H2020-ICT-2016-1
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Enabling responsible ICT-related research and innovation

**Responsible Ethical Learning with Robotics**


# Appendix 1

# Outcome of EPPI-inspired database searches

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# Index

# APPENDIX 1

## INTRODUCTION

This appendix presents the search data that served as the foundation for the EPPI-inspired systematic reviews of REELER concepts.

Part A covers findings relevant to the **core concepts**, including *Robot as Materiality and Concept; Collaborative Learning;* and *Human Proximity*.

Part B covers findings relevant to the **other relevant concepts**, including *Artificial Intelligence; Design Process; Science and Technology Studies;* and *Human-Robot Interaction.*

The structure of our search processes was iterative. The initial search often included the primary search term while subsequent searches included secondary search terms in order to find literature relevant to the REELER project. For example, in our search for *Collaborative Learning,* we searched "collaborative learning" and then performed subsequent searches cross-referencing e.g. "collaborative learning" with "robot", "work", "ethics", "gender", etc. In this way, a search process might return literature relevant for review for several REELER concepts. While we attempt to structure these appendices according to topic, the content inevitably reflects the interwoven nature of the searches and the literature.

# PART A: CORE CONCEPTS

# i. ROBOT AS CONCEPT AND MATERIALITY

## Search methodology

A general search for *robot, robotics,* and variations on this word returns well over 300,000 hits in SCOPUS. Such a search is too broad and does not address the robot as an ontological concept. The concept *robot* has been included in most of our searches because it frames all of our concepts in the context of the REELER project. For example, a search for *STS* and *robot* returned literature for both the Science and Technology Studies review and the Robot as Materiality and Concept review. For this reason, you will find selected searches for this review here, and other supporting searches under different headings.

I searched the US Department of Education database ERIC for the terms *robot* and *robotics*. I performed subsequent searches with other keywords relevant to education. After reviewing the results for both searches, I found that the additional search terms (*learning, education,* etc.) limited the search unnecessarily. Because ERIC is a database for education / pedagogy, the inclusion of *learning* and *education* was redundant and their inclusion omitted relevant results. A search for (*robotics* OR *robot* OR *robots*) returned 661 mostly relevant results.

I then searched AnthroSource for *robot* and *robotics,* in combination with other relevant terms. The search returned roughly 100-200 hits for the various combinations. After skimming article titles for a few of these searches, I could find no relevant results.

Finally, I searched SCOPUS for the same search terms, returning many more hits. Of course, SCOPUS covers many disciplines and the words *learning, teaching,* and *education* can be used in other contexts. *Classroom* and/or *education* robot** seemed to be the best terms for narrowing our search to the most relevant results. A search for (education* robot*) returned 916 hits, mostly in computer sciences and engineering, with a steep upwards trend after 2012. Further refining would be necessary to return mostly relevant results in SCOPUS, but the trend identified in SCOPUS is useful in refining the already relevant results in ERIC.

I returned to ERIC and refined the search criteria. I performed searches for (*robotics* OR *robot* OR *robots*) since 2013 [220 hits], and for *educational robot(s)* [14 hits]. I reviewed abstracts and articles for the results of these two searches. The discussion section is based on these particular search results.

## Database queries

| Search Queries in ERIC | Number of hits |
|---|---|
| **robot** | **366** |
| robot AND education | 260 |
| robot AND learning | 168 |
| robot AND teaching | 134 |
| robot AND school | 127 |
| robot AND teachers | 88 |
| robot AND classroom | 56 |
| robot AND learn | 49 |
| robot AND teach | 23 |
| **robotics** | **569** |
| robotics [Since 2013] | 199 |
| robotics AND education | 437 |
| robotics AND learning | 292 |
| robotics AND school | 224 |
| robotics AND teaching | 223 |
| robotics AND teachers | 166 |

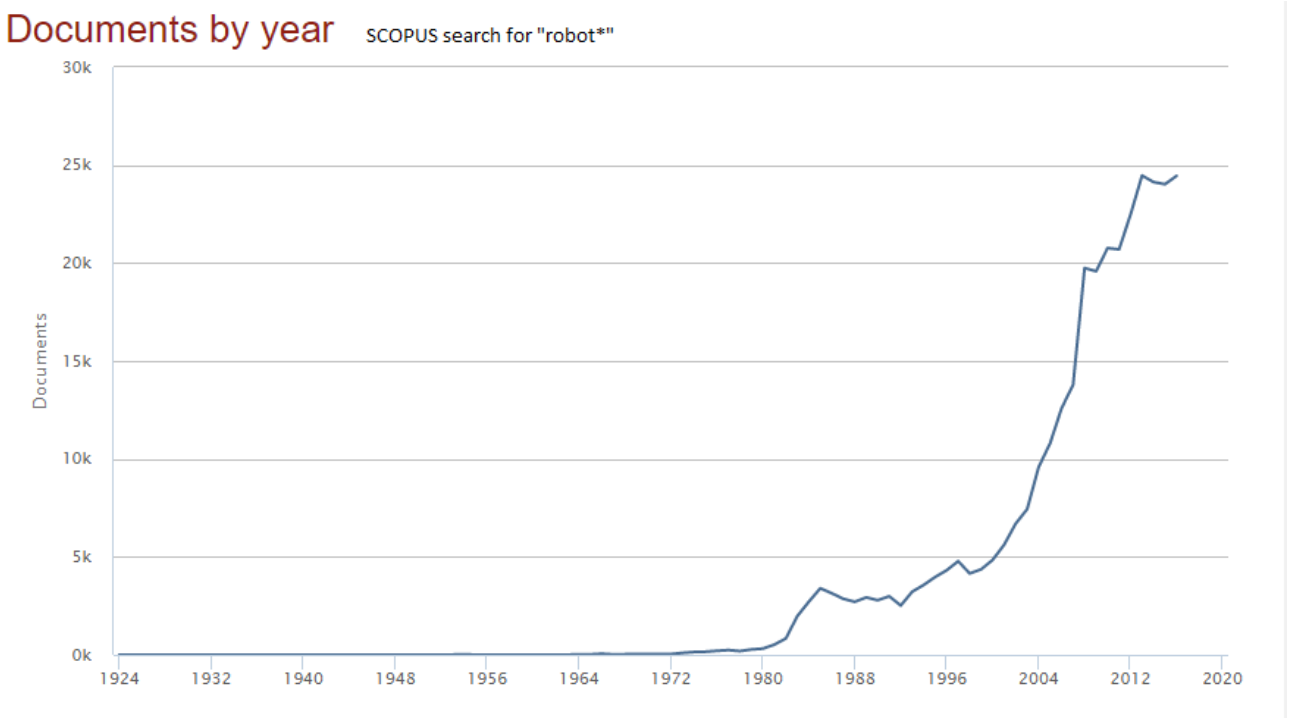
| | |
|---|---|
| robotics AND classroom | 102 |
| robotics AND learn | 66 |
| robotics AND teach | 44 |
| educational robot(s) | 14 |
| **robotics OR robot OR robots** | 661 |
| robotics OR robot OR robots (within the past 5 years) | 220 |

| Search Queries in SCOPUS | Number of hits |
|---|---|
| **robot*** | **340,560** |
| **robot(s)** | **246,563** |
| **robotic(s)** | **199,645** |
| Education* robot* | 916 |
| TITLE-ABSTRACT-KEY | |
| robot* AND learn* | 37,976 |
| robot* AND educat* | 10,957 |
| robot* AND teach* | 6,709 |
| robot* AND school | 2,398 |
| robot* AND classroom | 747 |
| TITLE only | |
| robot* AND learn* | 5,126 |
| robot* AND educat* | 1,109 |
| robot* AND teach* | 980 |
| robot* AND school | 226 |
| robot* AND classroom | 77 |

| Search Queries in AnthroSource | Number of hits |
|---|---|
| **robot** | **248** |
| robot (TITLE only) | 2 |
| robot AND learning | 203 |
| robot AND learn | 203 |
| robot AND school | 196 |
| robot AND teaching | 172 |
| robot AND teach | 172 |
| robot AND education | 165 |
| robot AND teachers | 154 |
| robot AND classroom | 123 |
| **robotics** | **123** |
| robotics (TITLE only) | 0 |
| robotics AND learning | 106 |
| robotics AND learn | 106 |
| robotics AND school | 93 |
| robotics AND education | 92 |
| robotics AND teaching | 88 |
| robotics AND teach | 88 |
| robotics AND teachers | 33 |
| robotics AND classroom | 19 |

## Charts and trends

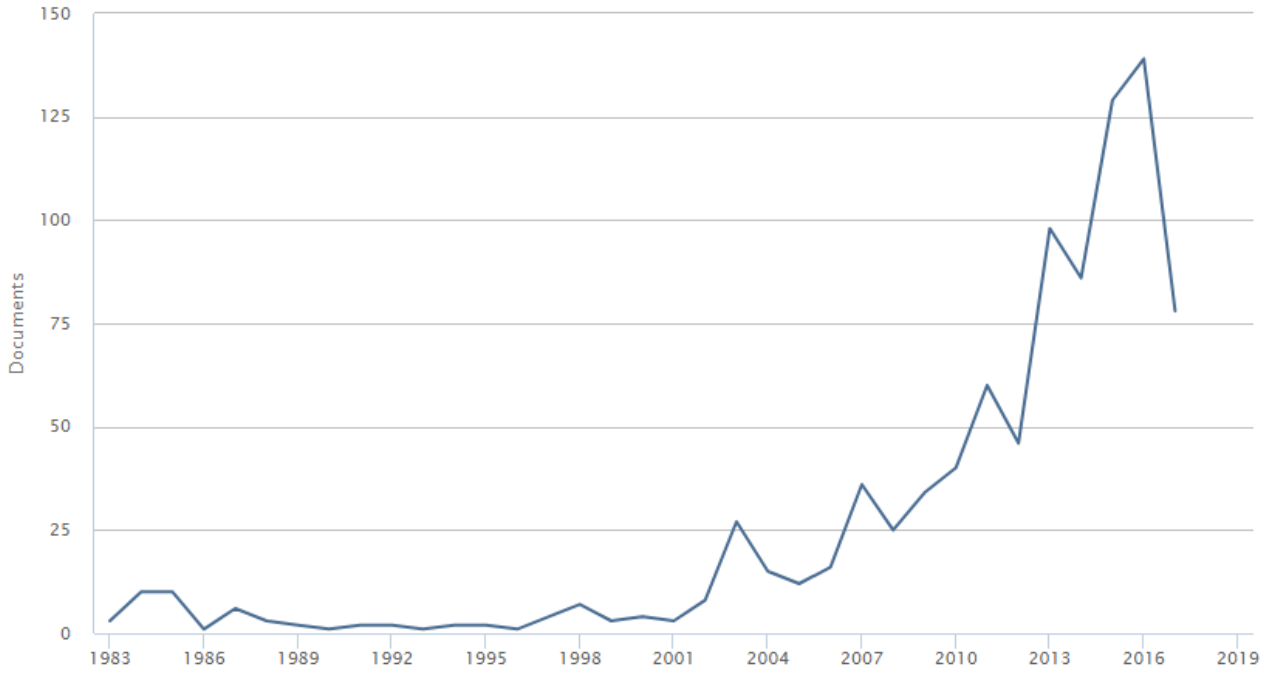
A search of SCOPUS for robot* began with 3 hits in 1924, following the publication of Čapek's *R.U.R.*, which coined the term. There was very little peer-reviewed literature mentioning *robot* until the 1980s. In the 1980s and 90s, there was a steady rise in peer-reviewed publications. Beginning in the year 2000, there was an exponential growth in mention, from under 5k texts per year to almost 25k texts per year.




