lodz University of Technology
Stefanowskiego 18/22, 90-924 Lodz, Poland
ph. +4842 6312554, fax +4842 6312551
Email: igor.zubrycki@dokt.p.lodz.pl, granosik@p.lodz.pl

***Abstract*—Our pilot project, led by Lodz University of Technology together with Academy of Fine Arts, is aimed at designing and prototyping equipment that therapists may use with their patients who are children with mental disorders. We present some of the outcomes of this co-operation and highlight the conditions necessary for the success of such ventures: creativity, communication and deep thinking.**

I. INTRODUCTION

The ‘Rehabilitation and Service Robotics’ course, offered in the second semester of the Control Engineering and Robotics Graduate degree at Lodz University of Technology (TUL), provides an overview in the theoretical basis of modern robotics. In the past, as a practical part of this course, students would work on some (usually technical) subjects related to design of rehabilitation or medical systems (e.g., drives, sensors, control). Service robotics has become a more realistic future career scenario for master’s students in Europe, contrasted to mostly research careers in the past, and therefore we have decided to engage our students in a real-world project that would introduce them to robotics as it really is – a demanding, interdisciplinary and challenging discipline.

In particular, we wanted students to participate in a real life design of Human-Robot Interaction (HRI). Our group is engaged in teaching HRI (an article about our practices for undergraduate students was presented in [1]) but up to this point we have not engaged students in projects of this scale.

Our partner institution, Strzeminski Academy of Fine Arts Lodz (Academy in short), conducts one year classes on Ergonomic design, which is taught at the master level. Since the beginning of this program, its mission has been to train designers to be able to understand the needs of people with disabilities, through various projects related to medical and rehabilitation applications.

These two classes became the basis for the interdisciplinary project engaging master’s students from two universities. In this paper we describe our experience and, using it as an example, discuss topics of creativity and communication, that we believe are key to success of the students participating in such ventures.

The practical value of this project – creating tools for therapists of children with mental disabilities is important in itself, and we hope, that our example will motivate different robotics groups to “lend their brains” to help their societies, while educating students in the process.

II. SIMILAR PROJECTS

One of the most important goals of this educational project was teaching human-machine (robot) interaction and solving a real problem.

A. Nature of Human-Robot Interaction projects

HRI projects are particularly challenging as educational projects – as it is quite difficult to separate the technological side (robot construction, software) from the soft side (ease of use, understanding, design). These parts need to be designed and developed together because any change in one (e.g. shape of robot) changes the other (e.g. how the system is perceived) and vice versa.

The universal nature of these problems motivated HRI researchers to create guidelines for HRI accepted practices, as listed in [2], which we attempted to follow in our project:

- create an interdisciplinary team of experts. Our project graduate students from the ‘Control Engineering and Robotics’ and ‘Industrial Design’ programs, as well as therapists who were involved in project, were the subject matter experts.
- create real systems and evaluate these systems using experiments with human subjects. This postulate, which contrasts to doing only a proof of concept solution is a highly important part of our project. Students from the beginning were made aware their prototypes would be used by the real people.
- use established standards and common metrics so that project could be easier to maintain and its results evaluated and compared. Students used standard technical solutions (such as Arduino, ROS, Linux built-in tools) and established prototyping and testing practices (explained in detail in [1]) in their solutions.
- use longitudinal studies. While the core part of the project (the need-finding, designing and creating first prototypes of sensory therapy tools) was done in a period of one semester (from October 2014), the study itself started earlier and will take another year to complete. Our focus as a research group, is to study

how these tools influence therapists' well being and reduce their burnout [3]. Students, willing to continue their projects as their master's thesis, are working with the most prospective designs.

- experimenting with using both physical and simulated systems – this postulate was not implemented in last semester but is considered while the specialized software will be developed.

B. Teaching HRI

A number of institutions have HRI courses on their graduate curricula. A majority of the courses teach theoretical and practical aspects of conducting research in Human-Robot Interaction. We drew on the experience of Andrea Thomaz's class CS 7633 about social intelligence topics such as: anthropomorphism and embodiment, perceiving intent, emotional intelligence, learning through lectures and readings, and Ilah Nourbakhsh's class 16867: Principles of HRI [4].

C. Teaching robotics technology through real life, important projects

A project based course 'Technology for Developing Communities' from Carnegie Mellon Robotics Institute, studies ways to use advanced technologies (sensor networks, robotics) to help developing communities. Students are given background knowledge about problems occurring in developing countries and proceed to solve real problems through participatory research (knowledge for action). This consists of understanding situation priorities and perspectives, securing funding, co-opting stakeholders and creating realistic and very much needed technical solutions. While problems are real, solutions developed during the course are theoretical preparations for further work, which some willing students can expand into real solutions beyond the classroom [5].

III. RESEARCH PROJECT DESCRIPTION

Our project "Robotized Environment for Improving Therapists Everyday Work with Children with Severe Mental Disabilities" came to life after we had presented some robots to autistic children, during *Autism Day*, an event organized by Navicula Centre.

Through participant observations and ideation sessions, we distilled ideas that could be very helpful for therapists and have an immense educational value for our students. One of the most interesting ideas was a robotisation of the already existing sensory therapy tools that therapists use. By robotisation we mean adding different robotic features, such as actuation and sensing, and making them programmable in easy-to-use fashion.

Many autistic children have problems with over and under sensibility to different stimuli which results in stimuli either being painful which results in tantrums (over sensibility) or children being aloof (under sensibility). Sensory integration therapy is a tool for accustoming patients to stimuli through presenting various sensory opportunities. For therapy to be effective, it has to have some particular features: just-right challenges (adjusted for a specific patient's level of skills), ensuring physical safety and guiding patient's self-organisation (child can learn how to plan own behaviour) [6].

Features of effective therapy described above require high understanding of child's state and capabilities, therefore, we have proposed the tools to be programmable – so that therapist could use their knowledge in creating effective actuator-sensor loops for patient stimulation.

Therapists also wanted to have tools for multi sensory stimulation. This demanded a design that would provide access to different stimuli:that would be attractive to the child, effective in therapy and in the same time safe.

IV. EDUCATION GOALS – PROJECT BASED LEARNING

We consider student work as a serious contribution to the whole project. But also, the project should be an exciting way to expand their knowledge and learn important skills in the following areas.

Embedded systems – students worked on Intel Galileo boards (sponsored by Intel), which are small linux boards with input/output capabilities similar to the Arduino, and with additional ability to use USB or mini PCI based devices.

Internet of things – an important part of project was the requirement for the designed devices to be programmed/controlled from standard computers and tablets. Students therefore learned how to use standard protocols and make their devices part of a larger network.

For students from the Academy of Fine Arts, this interdisciplinary project was a chance to open up to the world of electronics and control engineering as well as describing their design needs to engineers. Students are very well prepared for designing form of product, they have a solid background in psychology and anthropometry, and therefore, could lead student teams at the beginning of the project. Both groups deepened their knowledge in human-machine interaction when a development proceeded into further stages.

A. Project based learning

This form seems to be ideal for realization of multidisciplinary projects with diverse group of students. Students acquire knowledge and elements of the core curriculum, but also apply what they know to solve authentic problems and produce results that matter [7]. They go through an extended process of inquiry in response to a complex question, problem, or challenge. The project started with direct contact with therapists from Navicula to discuss their needs and observe their work. Then a few alternative forms of the product were proposed – this part was mostly driven by students from Academy. Based on the presentation of these proposals clients (i.e., therapists) provided feedback and the whole group discussed results.