A search of SCOPUS for "education* robot*" (includes variations, such as *education robot* or *educational robotics)* returned 916 hits, with an increase in mention since 2002 and a sharp rise since 2012. This might suggest a rise in the use of robots in the field of education over the past five years. Nearly 68% of the results (621 documents) were categorized as computer science texts, 53% (484 documents) were categorized under Engineering, while just 22% (199 documents) were categorized under the social sciences.

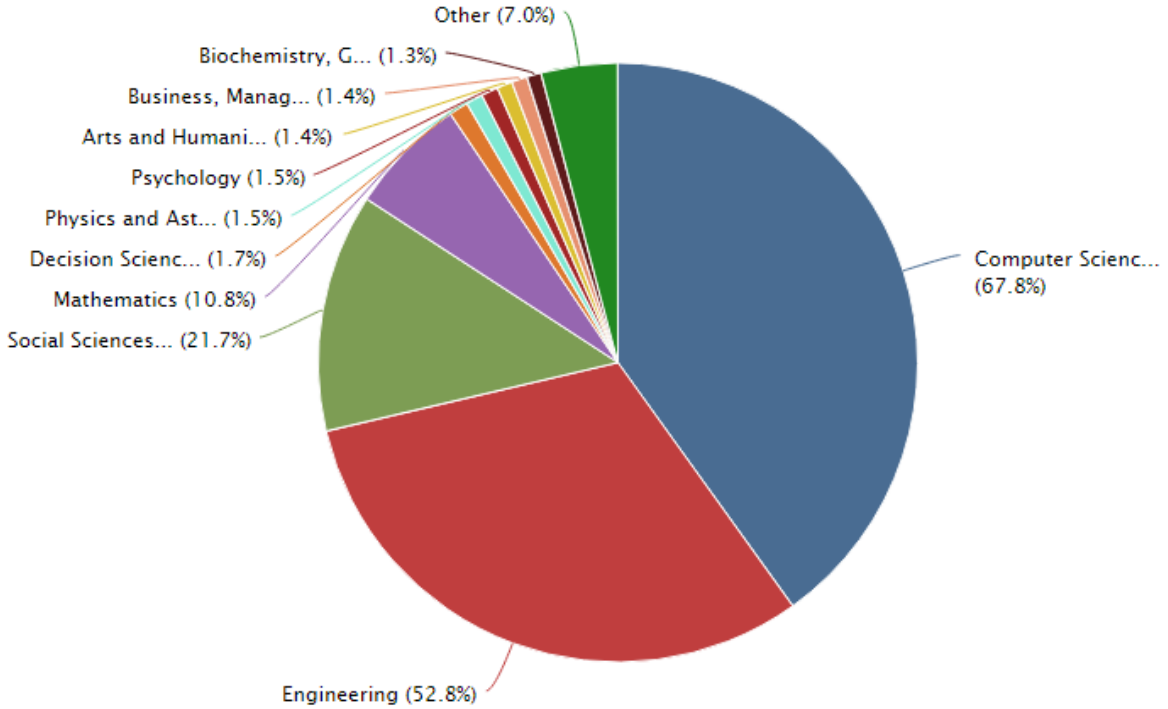
## Documents by year

SCOPUS search for ”education* robot*”




## Documents by subject area

SCOPUS search for ”education* robot*” (916 results)




## Selected literature


Chernyak, Nadia and Heather E. Gary. 2016. “Children's Cognitive and Behavioral Reactions to an Autonomous versus Controlled Social Robot Dog.” *Early Education and Development*, 27(8): 1175-1189.

ABSTRACT Research Findings: Interactive technology has become ubiquitous in young children's lives, but little is known about how children incorporate such technologies into their intuitive biological theories. Here we explore how the manner in which technology is introduced to young children impacts their biological reasoning, moral regard, and prosocial behavior toward it. We asked 5- and 7-year-old children to interact with a robot dog that was described either as moving autonomously or as remote controlled. Compared with a controlled robot, the autonomous robot caused children to ascribe higher emotional and physical sentience to the robot, to reference the robot as having desires and physiological states, and to reference moral concerns as applying to the robot. Children who owned a dog at home were more likely to behave prosocially toward the autonomous robot than those who did not. Practice or Policy: Recent work has begun to use robots as learning tools. Our results suggest that the manner in which robots are introduced to young children may differentially impact children's learning. Presenting robots as autonomous agents may help promote children's social-emotional development, whereas presenting robots as human controlled may help promote robots as purely cognitive educational tools.

Okita, Sandra. 2015. "The Potential of Peer Robots to Assist Human Creativity in Finding Problems and Problem Solving." *Teachers College Record*, 117(10).

ABSTRACT Many technological artifacts (e.g., humanoid robots, computer agents) consist of biologically inspired features of human-like appearance and behaviors that elicit a social response. The strong social components of technology permit people to share information and ideas with these artifacts. As robots cross the boundaries between humans and machines, the features of human interactions can be replicated to reveal new insights into the role of social relationships in learning and creativity. Peer robots can be designed to create ideal circumstances that enable new ways for students to reflect, reason, and learn. This, in turn, has increased expectations that robots and computer agents will enhance human learning and complement people's physical, social, and cognitive capabilities. This paper explores how peer-like robots and robotic systems may help students learn and engage in creative ways of thinking.

Toh, L. P. E., Causo, A., Tzuo, P. W., Chen, I. M., & Yeo, S. H. 2016. "A Review on the Use of Robots in Education and Young Children." *Educational Technology & Society*, 19 (2), 148–163.

ABSTRACT A systematic review was carried out to examine the use of robots in early childhood and lower level education. The paper synthesizes the findings of research studies carried out in the last ten years and looks at the influence of robots on children and education. Four major factors are examined – the type of studies conducted, the influence of robots on children's behaviour and development, the perception of stakeholders (parents, children and educators) on educational robots, and finally, the reaction of children on robot design or appearance. This review presents the approach taken by researchers in validating their use of robots including non-experimental (mixed-method, anecdotal, cross-sectional, longitudinal, correlational, and case studies) and quasi-experimental (pre- and post-test). The paper also shows that robot's influence on children's skills development could be grouped into four major categories: cognitive, conceptual, language and social (collaborative) skills. Mixed results are shown when it comes to parents' perception of the use of robots in their children's education while design was shown to influence children's perception of the robot's character or capabilities. A total of 27 out of 369 articles were reviewed based on several criteria.

EXCERPT "Lastly, design is usually the last consideration when incorporating robots into an application. However, as Woods (2006) and Sullivan & Bers (2013) studies showed, design could make a difference on robot perception and hence, how the children would interact with it. Unfortunately, not a lot of work has been done yet on this question," (154).

*[Complete title/abstract list (14) for "educational robot" search in ERIC. To repeat search, click here.]*

## Designing a Robot Teaching Assistant for Enhancing and Sustaining Learning Motivation

 Peer reviewed

 Direct link

Hung, I-Chun; Chao, Kuo-Jen; Lee, Ling; Chen, Nian-Shing – Interactive Learning Environments, 2013

Although many researchers have pointed out that educational robots can stimulate learners' learning motivation, the learning motivation will be hardly sustained and rapidly decreased over time if the amusement and interaction merely come from the new technology itself without incorporating instructional strategies. Many researchers have…

Descriptors: Teaching Assistants, Learning Motivation, Teaching Methods, Robotics

## Showing Up Is Half the Battle: Assessing Different Contextualized Learning Tools to Increase the Performance in Introductory Computer Science Courses

Peer reviewed

Download full text

Rolka, Christine; Remshagen, Anja – International Journal for the Scholarship of Teaching and Learning, 2015

Contextualized learning is considered beneficial for student success. In this article, we assess the impact of context-based learning tools on student grade performance in an introductory computer science course. In particular, we investigate two central questions: (1) does the use context-based learning tools, robots and animations, affect…

Descriptors: Introductory Courses, Computer Science Education, Context Effect, Grades (Scholastic)

## Learning to Explain: The Role of Educational Robots in Science Education

Peer reviewed

Download full text

Datteri, Edoardo; Zecca, Luisa; Laudisa, Federico; Castiglioni, Marco – Themes in Science and Technology Education, 2013

Educational robotics laboratories typically involve building and programming robotic systems to perform particular tasks or solve problems. In this paper we explore the potential educational value of a form of robot-supported educational activity that has been little discussed in the literature. During these activities, primary school children are…

Descriptors: Science Education, Educational Technology, Robotics, Influence of Technology

## An Exploration of Developing Active Exploring and Problem Solving Skill Lego Robot Course by the Application of Anchored Instruction Theory

Peer reviewed

Direct link

Chen, Chen-Yuan – Educational Research and Reviews, 2013

In recent years, researches had shown that the development of problem solving skill became important for education, and the educational robots are capable for promoting students not only understand the physical and mathematical concepts, but also have active and constructive learning. Meanwhile, the importance of situation in education is rising,…

Descriptors: Problem Solving, Learning Theories, Problem Based Learning, Learning Activities

## A Review on the Use of Robots in Education and Young Children

Peer reviewed

Direct link

Toh, Lai Poh Emily; Causo, Albert; Tzuo, Pei-Wen; Chen, I-Ming; Yeo, Song Huat – Educational Technology & Society, 2016

A systematic review was carried out to examine the use of robots in early childhood and lower level education. The paper synthesizes the findings of research studies carried out in the last ten years and looks at the influence of robots on children and education. Four major factors are examined--the type of studies conducted, the influence of…

Descriptors: Teaching Methods, Robotics, Child Behavior, Child Development

## Using Haptic and Auditory Interaction Tools to Engage Students with Visual Impairments in Robot Programming Activities

 Peer reviewed
 Direct link

Howard, A. M.; Park, Chung Hyuk; Remy, S. – IEEE Transactions on Learning Technologies, 2012

The robotics field represents the integration of multiple facets of computer science and engineering. Robotics-based activities have been shown to encourage K-12 students to consider careers in computing and have even been adopted as part of core computer-science curriculum at a number of universities. Unfortunately, for students with visual…

Descriptors: Robotics, Computer Interfaces, Federal Aid, Pilot Projects

## Using Tangible Companions for Enhancing Learning English Conversation

 Peer reviewed
 Direct link

Wang, Yi Hsuan; Young, Shelley S.-C.; Jang, Jyh-Shing Roger – Educational Technology & Society, 2013

In this study, the researchers attempted to extend the concept of learning companions from the virtual world to the real physical environment and made a breakthrough in technique development of tangible learning robots. The aim of this study was to explore an innovative way by combining the speech recognition technology with educational robots in…