Students had six weeks to request the necessary electronic components and fill-up the mock-up form with sensors, actuators, and control – this stage utilized students from the Lodz University of Technology. The second presentation of prototypes was organized on the Navicula premises and involved more therapists and management of the Centre. The project is continued in the second semester by the smaller groups from

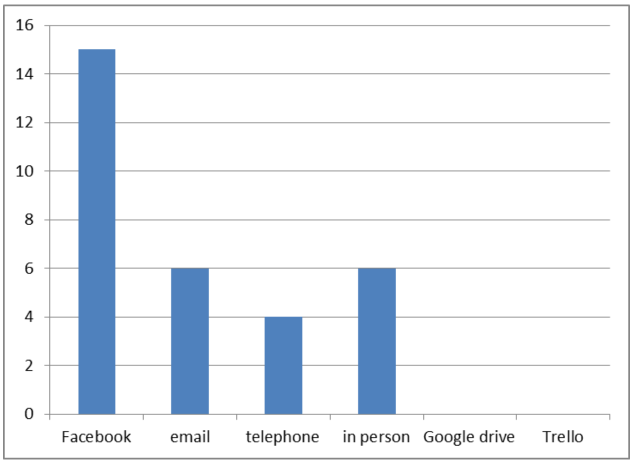

Fig. 1: Number of respondents declaring use of the different communication methods among teammates (6 possible choices were proposed in the project and included in the questionnaire, although two of them were never used)

both universities – mostly interested in their master's thesis based on this design.

B. Teams, communication, exploration

Thirty one students from two universities were involved in this project: 16 from the Academy (mostly females) and 15 from TUL (mostly males). Six teams were created on the first common meeting where students from the same school could choose mates and the subgroups were matched randomly. All contact information and necessary documentation were published on Google drive for internal usage of the project. Although, almost all possible means of communication were used, Facebook appeared to be the most popular followed by email and in person contacts as shown in fig. 1. What is interesting here is that students did not appreciate neither Google drive to further share data or exchange information nor Trello – the project management application where the special account was created. This is one of the lessons we have learned – we hoped to base the project on these tools (as they are commonly used in our everyday work), but both require some degree of knowledge and in future projects some of the time has to be committed to actually teach students how to use these tools effectively.

Even though we have received some information in regards to problems in exchanging information between students of different schools, finally the overall note for the quality of communication was above the average as shown in fig. 2.

The project's formula gave an opportunity for students to be creative. None of the faculty or therapists had a one right solution, therefore students had a large solution space to explore. However, results were average with respect to creativity (see fig. 5). While different in shape and form, devices initially had very similar functionality, they could be touched and watched, and responded by changing colour, vibrating and making sounds. None of the designs had functionalities of a typical robot, such as mobility or AI. While not necessarily bad, students' abilities were underutilised.

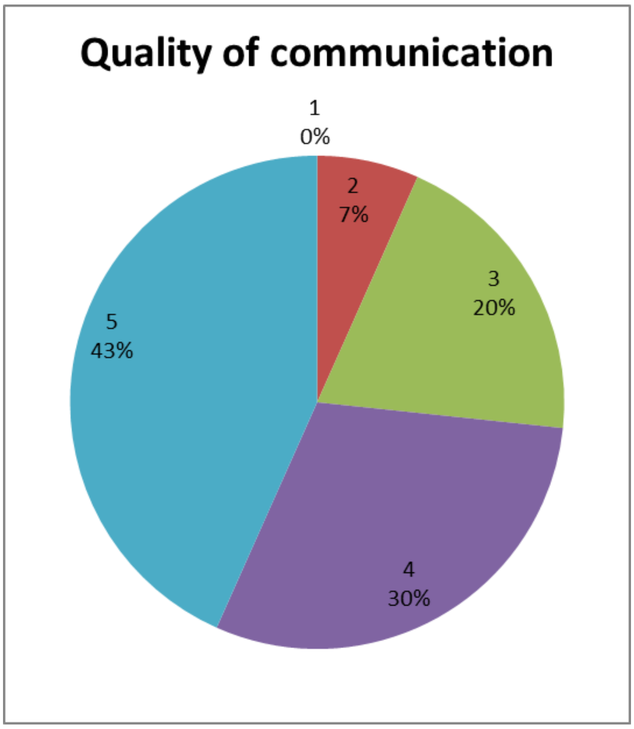

Fig. 2: Number of respondents rating the quality of communication between students of different schools (1 – no communication, 5 – excellent communication)

We believe that several factors could lead to more creative projects. One is to clearly state that all students are expected to be creative and contribute to a main task – at the beginning of this project Academy students were leaders in ideation, while TUL students took a role of 'supporting engineers'. Without interdisciplinary discussions design students came with creative ideas about form and texture but not about technology, as they did not understand what could and could not be done, and this resulted in overly simplistic solutions in that area (compared to the abilities that some of TUL students had). Because of that, students who decided to continue their work on this project have to understand the *goals* behind the devices being created and contribute actively into improving and implementing the solutions instead of only fulfilling the designers ideas.

Also worth noting is that groups that have frequently met in person made qualitatively better projects. We have decided that going forward, although more organizationally complicated, it is better for all students and faculty involved in the project to meet every week in person to report and discuss current matters. This allows for not only faster work, but feedback and discussion are much easier. Also, sometimes the faculty has the role of 'translators', as students from both schools have sometimes issues with understanding different vocabularies and the processes and procedures of their partners.

With reference to the educational outcome of the project we have asked students to what extent they have explored new areas of knowledge and how would they rate the knowledge development in the major area of their studies. They could rate these developments on a the scale from 1 to 5. As we can learn

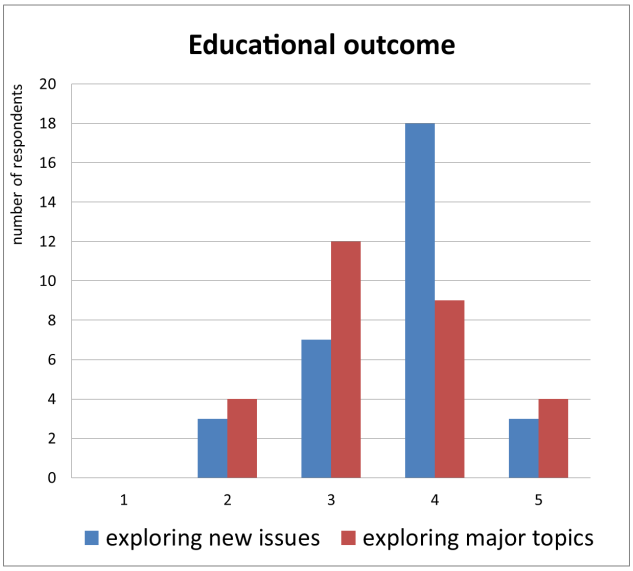

Fig. 3: Results of the questionnaire given to the students to what extent the project let them explore new issues and their major subjects (scaled from 1 - didnt to 5 - excellent progress)

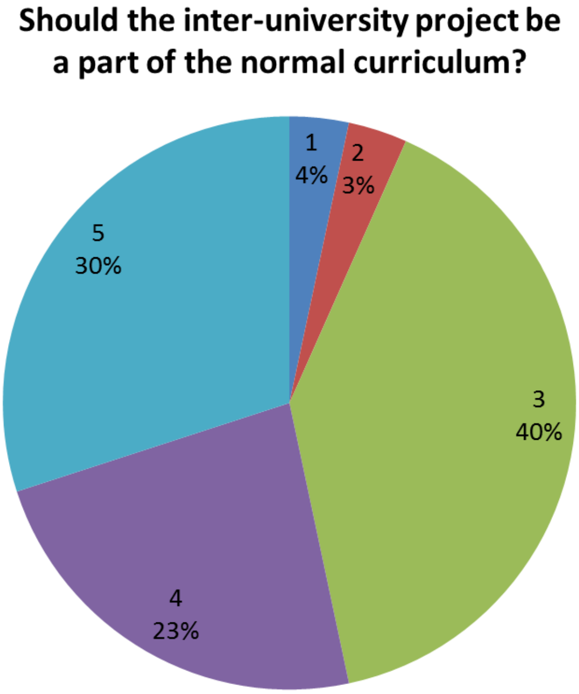

Fig. 4: Results of the questionnaire given to the students should the joint project be a part of the normal curriculum at both universities? (rated in the scale 1 – definitely NO, 5 – definitely YES)

from fig. 3, students took advantage of the interdisciplinarity of the project and focused much more on exploring new issues (not directly related to their major discipline). Moreover, most of them have seen the project as an interesting experience (worth some minor troubles they had).