Descriptors: Foreign Countries, Robotics, Educational Technology, English (Second Language)

## Increasing Students' Interest with Low-Cost CellBots

 Peer reviewed
 Direct link

Aroca, R. V.; Gomes, R. B.; Tavares, D. M.; Souza, A. A. S; Burlamaqui, A. M. F.; Caurin, G. A. P.; Goncalves, L. M. G. – IEEE Transactions on Education, 2013

This paper introduces the use of a flexible and affordable educational robot specifically developed for the practical experimentation inherent to technological disciplines. The robot has been designed to be reconfigurable and extendible, serving as an experimental platform across several undergraduate courses. As most students have a mobile cell…

Descriptors: Student Interests, Student Motivation, Undergraduate Study, Telecommunications

## Exploring the Possibility of Using Humanoid Robots as Instructional Tools for Teaching a Second Language in Primary School

Peer reviewed

Direct link

Chang, Chih-Wei; Lee, Jih-Hsien; Chao, Po-Yao; Wang, Chin-Yeh; Chen, Gwo-Dong – Educational Technology & Society, 2010

As robot technologies develop, many researchers have tried to use robots to support education. Studies have shown that robots can help students develop problem-solving abilities and learn computer programming, mathematics, and science. However, few studies discuss the use of robots to facilitate the teaching of second languages. We discuss whether…

Descriptors: Foreign Countries, Educational Media, Programming, Robotics

## Design and Evaluation of a DIY Construction System for Educational Robot Kits

Peer reviewed

Direct link

Vandevelde, Cesar; Wyffels, Francis; Ciocci, Maria-Cristina; Vanderborght, Bram; Saldien, Jelle – International Journal of Technology and Design Education, 2016

Building a robot from scratch in an educational context can be a challenging prospect. While a multitude of projects exist that simplify the electronics and software aspects of a robot, the same cannot be said for construction systems for robotics. In this paper, we present our efforts to create a low-cost do-it-yourself construction system for…

Descriptors: Robotics, Secondary School Students, Questionnaires, Secondary School Teachers

## Teachers' Perceptions of the Benefits and the Challenges of Integrating Educational Robots into Primary/Elementary Curricula

Peer reviewed

Direct link

Khanlari, Ahmad – European Journal of Engineering Education, 2016

Twenty-first century education systems should create an environment wherein students encounter critical learning components (such as problem-solving, teamwork, and communication skills) and embrace lifelong learning. A review of literature demonstrates that new technologies, in general, and robotics, in particular, are well suited for this aim.…

Descriptors: Teacher Attitudes, Robotics, Elementary School Teachers, Foreign Countries

## On the Effectiveness of Robot-Assisted Language Learning

Peer reviewed

Direct link

Lee, Sungjin; Noh, Hyungjong; Lee, Jonghoon; Lee, Kyusong; Lee, Gary Geunbae; Sagong, Seongdae; Kim, Munsang – ReCALL, 2011

This study introduces the educational assistant robots that we developed for foreign language learning and explores the effectiveness of robot-assisted language learning (RALL) which is in its early stages. To achieve this purpose, a course was designed in which students have meaningful interactions with intelligent robots in an immersive…

Descriptors: Second Language Learning, Robotics, Speech Skills, Listening Skills

## Study of the Hero-l Educational Robot.

Peer reviewed

Elmaghraby, Adel S.; Jagannathan, V. – CoED, 1985

Analyzes Heathkit's multi-sensor educational robot (Hero-l), which, unlike most industrial manipulators, is capable of moving using a set of wheels. Includes discussions of its mobility, arm manipulation, applications for controlling specific robot tasks, future research directions, and Hero-l limitations. (JN)

Descriptors: Engineering, Engineering Education, Higher Education, Robotics

## Hardware Development for a Mobile Educational Robot.

Peer reviewed

Mannaa, A. M.; And Others – European Journal of Engineering Education, 1987

Describes the development of a robot whose mainframe is essentially transparent and walks on four legs. Discusses various gaits in four-legged motion. Reports on initial trials of a full-sized model without computer-control, including smoothness of motion and actual obstacle crossing features. (CW)

Descriptors: Automation, College Science, Computer Oriented Programs, Electromechanical Technology

*[Complete title/abstract list (220) for "robotics" OR robot OR "robots" search in ERIC, since 2013. To repeat search, click here.]*

## Robotic Teaching Assistance for the "Tower of Hanoi" Problem

Peer reviewed

Direct link

Thien, Nguyen Duc; Terracina, Annalisa; Iocchi, Luca; Mecella, Massimo – International Journal of Distance Education Technologies, 2016

In this work the authors investigate the effectiveness of robotics in education. Rather than creating excitement for children when playing with robots in games, they are examining the overall learning environment where a robot acts as a teaching assistant. They designed a suitable lesson plan when groups of teenagers participate in activities…

Descriptors: Teaching Methods, Robotics, Lesson Plans, Adolescents

## Robotics for Computer Scientists: What's the Big Idea?

Peer reviewed

Direct link

Touretzky, David S. – Computer Science Education, 2013

Modern robots, like today's smartphones, are complex devices with intricate software systems. Introductory robot programming courses must evolve to reflect this reality, by teaching students to make use of the sophisticated tools their robots provide rather than reimplementing basic algorithms. This paper focuses on teaching with Tekkotsu, an open…

Descriptors: Robotics, Computer Science Education, Programming, Science Curriculum

## The Microcontroller: A Paradigm for a Robot Building Block

Peer reviewed
Direct link

Hammons, John; Deal, Walter F., III – Technology and Engineering Teacher, 2013

Microcontrollers are used extensively in transportation and communications technologies, in automobiles to monitor and control engine speed and performance so as to maximize fuel economy and efficiency, and by manufacturing industries to produce "smart" technology. The flexibility, imagination, and spirit that make these tiny devices so…

Descriptors: Engineering, Engineering Education, Robotics, High School Students

## Children's Cognitive and Behavioral Reactions to an Autonomous versus Controlled Social Robot Dog

Peer reviewed
Direct link

Chernyak, Nadia; Gary, Heather E. – Early Education and Development, 2016

Research Findings: Interactive technology has become ubiquitous in young children's lives, but little is known about how children incorporate such technologies into their intuitive biological theories. Here we explore how the manner in which technology is introduced to young children impacts their biological reasoning, moral regard, and prosocial…

Descriptors: Young Children, Robotics, Animals, Attribution Theory

## The Potential of Peer Robots to Assist Human Creativity in Finding Problems and Problem Solving

Peer reviewed
Direct link

Okita, Sandra – Teachers College Record, 2015

Many technological artifacts (e.g., humanoid robots, computer agents) consist of biologically inspired features of human-like appearance and behaviors that elicit a social response. The strong social components of technology permit people to share information and ideas with these artifacts. As robots cross the boundaries between humans and…

Descriptors: Robotics, Creativity, Problem Solving, Technology Uses in Education

## Students Learn Programming Faster through Robotic Simulation

Peer reviewed
Direct link

Liu, Allison; Newsom, Jeff; Schunn, Chris; Shoop, Robin – Tech Directions, 2013

Schools everywhere are using robotics education to engage kids in applied science, technology, engineering, and mathematics (STEM) activities, but teaching programming can be challenging due to lack of resources. This article reports on using Robot Virtual Worlds (RVW) and curriculum available on the Internet to teach robot programming. It also…

Descriptors: Robotics, Programming, Computer Simulation, STEM Education

## The Development of a Robot-Based Learning Companion: A User-Centered Design Approach

Peer reviewed

Direct link

Hsieh, Yi-Zeng; Su, Mu-Chun; Chen, Sherry Y.; Chen, Gow-Dong – Interactive Learning Environments, 2015

A computer-vision-based method is widely employed to support the development of a variety of applications. In this vein, this study uses a computer-vision-based method to develop a playful learning system, which is a robot-based learning companion named RobotTell. Unlike existing playful learning systems, a user-centered design (UCD) approach is…

Descriptors: Robotics, Technology Uses in Education, Human Factors Engineering, Design

## Experiences in Developing an Experimental Robotics Course Program for Undergraduate Education

Peer reviewed

Direct link

Jung, Seul – IEEE Transactions on Education, 2013

An interdisciplinary undergraduate-level robotics course offers students the chance to integrate their engineering knowledge learned throughout their college years by building a robotic system. Robotics is thus a core course in system and control-related engineering education. This paper summarizes the experience of developing robotics courses…

Descriptors: Robotics, Interdisciplinary Approach, Undergraduate Study, Courses

## Design and Evaluation of a DIY Construction System for Educational Robot Kits

Peer reviewed

Direct link

Vandevelde, Cesar; Wyffels, Francis; Ciocci, Maria-Cristina; Vanderborght, Bram; Saldien, Jelle – International Journal of Technology and Design Education, 2016

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Descriptors: Robotics, Secondary School Students, Questionnaires, Secondary School Teachers

## A Review on the Use of Robots in Education and Young Children

Peer reviewed

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Toh, Lai Poh Emily; Causo, Albert; Tzuo, Pei-Wen; Chen, I-Ming; Yeo, Song Huat – Educational Technology & Society, 2016

A systematic review was carried out to examine the use of robots in early childhood and lower level education. The paper synthesizes the findings of research studies carried out in the last ten years and looks at the influence of robots on children and education. Four major factors are examined--the type of studies conducted, the influence of…

Descriptors: Teaching Methods, Robotics, Child Behavior, Child Development

## Building Teen Futures with Underwater Robotics

Peer reviewed

Direct link

Wallace, Michael L.; Freitas, William M. – Journal of Extension, 2016

Preparing young Americans with science and technology skills has been on the forefront of educational reform for several years, and Extension has responded. Robotics projects have become a natural fit for 4-H clubs, with members' experiences ranging from using Lego® Mindstorms® and other "purchase and assemble" robotics kits to building…

Descriptors: Robotics, Youth Clubs, Extension Education, Program Effectiveness

## Resources for Underwater Robotics Education

Peer reviewed

Direct link

Wallace, Michael L.; Freitas, William M. – Journal of Extension, 2016

4-H clubs can build and program underwater robots from raw materials. An annotated resource list for engaging youth in building underwater remotely operated vehicles (ROVs) is provided. This article is a companion piece to the Research in Brief article "Building Teen Futures with Underwater Robotics" in this issue of the "Journal of…

Descriptors: Robotics, Youth Clubs, Extension Education, STEM Education

## Mapping Robots to Therapy and Educational Objectives for Children with Autism Spectrum Disorder

Peer reviewed

Direct link

Huijnen, Claire A. G. J.; Lexis, Monique A. S.; Jansens, Rianne; de Witte, Luc P. – Journal of Autism and Developmental Disorders, 2016

The aim of this study was to increase knowledge on therapy and educational objectives professionals work on with children with autism spectrum disorder (ASD) and to identify corresponding state of the art robots. Focus group sessions (n = 9) with ASD professionals (n = 53) from nine organisations were carried out to create an objectives overview,…

Descriptors: Pervasive Developmental Disorders, Autism, Educational Objectives, Children