Most of the students would see inter-university projects as a normal part of their curricula (see fig. 4) although only a few decided to continue this topic as a Master Thesis. Also not all of Academy students decided to continue their projects. Students, when asked about their decisions, stated such reasons as problems with communication and unclear goals. This also prompted us to force a tighter cooperation between groups.

V. RESULTS

During one semester of the joint project we have seen two presentations of the preliminary ideas and pre-prototypes showing technology demonstration. What is the most important in our opinion is satisfaction of the clients – therapists from Navicula Centre. The majority of the respondents (7 people) rated the project as correct and useful for their practice, however, the novelty of the presented ideas was rather average, as shown in fig. 5. They have also commented on all presented projects and ranked them.

Four of the top designs are being developed as prototypes ready to be tested with therapists and children. Due to different structure of curricula at Academy and TUL we cannot continue this project in the same form for the second semester. However, three students from the Lodz University of Technology continue the co-operation doing their Master Thesis and most of the students from Academy will further develop their ideas.

As a master thesis, students integrate particular designs into one system, with features of a ubiquitous robotic system, where physical mechatronic solutions are connected and integrated with AI functionalities (voice recognition, emotion recognition) and that could be programmed and changed by therapists through different modalities (physical interfaces and programming interface based on Scratch).

Therapeutic needs of children differ considerably, as children have different levels of disability, skills, age and stimuli sensitivity. We therefore encouraged students to create diverse designs to have a range of different prototypes to test, as well as create flexible and programmable designs, that therapists could change and program themselves.

Roboticized therapeutic devices created by student groups varied both in shape, functionalities, size and form. While some of the designs could be considered more therapeutic toys other were more similar to a therapeutic playgrounds.

The ‘Exploration box’, shown in fig. 6, is a programmable box that can be thrown, pushed or caressed, and that responds by moving, generating sounds and voice, or vibrating. This device utilizes many robotic features including mobility and sensing (accelerometer, touch sensors. The focus of this device was on the kinesthetic type of therapy, where children are encouraged to move and play with objects, exploring their features, such as weight or texture. Therapist will be able to program how the box responds, so that it could, for example, play the child’s favorite tune when a preferable action has occurred or present some available action through blinking or telling.

The current design (fig. 6) is a second iteration obtained after discussions with therapists. The group changed their design from a immobile large box that child could touch to

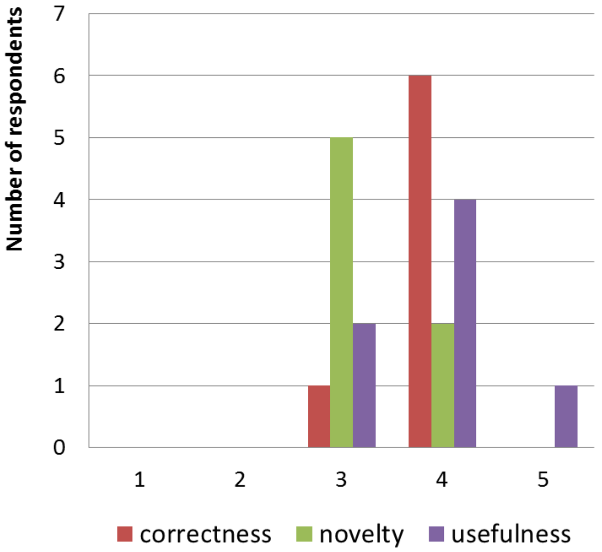

Fig. 5: Results of the questionnaire given to the therapists from Navicula Centre their notes in three categories: correctness, usefulness and novelty of the presented designs, rated in the scale 1 (low) – 5 (high)

Fig. 6: Exploration box authors: Magdalena Bartczak, Olga Rogalska, Szymon Surma, Magdalena Gregorczyk, Dariusz Urbański

a smaller one that could be moved and played with. As a consequence, the new box has to be rugged and light. As the therapists will be able to animate the robot's movement – the group is currently set to design a pair of soles on the bottom of the robot, actuated by servos, so that it could express a range of motions.