## Developing Creative Behavior in Elementary School Students with Robotics

Peer reviewed
Direct link

Nemiro, Jill; Larriva, Cesar; Jawaharlal, Mariappan – Journal of Creative Behavior, 2017

The School Robotics Initiative (SRI), a problem-based robotics program for elementary school students, was developed with the objective of reaching students early on to instill an interest in Science, Technology, Engineering, and Math disciplines. The purpose of this exploratory, observational study was to examine how the SRI fosters student…

Descriptors: Elementary School Students, Robotics, Creative Thinking, Grade 4

## Learning to Explain: The Role of Educational Robots in Science Education

Peer reviewed
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Datteri, Edoardo; Zecca, Luisa; Laudisa, Federico; Castiglioni, Marco – Themes in Science and Technology Education, 2013

Educational robotics laboratories typically involve building and programming robotic systems to perform particular tasks or solve problems. In this paper we explore the potential educational value of a form of robot-supported educational activity that has been little discussed in the literature. During these activities, primary school children are…

Descriptors: Science Education, Educational Technology, Robotics, Influence of Technology

## Pilot Clinical Application of an Adaptive Robotic System for Young Children with Autism

Peer reviewed
Direct link

Bekele, Esubalew; Crittendon, Julie A.; Swanson, Amy; Sarkar, Nilanjan; Warren, Zachary E. – Autism: The International Journal of Research and Practice, 2014

It has been argued that clinical applications of advanced technology may hold promise for addressing impairments associated with autism spectrum disorders. This pilot feasibility study evaluated the application of a novel adaptive robot-mediated system capable of both administering and automatically adjusting joint attention prompts to a small…

Descriptors: Robotics, Young Children, Autism, Assistive Technology

## Open-Box Muscle-Computer Interface: Introduction to Human-Computer Interactions in Bioengineering, Physiology, and Neuroscience Courses

Peer reviewed
Direct link

Landa-Jiménez, M. A.; González-Gaspar, P.; Pérez-Estudillo, C.; López-Meraz, M. L.; Morgado-Valle, C.; Beltran-Parrazal, L. – Advances in Physiology Education, 2016

A Muscle-Computer Interface (muCI) is a human-machine system that uses electromyographic (EMG) signals to communicate with a computer. Surface EMG (sEMG) signals are currently used to command robotic devices, such as robotic arms and hands, and mobile robots, such as wheelchairs. These signals reflect the motor intention of a user before the…

Descriptors: Physiology, Neurosciences, Robotics, Muscular Strength

## Reversal Learning Task in Children with Autism Spectrum Disorder: A Robot-Based Approach

Peer reviewed

Direct link

Costescu, Cristina A.; Vanderborght, Bram; David, Daniel O. – Journal of Autism and Developmental Disorders, 2015

Children with autism spectrum disorder (ASD) engage in highly perseverative and inflexible behaviours. Technological tools, such as robots, received increased attention as social reinforces and/or assisting tools for improving the performance of children with ASD. The aim of our study is to investigate the role of the robotic toy Keepon in a…

Descriptors: Pervasive Developmental Disorders, Autism, Children, Robotics

## Framework for Educational Robotics: A Multiphase Approach to Enhance User Learning in a Competitive Arena

Peer reviewed

Direct link

Lye, Ngit Chan; Wong, Kok Wai; Chiou, Andrew – Interactive Learning Environments, 2013

Educational robotics involves using robots as an educational tool to provide a long term, and progressive learning activity, to cater to different age group. The current concern is that, using robots in education should not be an instance of a one-off project for the sole purpose of participating in a competitive event. Instead, it should be a…

Descriptors: Robotics, Educational Technology, Teaching Methods, Technology Uses in Education

## Introduction to Autonomous Mobile Robotics Using "Lego Mindstorms" NXT

Peer reviewed

Direct link

Akin, H. Levent; Meriçli, Çetin; Meriçli, Tekin – Computer Science Education, 2013

Teaching the fundamentals of robotics to computer science undergraduates requires designing a well-balanced curriculum that is complemented with hands-on applications on a platform that allows rapid construction of complex robots, and implementation of sophisticated algorithms. This paper describes such an elective introductory course where the…

Descriptors: Robotics, Computer Science Education, Undergraduate Study, Introductory Courses

## The Role of Physicality in Rich Programming Environments

Peer reviewed

Direct link

Liu, Allison S.; Schunn, Christian D.; Flot, Jesse; Shoop, Robin – Computer Science Education, 2013

Computer science proficiency continues to grow in importance, while the number of students entering computer science-related fields declines. Many rich programming environments have been created to motivate student interest and expertise in computer science. In the current study, we investigated whether a recently created environment, Robot…

Descriptors: Computer Science Education, Programming, Robotics, Teaching Methods

## Using Multi-Robot Systems for Engineering Education: Teaching and Outreach with Large Numbers of an Advanced, Low-Cost Robot

Peer reviewed

Direct link

McLurkin, J.; Rykowski, J.; John, M.; Kaseman, Q.; Lynch, A. J. – IEEE Transactions on Education, 2013

This paper describes the experiences of using an advanced, low-cost robot in science, technology, engineering, and mathematics (STEM) education. It presents three innovations: It is a powerful, cheap, robust, and small advanced personal robot; it forms the foundation of a problem-based learning curriculum; and it enables a novel multi-robot…

Descriptors: Robotics, STEM Education, Engineering Education, Problem Based Learning

## Starting and Teaching Basic Robotics in the Classroom: Modern, Engaging Engineering in Technology Education

Peer reviewed

Direct link

Bianco, Andrew S. – Technology and Engineering Teacher, 2014

All technology educators have favorite lessons and projects that they most desire to teach. Many teachers might ask why teach robotics when there are many other concepts to cover with the students? The answer to this question is to engage students in science, technology, engineering, and math (commonly referred to as STEM) concepts. In order for…

Descriptors: Robotics, Class Activities, Classroom Techniques, Technology Education

## A Robot-Partner for Preschool Children Learning English Using Socio-Cognitive Conflict

Peer reviewed

Direct link

Mazzoni, Elvis; Benvenuti, Martina – Educational Technology & Society, 2015

This paper presents an exploratory study in which a humanoid robot (MecWilly) acted as a partner to preschool children, helping them to learn English words. In order to use the Socio-Cognitive Conflict paradigm to induce the knowledge acquisition process, we designed a playful activity in which children worked in pairs with another child or with…

Descriptors: Foreign Countries, Preschool Children, English (Second Language), Second Language Learning

## Programming with the KIBO Robotics Kit in Preschool Classrooms

Peer reviewed

Direct link

Elkin, Mollie; Sullivan, Amanda; Bers, Marina Umaschi – Computers in the Schools, 2016

KIBO is a developmentally appropriate robotics kit for young children that is programmed using interlocking wooden blocks; no screens or keyboards are required. This study describes a pilot KIBO robotics curriculum at an urban public preschool in Rhode Island and presents data collected on children's knowledge of foundational programming concepts…

Descriptors: Programming, Preschool Children, Robotics, Developmentally Appropriate Practices

## Software for Project-Based Learning of Robot Motion Planning

Peer reviewed
Direct link

Moll, Mark; Bordeaux, Janice; Kavraki, Lydia E. – Computer Science Education, 2013

Motion planning is a core problem in robotics concerned with finding feasible paths for a given robot. Motion planning algorithms perform a search in the high-dimensional continuous space of robot configurations and exemplify many of the core algorithmic concepts of search algorithms and associated data structures. Motion planning algorithms can…

Descriptors: Computer Software, Active Learning, Student Projects, Robotics

## Can Robotic Interaction Improve Joint Attention Skills?

Peer reviewed
Direct link

Warren, Zachary E.; Zheng, Zhi; Swanson, Amy R.; Bekele, Esubalew; Zhang, Lian; Crittendon, Julie A.; Weitlauf, Amy F.; Sarkar, Nilanjan – Journal of Autism and Developmental Disorders, 2015

Although it has often been argued that clinical applications of advanced technology may hold promise for addressing impairments associated with autism spectrum disorder (ASD), relatively few investigations have indexed the impact of intervention and feedback approaches. This pilot study investigated the application of a novel robotic interaction…

Descriptors: Robotics, Autism, Pervasive Developmental Disorders, Technology Uses in Education

## Brief Report: Development of a Robotic Intervention Platform for Young Children with ASD

Peer reviewed
Direct link

Warren, Zachary; Zheng, Zhi; Das, Shuvajit; Young, Eric M.; Swanson, Amy; Weitlauf, Amy; Sarkar, Nilanjan – Journal of Autism and Developmental Disorders, 2015

Increasingly researchers are attempting to develop robotic technologies for children with autism spectrum disorder (ASD). This pilot study investigated the development and application of a novel robotic system capable of dynamic, adaptive, and autonomous interaction during imitation tasks with embedded real-time performance evaluation and…

Descriptors: Robotics, Intervention, Young Children, Pervasive Developmental Disorders

## Authoring Robot-Assisted Instructional Materials for Improving Learning Performance and Motivation in EFL Classrooms

Peer reviewed

Direct link

Hong, Zeng-Wei; Huang, Yueh-Min; Hsu, Marie; Shen, Wei-Wei – Educational Technology & Society, 2016

Anthropomorphized robots are regarded as beneficial tools in education due to their capabilities of improving teaching effectiveness and learning motivation. Therefore, one major trend of research, known as Robot- Assisted Language Learning (RALL), is trying to develop robots to support teaching and learning English as a foreign language (EFL). As…

Descriptors: Foreign Countries, English (Second Language), Second Language Instruction, Second Language Learning

## Brief Report: A Pilot Summer Robotics Camp to Reduce Social Anxiety and Improve Social/Vocational Skills in Adolescents with ASD

Peer reviewed

Direct link

Kaboski, Juhi R.; Diehl, Joshua John; Beriont, Jane; Crowell, Charles R.; Villano, Michael; Wier, Kristin; Tang, Karen – Journal of Autism and Developmental Disorders, 2015

This pilot study evaluated a novel intervention designed to reduce social anxiety and improve social/vocational skills for adolescents with autism spectrum disorder (ASD). The intervention utilized a shared interest in robotics among participants to facilitate natural social interaction between individuals with ASD and typically developing (TD)…

Descriptors: Pilot Projects, Summer Programs, Autism, Pervasive Developmental Disorders

## Social Robots as Embedded Reinforcers of Social Behavior in Children with Autism

Peer reviewed

Direct link

Kim, Elizabeth S.; Berkovits, Lauren D.; Bernier, Emily P.; Leyzberg, Dan; Shic, Frederick; Paul, Rhea; Scassellati, Brian – Journal of Autism and Developmental Disorders, 2013

In this study we examined the social behaviors of 4- to 12-year-old children with autism spectrum disorders (ASD; N = 24) during three tradic interactions with an adult confederate and an interaction partner, where the interaction partner varied randomly among (1) another adult human, (2) a touchscreen computer game, and (3) a social dinosaur…

Descriptors: Social Behavior, Therapy, Interpersonal Relationship, Autism

## Pedagogical and Technological Augmentation of Mobile Learning for Young Children Interactive Learning Environments

Peer reviewed

Direct link

Kim, Yanghee; Smith, Diantha – Interactive Learning Environments, 2017

The ubiquity and educational potential of mobile applications are well acknowledged. This paper proposes six theory-based, pedagogical strategies to guide interaction design of mobile apps for young children. Also, to augment the capabilities of mobile devices, we used a humanoid robot integrated with a smartphone and developed an English-learning…

Descriptors: Telecommunications, Handheld Devices, Teaching Methods, Young Children

## Dragons, Ladybugs, and Softballs: Girls' STEM Engagement with Human-Centered Robotics

Peer reviewed

Direct link

Gomoll, Andrea; Hmelo-Silver, Cindy E.; Šabanovic, Selma; Francisco, Matthew – Journal of Science Education and Technology, 2016

Early experiences in science, technology, engineering, and math (STEM) are important for getting youth interested in STEM fields, particularly for girls. Here, we explore how an after-school robotics club can provide informal STEM experiences that inspire students to engage with STEM in the future. Human-centered robotics, with its emphasis on the…

Descriptors: Females, STEM Education, Robotics, After School Programs

## Using Robots and Contract Learning to Teach Cyber-Physical Systems to Undergraduates

Peer reviewed

Direct link

Crenshaw, T. L. A. – IEEE Transactions on Education, 2013

Cyber-physical systems are a genre of networked real-time systems that monitor and control the physical world. Examples include unmanned aerial vehicles and industrial robotics. The experts who develop these complex systems are retiring much faster than universities are graduating engineering majors. As a result, it is important for undergraduates…

Descriptors: Robotics, Undergraduate Students, Engineering Education, Student Projects

## The Maiden Voyage of a Kinematics Robot

Peer reviewed

Direct link

Greenwolfe, Matthew L. – Physics Teacher, 2015

In a Montessori preschool classroom, students work independently on tasks that absorb their attention in part because the apparatus are carefully designed to make mistakes directly observable and limit exploration to one aspect or dimension. Control of error inheres in the apparatus itself, so that teacher intervention can be minimal. Inspired by…

Descriptors: Robotics, Mechanics (Physics), Preschool Children, Preschool Education

## An Engineering Mentor's Take on "FIRST" Robotics

Peer reviewed

Direct link

Jackson, Jim – Tech Directions, 2013

In this article, the author describes a program that he says has "made being smart cool." "FIRST" (For Inspiration and Recognition of Science and Technology) Robotics has made a significant contribution toward progress in advancing science, technology, engineering, and mathematics (STEM) courses and STEM careers with young people. "FIRST" Robotics…

Descriptors: Robotics, STEM Education, After School Programs, Secondary School Students

## The Effect of a Classroom-Based Intensive Robotics and Programming Workshop on Sequencing Ability in Early Childhood

Peer reviewed

Direct link

Kazakoff, Elizabeth R.; Sullivan, Amanda; Bers, Marina U. – Early Childhood Education Journal, 2013

This paper examines the impact of programming robots on sequencing ability during a 1-week intensive robotics workshop at an early childhood STEM magnet school in the Harlem area of New York City. Children participated in computer programming activities using a developmentally appropriate tangible programming language CHERP, specifically designed…

Descriptors: Children, Robotics, Programming Languages, Control Groups

## The Wheels on the Bot Go Round and Round: Robotics Curriculum in Pre-Kindergarten

Peer reviewed

Direct link

Sullivan, Amanda; Kazakoff, Elizabeth R.; Bers, Marina Umashi – Journal of Information Technology Education: Innovations in Practice, 2013

This paper qualitatively examines the implementation of an intensive weeklong robotics curriculum in three Pre-Kindergarten classrooms (N = 37) at an early childhood STEM (science, technology, engineering, and math) focused magnet school in the Harlem area of New York City. Children at the school spent one week participating in computer…

Descriptors: Robotics, Preschool Children, STEM Education, Magnet Schools

## Children with Autism Spectrum Disorders Make a Fruit Salad with Probo, the Social Robot: An Interaction Study

Peer reviewed

Direct link

Simut, Ramona E.; Vanderfaeillie, Johan; Peca, Andreea; Van de Perre, Greet; Vanderborght, Bram – Journal of Autism and Developmental Disorders, 2016

Social robots are thought to be motivating tools in play tasks with children with autism spectrum disorders. Thirty children with autism were included using a repeated measurements design. It was investigated if the children's interaction with a human differed from the interaction with a social robot during a play task. Also, it was examined if…

Descriptors: Pervasive Developmental Disorders, Autism, Children, Food

## Group Tasks, Activities, Dynamics, and Interactions in Collaborative Robotics Projects with Elementary and Middle School Children

Peer reviewed

Direct link

Yuen, Timothy T.; Boecking, Melanie; Stone, Jennifer; Tiger, Erin Price; Gomez, Alvaro; Guillen, Adrienne; Arreguin, Analisa – Journal of STEM Education: Innovations and Research, 2014

Robotics provide the opportunity for students to bring their individual interests, perspectives and areas of expertise together in order to work collaboratively on real-world science, technology, engineering and mathematics (STEM) problems. This paper examines the nature of collaboration that manifests in groups of elementary and middle school…

Descriptors: STEM Education, Engineering Education, Robotics, Middle School Students

## A Behavior-Based Approach for Educational Robotics Activities

Peer reviewed

Direct link

De Cristoforis, P.; Pedre, S.; Nitsche, M.; Fischer, T.; Pessacg, F.; Di Pietro, C. – IEEE Transactions on Education, 2013

Educational robotics proposes the use of robots as a teaching resource that enables inexperienced students to approach topics in fields unrelated to robotics. In recent years, these activities have grown substantially in elementary and secondary school classrooms and also in outreach experiences to interest students in science, technology,…

Descriptors: Robotics, STEM Education, Computer Interfaces, Programming

## An Ethnographic Eye on Religion in Everyday Life

Peer reviewed

Direct link

Berglund, Jenny – British Journal of Religious Education, 2014

There are many pitfalls associated with teaching about religions. One such pitfall entails the risk of presenting religions as stereotypical monolithic systems; that is, all who belong to a particular religious tradition think and act in the same way. I like to call this sort of stereotyping the "robotic tendency" because it has a habit…

Descriptors: Ethnography, Religion, Stereotypes, Religious Education

## Instructional Design Using an In-House Built Teaching Assistant Robot to Enhance Elementary School English-as-a-Foreign-Language Learning

Peer reviewed

Direct link

Wu, Wen-Chi Vivian; Wang, Rong-Jyue; Chen, Nian-Shing – Interactive Learning Environments, 2015

This paper presents a design for a cutting-edge English program in which elementary school learners of English as a foreign language in Taiwan had lively interactions with a teaching assistant robot. Three dimensions involved in the design included (1) a pleasant and interactive classroom environment as the learning context, (2) a teaching…

Descriptors: English (Second Language), Second Language Instruction, Robotics, Elementary School Students

## Hands Off: Mentoring a Student-Led Robotics Team

Peer reviewed
Direct link

Dolenc, Nathan R.; Mitchell, Claire E.; Tai, Robert H. – International Journal of Science Education, Part B: Communication and Public Engagement, 2016

Mentors play important roles in determining the working environment of out-of-school-time clubs. On robotics teams, they provide guidance in hopes that their protégés progress through an engineering process. This study examined how mentors on one robotics team who defined their mentoring style as "let the students do the work" navigated…

Descriptors: Science Instruction, Mentors, Robotics, Clubs

## Pre-Schoolers' Interest and Caring Behaviour around a Humanoid Robot

Peer reviewed
Direct link

Ioannou, Andri; Andreou, Emily; Christofi, Maria – TechTrends: Linking Research and Practice to Improve Learning, 2015

This exploratory case study involved a humanoid robot, NAO, and four pre-schoolers. NAO was placed in an indoor playground together with other toys and appeared as a peer who played, talked, danced and said stories. Analysis of video recordings focused on children's behaviour around NAO and how the robot gained children's attention and…

Descriptors: Caring, Robotics, Case Studies, Playground Activities

## Design-Oriented Enhanced Robotics Curriculum

Peer reviewed
Direct link

Yilmaz, M.; Ozcelik, S.; Yilmazer, N.; Nekovei, R. – IEEE Transactions on Education, 2013

This paper presents an innovative two-course, laboratory-based, and design-oriented robotics educational model. The robotics curriculum exposed senior-level undergraduate students to major robotics concepts, and enhanced the student learning experience in hybrid learning environments by incorporating the IEEE Region-5 annual robotics competition…

Descriptors: Robotics, College Curriculum, College Seniors, Elective Courses

## Embodied Computation: An Active-Learning Approach to Mobile Robotics Education

Peer reviewed
Direct link

Riek, L. D. – IEEE Transactions on Education, 2013

This paper describes a newly designed upper-level undergraduate and graduate course, Autonomous Mobile Robots. The course employs active, cooperative, problem-based learning and is grounded in the fundamental computational problems in mobile robotics defined by Dudek and Jenkin. Students receive a broad survey of robotics through lectures, weekly…

Descriptors: Robotics, Active Learning, Cooperative Learning, Problem Based Learning

## Robots Bring Math-Powered Ideas to Life

Peer reviewed

Direct link

Allen, Kasi C. – Mathematics Teaching in the Middle School, 2013

What if every middle school student learned to create a robot in math class? What if every middle school had a robotics team? Would students view mathematics differently? Would they have a different relationship with technology? Might they see science and engineering as fields driven by innovation rather than memorization? As students find…

Descriptors: Robotics, Mathematics Instruction, Middle Schools, Secondary School Mathematics

## Improving Collaborative Play between Children with Autism Spectrum Disorders and Their Siblings: The Effectiveness of a Robot-Mediated Intervention Based on Lego® Therapy

Peer reviewed

Direct link

Huskens, Bibi; Palmen, Annemiek; Van der Werff, Marije; Lourens, Tino; Barakova, Emilia – Journal of Autism and Developmental Disorders, 2015

The aim of the study was to investigate the effectiveness of a brief robot-mediated intervention based on Lego® therapy on improving collaborative behaviors (i.e., interaction initiations, responses, and play together) between children with ASD and their siblings during play sessions, in a therapeutic setting. A concurrent multiple baseline design…

Descriptors: Autism, Pervasive Developmental Disorders, Children, Siblings

## A Contest-Oriented Project for Learning Intelligent Mobile Robots

Peer reviewed

Direct link

Huang, Hsin-Hsiung; Su, Juing-Huei; Lee, Chyi-Shyong – IEEE Transactions on Education, 2013

A contest-oriented project for undergraduate students to learn implementation skills and theories related to intelligent mobile robots is presented in this paper. The project, related to Micromouse, Robotrace (Robotrace is the title of Taiwanese and Japanese robot races), and line-maze contests was developed by the embedded control system research…

Descriptors: Robotics, Competition, Student Projects, Active Learning

## Showing Up Is Half the Battle: Assessing Different Contextualized Learning Tools to Increase the Performance in Introductory Computer Science Courses

Peer reviewed

Download full text

Rolka, Christine; Remshagen, Anja – International Journal for the Scholarship of Teaching and Learning, 2015