'Magic holes' offers an object with a set of holes that have different functionalities encouraging exploration, as shown in fig. 7. Holes can warm up, vibrate, light up or make sounds reaction to hand moving inside. The design aim behind this project was to encourage exploration through holes that would light up.

The prototype was manufactured with a soft foam covered with rubber shell. This allowed for a safe exploration.

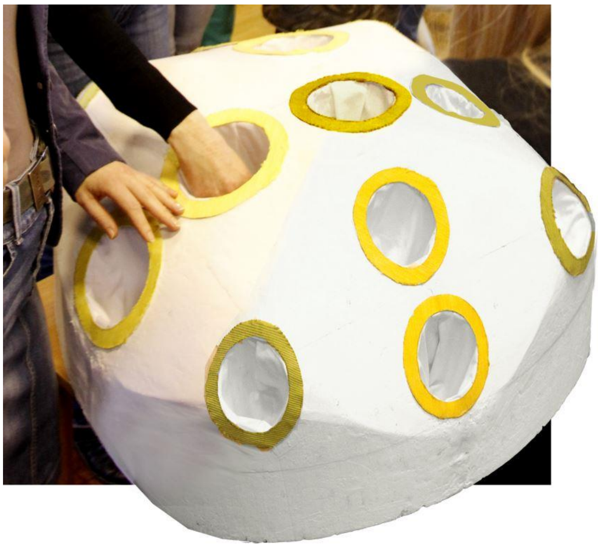

Fig. 7: Magic holes authors: Olga Maciaszczyk, Anna Wawszczak, Monika Kocot, Mateusz Pakosz, Adrian Kowalik, Tomasz Karolczak

Fig. 8: Sensible Sleeve authors: Kornelia Kulik, Dominika Rajska, Krzysztof Barzdo, Mieszko Polański, Mateusz Wodziński, Maciej Jarosiński, Łukasz Matusiak

'Sensible sleeve' (see fig. 8) is similar to a sensible "car wash" for an arm where the child can sense warm/cold air, vibrations, tingling sensations. The device senses movement of a hand, tapping on the cover and the user's voice.

The design aim was to integrate different stimuli for a child, such as visual (through LED strip around the device), sound and touch through interaction with the sleeve. Since some of the children can be afraid to put their hand into the sleeve, or simultaneously stimulate both hands, the device can be used as two separate halves. As the device uses a considerable amount of power (mostly from Thermoelectric Cooler Modules) it is a corded device.

'Interactive Bricks' (see fig. 9) is a set of bricks used to control stimuli through building a tower. The height of the tower controls the strength of the stimuli. Designers proposed a game where the child can build a beehive by putting together bricks that are buzzing. This prototype could not only be used

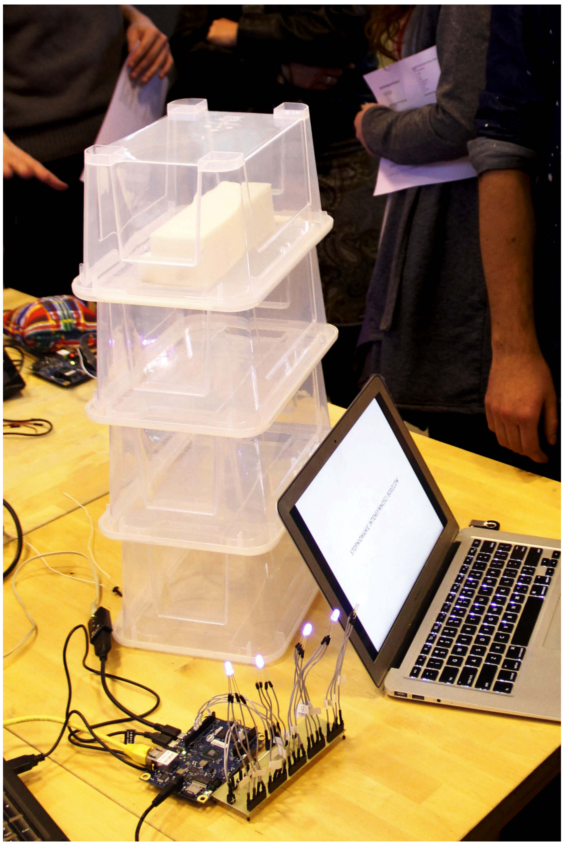

Fig. 9: Interactive Bricks – authors: Iza Mrozowska, Adrian Dutkowski, Michał Wyszyński, Konrad Kustosik, Tomasz Wasilewski