Contextualized learning is considered beneficial for student success. In this article, we assess the impact of context-based learning tools on student grade performance in an introductory computer science course. In particular, we investigate two central questions: (1) does the use context-based learning tools, robots and animations, affect…

Descriptors: Introductory Courses, Computer Science Education, Context Effect, Grades (Scholastic)

## Designing a Robot Teaching Assistant for Enhancing and Sustaining Learning Motivation

Peer reviewed

Direct link

Hung, I-Chun; Chao, Kuo-Jen; Lee, Ling; Chen, Nian-Shing – Interactive Learning Environments, 2013

Although many researchers have pointed out that educational robots can stimulate learners' learning motivation, the learning motivation will be hardly sustained and rapidly decreased over time if the amusement and interaction merely come from the new technology itself without incorporating instructional strategies. Many researchers have…

Descriptors: Teaching Assistants, Learning Motivation, Teaching Methods, Robotics

## First-Hand Experience with Engineering Design and Career Interest in Engineering: An Informal STEM Education Case Study

Peer reviewed

Download full text

Ayar, Mehmet C. – Educational Sciences: Theory and Practice, 2015

The purpose of this study is to present students' experiences, interest in engineering, and personal narratives while participating in a robotics summer camp in a metropolitan city in Turkey. In this study, I used qualitative data collection methods such as interviews, field notes, and observations. I used the four principles of Engle and Conant…

Descriptors: Foreign Countries, Engineering Education, Design, Vocational Interests

## Examining Young Children's Perception toward Augmented Reality-Infused Dramatic Play

Peer reviewed

Direct link

Han, Jeonghye; Jo, Miheon; Hyun, Eunja; So, Hyo-jeong – Educational Technology Research and Development, 2015

Amid the increasing interest in applying augmented reality (AR) in educational settings, this study explores the design and enactment of an AR-infused robot system to enhance children's satisfaction and sensory engagement with dramatic play activities. In particular, we conducted an exploratory study to empirically examine children's perceptions…

Descriptors: Simulated Environment, Play, Robotics, Satisfaction

## Put Your Robot In, Put Your Robot Out: Sequencing through Programming Robots in Early Childhood

Peer reviewed
Direct link

Kazakoff, Elizabeth R.; Bers, Marina Umaschi – Journal of Educational Computing Research, 2014

This article examines the impact of programming robots on sequencing ability in early childhood. Thirty-four children (ages 4.5-6.5 years) participated in computer programming activities with a developmentally appropriate tool, CHERP, specifically designed to program a robot's behaviors. The children learned to build and program robots over three…

Descriptors: Robotics, Early Childhood Education, Programming, Computer Uses in Education

## Teachers' Perceptions of the Benefits and the Challenges of Integrating Educational Robots into Primary/Elementary Curricula

Peer reviewed
Direct link

Khanlari, Ahmad – European Journal of Engineering Education, 2016

Twenty-first century education systems should create an environment wherein students encounter critical learning components (such as problem-solving, teamwork, and communication skills) and embrace lifelong learning. A review of literature demonstrates that new technologies, in general, and robotics, in particular, are well suited for this aim.…

Descriptors: Teacher Attitudes, Robotics, Elementary School Teachers, Foreign Countries

## Social Robots vs. Computer Display: Does the Way Social Stories Are Delivered Make a Difference for Their Effectiveness on ASD Children?

Peer reviewed
Direct link

Pop, Cristina A.; Simut, Ramona E.; Pintea, Sebastian; Saldien, Jelle; Rusu, Alina S.; Vanderfaeillie, Johan; David, Daniel O.; Lefeber, Dirk; Vanderborght, Bram – Journal of Educational Computing Research, 2013

Background and Objectives: The aim of this exploratory study is to test whether social stories presented by a social robot have a greater effect than ones presented on a computer display in increasing the independency in expressing social abilities of children with autism spectrum disorders (ASD). Although much progress has been made in developing…

Descriptors: Autism, Pervasive Developmental Disorders, Intervention, Story Telling

## Robotics Intrigue Middle School Students and Build STEM Skills

Peer reviewed
Direct link

Grubbs, Michael – Technology and Engineering Teacher, 2013

As science, technology, engineering and mathematics (STEM) education demands greater integration across all subject areas, technology teachers can showcase many of the cross-curricular projects already occurring inside their classrooms that intrigue students and build their STEM skills. Robotics, just one of those projects, has become an excellent…

Descriptors: Engineering, Robotics, Technology Education, Middle School Students

## SyRoTek--Distance Teaching of Mobile Robotics

Peer reviewed
Direct link

Kulich, M.; Chudoba, J.; Kosnar, K.; Krajnik, T.; Faigl, J.; Preucil, L. – IEEE Transactions on Education, 2013

E-learning is a modern and effective approach for training in various areas and at different levels of education. This paper gives an overview of SyRoTek, an e-learning platform for mobile robotics, artificial intelligence, control engineering, and related domains. SyRoTek provides remote access to a set of fully autonomous mobile robots placed in…

Descriptors: Robotics, Artificial Intelligence, Electronic Learning, Distance Education

## A Case Study of Collaboration with Multi-Robots and Its Effect on Children's Interaction

Peer reviewed
Direct link

Hwang, Wu-Yuin; Wu, Sheng-Yi – Interactive Learning Environments, 2014

Learning how to carry out collaborative tasks is critical to the development of a student's capacity for social interaction. In this study, a multi-robot system was designed for students. In three different scenarios, students controlled robots in order to move dice; we then examined their collaborative strategies and their behavioral…

Descriptors: Robotics, Cooperative Learning, Elementary School Students, Cooperation

## Robots in Education: New Trends and Challenges from the Japanese Market

Peer reviewed
Download full text

Basoeki, Fransiska; Dalla Libera, Fabio; Menegatti, Emanuele; Moro, Michele – Themes in Science and Technology Education, 2013

The paper introduces and compares the use of current robotics kits developed by different companies in Japan for education purposes. These kits are targeted to a large audience: from primary school students, to university students and also up to adult lifelong learning. We selected company and kits that are most successful in the Japanese market.…

Descriptors: Foreign Countries, Robotics, Trend Analysis, Barriers

## Let's Dance the "Robot Hokey-Pokey!": Children's Programming Approaches and Achievement throughout Early Cognitive Development

Peer reviewed
Direct link

Flannery, Louise P.; Bers, Marina Umaschi – Journal of Research on Technology in Education, 2013

Young learners today generate, express, and interact with sophisticated ideas using a range of digital tools to explore interactive stories, animations, computer games, and robotics. In recent years, new developmentally appropriate robotics kits have been entering early childhood classrooms. This paper presents a retrospective analysis of one…

Descriptors: Developmentally Appropriate Practices, Robotics, Early Childhood Education, Programming

## Integrating Mobile Robotics and Vision with Undergraduate Computer Science

Peer reviewed

Direct link

Cielniak, G.; Bellotto, N.; Duckett, T. – IEEE Transactions on Education, 2013

This paper describes the integration of robotics education into an undergraduate Computer Science curriculum. The proposed approach delivers mobile robotics as well as covering the closely related field of Computer Vision and is directly linked to the research conducted at the authors' institution. The paper describes the most relevant details of…

Descriptors: Robotics, Computer Science Education, College Curriculum, Integrated Curriculum

## Learning through Creating Robotic Models of Biological Systems

Peer reviewed

Direct link

Cuperman, Dan; Verner, Igor M. – International Journal of Technology and Design Education, 2013

This paper considers an approach to studying issues in technology and science, which integrates design and inquiry activities towards creating and exploring technological models of scientific phenomena. We implemented this approach in a context where the learner inquires into a biological phenomenon and develops its representation in the form of a…

Descriptors: Biological Sciences, Robotics, Middle School Students, Preservice Teachers

## The Architecture of Children's Use of Language and Tools When Problem Solving Collaboratively with Robotics

Peer reviewed

Direct link

Mills, Kathy A.; Chandra, Vinesh; Park, Ji Yong – Australian Educational Researcher, 2013

This paper demonstrates, following Vygotsky, that language and tool use has a critical role in the collaborative problem-solving behaviour of school-age children. It reports original ethnographic classroom research examining the convergence of speech and practical activity in children's collaborative problem solving with robotics programming…

Descriptors: Foreign Countries, Problem Solving, Robotics, Ethnography

## The Relative Merits of Transparency: Investigating Situations that Support the Use of Robotics in Developing Student Learning Adaptability across Virtual and Physical Computing Platforms

Peer reviewed

Direct link

Okita, Sandra Y. – British Journal of Educational Technology, 2014

This study examined whether developing earlier forms of knowledge in specific learning environments prepares students better for future learning when they are placed in an unfamiliar learning environment. Forty-one students in the fifth and sixth grades learned to program robot movements using abstract concepts of speed, distance and direction.…

Descriptors: Robotics, Electronic Learning, Programming, Learning Processes

## Industrial-Like Vehicle Platforms for Postgraduate Laboratory Courses on Robotics

Peer reviewed

Direct link

Navarro, P. J.; Fernandez, C.; Sanchez, P. – IEEE Transactions on Education, 2013

The interdisciplinary nature of robotics allows mobile robots to be used successfully in a broad range of courses at the postgraduate level and in Ph.D. research. Practical industrial-like mobile robotic demonstrations encourage students and increase their motivation by providing them with learning benefits not achieved with traditional…

Descriptors: Robotics, Graduate Study, Computer Science Education, Computer Software

## "I Want My Robot to Look for Food": Comparing Kindergartner's Programming Comprehension Using Tangible, Graphic, and Hybrid User Interfaces

Peer reviewed

Direct link

Strawhacker, Amanda; Bers, Marina U. – International Journal of Technology and Design Education, 2015

In recent years, educational robotics has become an increasingly popular research area. However, limited studies have focused on differentiated learning outcomes based on type of programming interface. This study aims to explore how successfully young children master foundational programming concepts based on the robotics user interface (tangible,…

Descriptors: Robotics, Kindergarten, Young Children, Technology Uses in Education

## Geometry in Early Years: Sowing Seeds for a Mathematical Definition of Squares and Rectangles

Peer reviewed

Direct link

Bartolini Bussi, Maria G.; Baccaglini-Frank, Anna – ZDM: The International Journal on Mathematics Education, 2015

In early years schooling it is becoming common to propose activities that involve moving along paths, or programming robots to do so. In order to promote continuity towards the introduction of geometry in primary school, we developed a long-term teaching experiment (with 15 sessions) carried out over 4 months in a first grade classroom in northern…

Descriptors: Geometry, Geometric Concepts, Elementary School Mathematics, Elementary School Students

## Building Bridges, Robots, and High Expectations

Peer reviewed

Download full text

Bennie, Fiona; Corbett, Charlotte; Palo, Angela – Odyssey: New Directions in Deaf Education, 2015

This article describes an after-school program at the Horace Mann School for the Deaf (HMS), the oldest public day school for deaf students in the United States, where almost half of the student body imagined and created bridge and robotic machines. The Deaf Robotics Engineering and Math Team, or the DREAM Team club, included HMS students in…

Descriptors: After School Programs, Robotics, Deafness, Program Descriptions

## Increasing Students' Interest with Low-Cost CellBots

Peer reviewed

Direct link

Aroca, R. V.; Gomes, R. B.; Tavares, D. M.; Souza, A. A. S; Burlamaqui, A. M. F.; Caurin, G. A. P.; Goncalves, L. M. G. – IEEE Transactions on Education, 2013

This paper introduces the use of a flexible and affordable educational robot specifically developed for the practical experimentation inherent to technological disciplines. The robot has been designed to be reconfigurable and extendible, serving as an experimental platform across several undergraduate courses. As most students have a mobile cell…

Descriptors: Student Interests, Student Motivation, Undergraduate Study, Telecommunications

## Why Are There Developmental Stages in Language Learning? A Developmental Robotics Model of Language Development

Peer reviewed

Direct link

Morse, Anthony F.; Cangelosi, Angelo – Cognitive Science, 2017

Most theories of learning would predict a gradual acquisition and refinement of skills as learning progresses, and while some highlight exponential growth, this fails to explain why natural cognitive development typically progresses in stages. Models that do span multiple developmental stages typically have parameters to "switch" between…

Descriptors: Vocabulary Development, Language Acquisition, Language Processing, Learning Theories

## Beyond the Middle Finger: Affective Labour, an Ethic of Care and the Reform of Teacher Education

Peer reviewed

Direct link

Renshaw, Peter – Teaching Education, 2017

The centrality of relationships between teachers and students is revealed in the articles in this special issue on alternative schools. This should characterise the mainstream but the Australian Professional Standards for Teachers avoids any reference to care or affect or to the importance of forming ethically informed caring relationships with…

Descriptors: Foreign Countries, Educational Change, Teacher Education, Teacher Student Relationship

## Augmenting a Child's Reality: Using Educational Tablet Technology

Peer reviewed

Direct link

Tanner, Patricia; Karas, Carly; Schofield, Damian – Journal of Information Technology Education: Innovations in Practice, 2014

This study investigates the classroom integration of an innovative technology, augmented reality. Although the process of adding new technologies into a classroom setting can be daunting, the concept of augmented reality has demonstrated the ability to educate students and to assist with their comprehension of a procedural task. One half of the…

Descriptors: Handheld Devices, Educational Technology, Telecommunications, Technology Uses in Education

## Augmenting a Child's Reality: Using Educational Tablet Technology

Peer reviewed

Direct link

Tanner, Patricia; Karas, Carly; Schofield, Damian – Journal of Information Technology Education: Research, 2014

This study investigates the classroom integration of an innovative technology, augmented reality. Although the process of adding new technologies into a classroom setting can be daunting, the concept of augmented reality has demonstrated the ability to educate students and to assist with their comprehension of a procedural task. One half of the…

Descriptors: Computer Simulation, Handheld Devices, Computer Uses in Education, Robotics

## Transmedia Dynamics in Education: The Case of Robot Heart Stories

Peer reviewed

Direct link

Gambarato, Renira Rampazzo; Dabagian, Lilit – Educational Media International, 2016

This article discusses the potentiality and risks of applying transmedia storytelling strategies in the realm of education. The empirical approach is used to analyze the experiential education project Robot Heart Stories, developed in 2011 in Canada and the United States. The theoretical framework focuses on the conceptualization of transmedia…

Descriptors: Case Studies, Story Telling, Educational Games, Experiential Learning

## Are Commercial "Personal Robots" Ready for Language Learning? Focus on Second Language Speech

Peer reviewed

Download full text

Moussalli, Souheila; Cardoso, Walcir – Research-publishing.net, 2016

Today's language classrooms are challenged with limited classroom time and lack of input, and output practice in a stress-free environment (Hsu, 2015). The use of commercial, readily available tools such as Personal Robots (PRs; e.g. Amazon's Echo, Jibo) might promote language learning by freeing up class time, allowing for a more focused…

Descriptors: Second Language Instruction, Educational Technology, Technology Uses in Education, Robotics

## Teaching of Computer Science Topics Using Meta-Programming-Based GLOs and LEGO Robots

Peer reviewed

Download full text

Štuikys, Vytautas; Burbaite, Renata; Damaševicius, Robertas – Informatics in Education, 2013

The paper's contribution is a methodology that integrates two educational technologies (GLO and LEGO robot) to teach Computer Science (CS) topics at the school level. We present the methodology as a framework of 5 components (pedagogical activities, technology driven processes, tools, knowledge transfer actors, and pedagogical outcomes) and…

Descriptors: Educational Technology, Robotics, Computer Science Education, Teaching Methods

## Digital Learning Playground: Supporting Authentic Learning Experiences in the Classroom

Peer reviewed

Direct link

Chen, Gwo-Dong; Nurkhamid; Wang, Chin-Yeh; Yang, Su-Hang; Lu, Wei-Yuan; Chang, Chih-Kai – Interactive Learning Environments, 2013

This study proposes a platform to provide a near-authentic environment, context, and situation for task-based learning. The platform includes two projection screens (a vertical and a horizontal screen) combined for situated or authentic learning. The horizontal screen extends the vertical screen scene to form a space for learning activities and…

Descriptors: Foreign Countries, English (Second Language), Second Language Instruction, Pretests Posttests

## Using Tangible Companions for Enhancing Learning English Conversation

Peer reviewed

Direct link

Wang, Yi Hsuan; Young, Shelley S.-C.; Jang, Jyh-Shing Roger – Educational Technology & Society, 2013

In this study, the researchers attempted to extend the concept of learning companions from the virtual world to the real physical environment and made a breakthrough in technique development of tangible learning robots. The aim of this study was to explore an innovative way by combining the speech recognition technology with educational robots in…

Descriptors: Foreign Countries, Robotics, Educational Technology, English (Second Language)

## Exciting Young Students in Grades K-8 about STEM through an Afterschool Robotics Challenge

Peer reviewed

Download full text

Karp, Tanja; Maloney, Patricia – American Journal of Engineering Education, 2013

In this paper, we describe the successful implementation of an afterschool LEGO robotics program for elementary and middle school students that is annually offered by the Whitacre College of Engineering at Texas Tech University. Three events are held on campus: the kickoff, a trial run, and the competition, spread over a period of eight weeks. In…

Descriptors: Robotics, Elementary School Students, STEM Education, Middle School Students

## So Long, Robot Reader! A Superhero Intervention Plan for Improving Fluency

Peer reviewed
Direct link

Marcell, Barclay; Ferraro, Christine – Reading Teacher, 2013

This article presents an engaging means for turning disfluent readers into prosody superstars. Each week students align with Poetry Power Man and his superhero friends to battle the evil Robot Reader and his sidekicks. The Fluency Foursome helps students adhere to the multidimensional aspects of fluency where expression and comprehension are…

Descriptors: Reading Fluency, Reading Instruction, Intervention, Poetry

## 5-7 Year Old Children's Conceptions of Behaving Artifacts and the Influence of Constructing Their Behavior on the Development of Theory of Mind (ToM) and Theory of Artificial Mind (ToAM)

Peer reviewed
Direct link

Spektor-Precel, Karen; Mioduser, David – Interdisciplinary Journal of e-Skills and Lifelong Learning, 2015

Nowadays, we are surrounded by artifacts that are capable of adaptive behavior, such as electric pots, boiler timers, automatic doors, and robots. The literature concerning human beings' conceptions of "traditional" artifacts is vast, however, little is known about our conceptions of behaving artifacts, nor of the influence of the…

Descriptors: Foreign Countries, Young Children, Theory of Mind, Behavior

## "iRobiQ": The Influence of Bidirectional Interaction on Kindergarteners' Reading Motivation, Literacy, and Behavior

Peer reviewed
Direct link

Hsiao, Hsien-Sheng; Chang, Cheng-Sian; Lin, Chien-Yu; Hsu, Hsiu-Ling – Interactive Learning Environments, 2015

This study focused on an intelligent robot which was viewed as a language teaching/learning tool to improve children's reading ability, reading interest, and learning behavior. The iRobiQ, with its multimedia contents, was employed to encourage children to read, speak, and answer questions. Fifty-seven pre-kindergarteners participated in this…

Descriptors: Robotics, Artificial Intelligence, Teaching Methods, Reading Ability

## Tour Guide Robots: An Integrated Research and Design Platform to Prepare Engineering and Technology Students

Peer reviewed
Direct link

Yelamarthi, Kumar – Journal of STEM Education: Innovations and Research, 2016

Many interesting research and design questions occur at the intersections of traditional disciplines, yet most coursework and research programs for undergraduate engineering students are focused on one discipline. This leads to underutilization of the potential in better preparing students through multidisciplinary projects. Identifying this…

Descriptors: STEM Education, Robotics, Engineering Education, Technology Education

## Managing Uncertainty during Collaborative Problem Solving in Elementary School Teams: The Role of Peer Influence in Robotics Engineering Activity

Peer reviewed
Direct link

Jordan, Michelle E.; McDaniel, Reuben R., Jr. – Journal of the Learning Sciences, 2014

This study investigated how interaction with peers influenced the ways students managed uncertainty during collaborative problem solving in a 5th-grade class. The analysis focused on peer responses to individuals' attempts to manage uncertainty they experienced while engaged in collaborative efforts to design, build, and program robots and…

Descriptors: Robotics, Peer Influence, Cooperative Learning, Problem Solving

## Making Friends and Buying Robots: How to Leverage Collaborations and Collections to Support STEM Learning

Peer reviewed
Direct link

Kvenild, Cassandra; Shepherd, Craig E.; Smith, Shannon M.; Thielk, Emma – Knowledge Quest, 2017

In a climate of increased interest in science, technology, engineering, and math (STEM), school libraries have unique opportunities to grow collections and cultivate partnerships in the sciences. At the federal level and in many states, STEM initiatives encourage hands-on exposure to technologies and open the door for student-led discovery of…

Descriptors: STEM Education, Robotics, Information Technology, Learning Resources Centers

## The Effectiveness of Simulated Robots for Supporting the Learning of Introductory Programming: A Multi-Case Case Study

Peer reviewed
Direct link

Major, Louis; Kyriacou, Theocharis; Brereton, Pearl – Computer Science Education, 2014

This work investigates the effectiveness of simulated robots as tools to support the learning of programming. After the completion of a systematic review and exploratory research, a multi-case case study was undertaken. A simulator, named Kebot, was developed and used to run four 10-hour programming workshops. Twenty-three student participants…

Descriptors: Robotics, Computer Simulation, Programming, Teaching Methods

## Research-Based Design of Pedagogical Agent Roles: A Review, Progress, and Recommendations

Peer reviewed

Direct link

Kim, Yanghee; Baylor, Amy L. – International Journal of Artificial Intelligence in Education, 2016

In this paper we review the contribution of our original work titled "Simulating Instructional Roles Through Pedagogical Agents" published in the "International Journal of Artificial Intelligence and Education" (Baylor and Kim in "Computers and Human Behavior," 25(2), 450-457, 2005). Our original work operationalized…

Descriptors: Artificial Intelligence, Intelligent Tutoring Systems, Computer Interfaces, Instructional Design