in sensory therapy (it has the ability to generate sound, and whole brick can light up) but also to learn cognitive skills.

Interactive Bricks is also a project that is challenging to make the design and electronics work together as proposed features are demanding – from one side the bricks must be light enough for the child to pick it up, robust so it could not be destroyed easily, and powerful enough to have programmable interaction, react to proximity of other bricks and change the sounds accordingly. Students are using an embedded Linux computer (Intel Galileo) inside the bricks to make it work.

All of the designs will have a common programming interface, being developed by the students now in the second semester. While initially students created their own control programs for laptops and tablets (based on Processing language), therapists expressed the need to have a bigger scope of control – thus the need for a programming interface, that would still be still easy enough to be used by non-professional programmers. We decided to use Scratch as a basis for our programming interface, as it is commonly used, has a large community and had multiple previous successes in introducing people to programing. As an alternative, especially because therapists are usually very involved in interacting with children, they will be able to use voice interfaces and physical interfaces (moving elements, drawing) to change device's behaviour. This is what students are working on during their master's thesis.

VI. CONCLUSION

We have presented some results at the halfway point of our interdisciplinary project aimed at supporting therapists who work with mentally disabled children. Except for the very important and concrete prototypes that were created, the student groups learned how to work in the interdisciplinary environment on a common task.

ACKNOWLEDGMENT

The authors would like to thank Prof. Anna Miarka from the Strzeminski Academy of Fine Arts Lodz for her help and support. Special thanks to therapists from the Navicula Centre: Aneta Lenarczyk, Aleksandra Skałecka, Ewelina Kobiela, Patrycja Gutowska, Paweł Kaniewski, Gerard Siekierski and Rafał Michalak for active participation in this project. Intel Technology Poland Sp. z o.o., Lodz University of Technology and Navicula Centre, provided funding for this project.

REFERENCES

[1] I. Zubrycki and G. Granosik, "Interactive robotics workshop," *Proc. of 4th Int. Workshop Teaching Robotics, Teaching with Robotics and 5th Int. Conf. Robotics in Education*, pp. 60–67, 2014.

[2] M. Goodrich, "6: Solution themes, scientific approaches, and challenge problems — human-robot interaction," 2015. [Online]. Available: http://humanrobotinteraction.org/6-solution-themes-scientific-approaches-and-challenge-problems/

[3] I. Zubrycki and G. Granosik, "A robotized environment for improving therapist everyday work with children with severe mental disabilities," in *Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction Extended Abstracts*, ser. HRI'15 Extended Abstracts. New York, NY, USA: ACM, 2015, pp. 203–204. [Online]. Available: http://doi.acm.org/10.1145/2701973.2702717

[4] I. Nourbakhsh, "Principles of human robot interaction," 2015. [Online]. Available: http://www.cs.cmu.edu/~illah/ri867.html

[5] R. Tongia, "Robotics institute: Courses," 2015. [Online]. Available: https://www.ri.cmu.edu/ri_static_content.html?menu_id=276

[6] L. D. Parham, E. S. Cohn, S. Spitzer, J. A. Koomar, L. J. Miller, J. P. Burke, B. Brett-Green, Z. Mailloux, T. A. May-Benson, S. S. Roley *et al.*, "Fidelity in sensory integration intervention research," *American Journal of Occupational Therapy*, vol. 61, no. 2, p. 216, 2007.

[7] T. Markham, "Project based learning," *Teacher Librarian*, pp. 38–42, 2011.