## Underwater Robots Surface in Utah

Peer reviewed

Direct link

Hurd, Randy C.; Hacking, Kip S.; Damarjian, Jennifer L.; Wright, Geoffrey A.; Truscott, Tadd – Technology and Engineering Teacher, 2015

Underwater robots (or ROVs: Remotely Operated Vehicles as they are typically called in industry) have recently become a very popular instructional STEM activity. Nationally, ROVs have been used in science and technology classrooms for several years in cities such as Seattle, San Diego, Virginia Beach, and other coastal areas. In the past two…

Descriptors: STEM Education, Robotics, Teaching Methods, Educational Technology

## An Embedded Systems Laboratory to Support Rapid Prototyping of Robotics and the Internet of Things

Peer reviewed

Direct link

Hamblen, J. O.; van Bekkum, G. M. E. – IEEE Transactions on Education, 2013

This paper describes a new approach for a course and laboratory designed to allow students to develop low-cost prototypes of robotic and other embedded devices that feature Internet connectivity, I/O, networking, a real-time operating system (RTOS), and object-oriented C/C++. The application programming interface (API) libraries provided permit…

Descriptors: Robotics, Engineering Education, Computer Science Education, Internet

## How to Build a Robot: Collaborating to Strengthen STEM Programming in a Citywide System

Peer reviewed

Download full text

Groome, Meghan; Rodríguez, Linda M. – Afterschool Matters, 2014

You have to stick with it. It takes time, patience, trial and error, failure, and persistence. It is almost never perfect or finished, but, with a good team, you can build something that works. These are the lessons youth learn when building a robot, as many do in the out-of-school time (OST) programs supported by the initiative described in this…

Descriptors: STEM Education, After School Programs, Robotics, Science Course Improvement Projects

## Road-Cleaning Device

Peer reviewed
Direct link

Roman, Harry T. – Technology and Engineering Teacher, 2014

Roadways are literally soaked with petrochemical byproducts, oils, gasoline, and other volatile substances that eventually run off into sewers and end up in rivers, waterways, and other undesirable places. Can the roads be cleaned of these wastes, with their proper disposal? Can vehicles, robots, or other devices be designed that could be driven…

Descriptors: Sanitation, Wastes, Fuels, Motor Vehicles

## Mindstorms Robots and the Application of Cognitive Load Theory in Introductory Programming

Peer reviewed
Direct link

Mason, Raina; Cooper, Graham – Computer Science Education, 2013

This paper reports on a series of introductory programming workshops, initially targeting female high school students, which utilised Lego Mindstorms robots. Cognitive load theory (CLT) was applied to the instructional design of the workshops, and a controlled experiment was also conducted investigating aspects of the interface. Results indicated…

Descriptors: Programming, Introductory Courses, Cognitive Processes, Difficulty Level

## An Exploration of Developing Active Exploring and Problem Solving Skill Lego Robot Course by the Application of Anchored Instruction Theory

Peer reviewed
Direct link

Chen, Chen-Yuan – Educational Research and Reviews, 2013

In recent years, researches had shown that the development of problem solving skill became important for education, and the educational robots are capable for promoting students not only understand the physical and mathematical concepts, but also have active and constructive learning. Meanwhile, the importance of situation in education is rising,…

Descriptors: Problem Solving, Learning Theories, Problem Based Learning, Learning Activities

## Communication in Creative Collaborations: The Challenges of Uncertainty and Desire Related to Task, Identity, and Relational Goals

Peer reviewed
Direct link

Jordan, Michelle E.; Babrow, Austin S. – Communication Education, 2013

This study offers a systematic analysis of uncertainty in communication education by examining communication goals and challenges in the context of collaborative creative problem-solving in engineering assignments. Engineering design projects are seen as having the potential to help K-12 students learn to deal with uncertainty as well as a means…

Descriptors: Elementary Secondary Education, Engineering, Brainstorming, Creativity

## Kids See Human Too: Adapting an Individual Differences Measure of Anthropomorphism for a Child Sample

Peer reviewed

Direct link

Severson, Rachel L.; Lemm, Kristi M. – Journal of Cognition and Development, 2016

The study of anthropomorphism in adults has received considerable interest with the development of the Individual Differences in Anthropomorphism Questionnaire (IDAQ; Waytz, Cacioppo, & Epley, 2010). Anthropomorphism in children--its development, correlates, and consequences--is also of significant interest, yet a comparable measure does not…

Descriptors: Individual Differences, Measures (Individuals), Questionnaires, Comparative Analysis

## Help at 3:00 AM! Providing 24/7 Timely Support to Online Students via a Virtual Assistant

Peer reviewed

Direct link

Vu, Phu; Fredrickson, Scott; Meyer, Richard – Online Journal of Distance Learning Administration, 2016

With a dearth of research on human-robot interaction in education and relatively high non-completion rates of online students, this study was conducted to determine the feasibility of using a virtual assistant (VA) to respond to questions and concerns of students and provide 24/7 online course content support. During a 16 week-long academic…

Descriptors: Electronic Learning, Robotics, Online Courses, Feasibility Studies

## Robot vs. Human Teacher: Instruction in the Digital Age for ESL Learners

Peer reviewed

Download full text

Kwok, Virginia H. Y. – English Language Teaching, 2015

Living in the twenty-first century, life unplugged seems impossible without the Internet, mobile phones, i-products or other types of electronic gadgets for long. While language educators are overwhelmingly occupied with investigating the impact of computers and mobile learning, here is a call to address the value of face-to-face instruction in…

Descriptors: Technology Uses in Education, Technology Integration, English (Second Language), Teaching Methods

## Motivating Students through Positive Learning Experiences: A Comparison of Three Learning Designs for Computer Programming Courses

Peer reviewed

Download full text

Lykke, Marianne; Coto, Mayela; Jantzen, Christian; Mora, Sonia; Vandel, Niels – Journal of Problem Based Learning in Higher Education, 2015

Based on the assumption that wellbeing, positive emotions and engagement influence motivation for learning, the aim of this paper is to provide insight into students' emotional responses to and engagement in different learning designs. By comparing students' reports on the experiential qualities of three different learning designs, their…

Descriptors: Foreign Countries, Problem Based Learning, Student Motivation, Learning Experience

## Robots, Programming and Coding, Oh My!

Peer reviewed

Direct link

Geist, Eugene – Childhood Education, 2016

Today's children need learning opportunities from cradle to career that build the knowledge and skills necessary to thrive in our interconnected and constantly changing world. This means putting 21st century skills, including creativity, innovation, critical thinking, and problem solving, at the center of learning, both in and out of school. As…

Descriptors: Coding, Programming, Robotics, Creativity

## Utilizing Multifaceted Rasch Measurement through Facets to Evaluate Science Education Data Sets Composed of Judges, Respondents, and Rating Scale Items: An Exemplar Utilizing the Elementary Science Teaching Analysis Matrix Instrument

Peer reviewed

Direct link

Boone, William J.; Townsend, J. Scott; Staver, John R. – Science Education, 2016

When collecting data, science education researchers frequently have multiple respondents evaluate multiple artifacts using multiple criteria. Herein, the authors introduce Multifaceted Rasch Measurement (MFRM) analysis and explain why MFRM must be used when "judges'" data are collected. The authors use data from elementary science…

Descriptors: Evaluation Methods, Elementary School Science, Methods Courses, Preservice Teacher Education

## Multimodal Learning Analytics and Education Data Mining: Using Computational Technologies to Measure Complex Learning Tasks

Peer reviewed

Download full text

Blikstein, Paulo; Worsley, Marcelo – Journal of Learning Analytics, 2016

New high-frequency multimodal data collection technologies and machine learning analysis techniques could offer new insights into learning, especially when students have the opportunity to generate unique, personalized artifacts, such as computer programs, robots, and solutions engineering challenges. To date most of the work on learning analytics…

Descriptors: Data Analysis, Data Collection, Educational Research, Constructivism (Learning)

## Digital Peers to Help Children's Text Comprehension and Perceptions

Peer reviewed

Direct link

Kim, Yanghee – Educational Technology & Society, 2013

Affable Reading Tutor (ART) is an online reading lesson designed for children who are starting to comprehend reading. A digital, human-like character (virtual peer) in ART serves as a peer model that demonstrates the use of the reading comprehension strategy called "questioning" to help improve the learners' comprehension of expository…

Descriptors: Reading Instruction, Teaching Methods, Computer Uses in Education, Educational Technology

## Education: The "Business" of America

Peer reviewed

Download full text

Ahmed, Nuwar – Penn GSE Perspectives on Urban Education, 2013

This article offers the author's views about the business aspects of school administration in the U.S., and discusses the mass school closures in Washington, D.C., New York City, and Chicago. These closures were intended to improve the educational systems within those cities, yet none have benefited from these reforms. She also explains the…

Descriptors: School Closing, Resistance to Change, Cost Effectiveness, Standardized Tests

## Physical Student-Robot Interaction with the ETHZ Haptic Paddle

Peer reviewed

Direct link

Gassert, R.; Metzger, J.; Leuenberger, K.; Popp, W. L.; Tucker, M. R.; Vigaru, B.; Zimmermann, R.; Lambercy, O. – IEEE Transactions on Education, 2013

Haptic paddles--low-cost one-degree-of-freedom force feedback devices--have been used with great success at several universities throughout the US to teach the basic concepts of dynamic systems and physical human-robot interaction (pHRI) to students. The ETHZ haptic paddle was developed for a new pHRI course offered in the undergraduate…

Descriptors: Robotics, Engineering Education, Undergraduate Students, Interaction

## The Physics of a Walking Robot

Peer reviewed

Direct link

Guemez, J.; Fiolhais, M. – Physics Education, 2013

The physics of walking is explored, using a toy as a concrete example and a "toy model" applied to it. Besides using Newton's second law, the problem is also discussed from the thermodynamical perspective. Once the steady state (constant velocity) is achieved, we show that the internal energy of the toy is dissipated as heat in the…

Descriptors: Physics, Robotics, Thermodynamics, Toys

## Computer Science (CS) in the Compulsory Education Curriculum: Implications for Future Research

Peer reviewed
Direct link

Passey, Don – Education and Information Technologies, 2017

The subject of computer science (CS) and computer science education (CSE) has relatively recently arisen as a subject for inclusion within the compulsory school curriculum. Up to this present time, a major focus of technologies in the school curriculum has in many countries been on applications of existing technologies into subject practice (both…

Descriptors: Computer Science Education, Integrated Curriculum, Required Courses, Educational Policy

## Robots Teaching Other Little Robots: Neoliberalism, CCSS, and Teacher Professionalism

Peer reviewed
Direct link

Endacott, Jason L.; Wright, Ginney P.; Goering, Christian Z.; Collet, Vicki S.; Denny, George S.; Davis, Jennifer Jennings – Review of Education, Pedagogy & Cultural Studies, 2015

Recent quantitative research on the implementation of the Common Core State Standards (CCSS) in schools across Arkansas has discovered that teachers' perceptions of job satisfaction, agency, and professionalism are significantly affected by their school leaders' openness towards autonomy, flexibility, and opinions of teachers (Matlock et al.…

Descriptors: Neoliberalism, Common Core State Standards, Professionalism, Teacher Attitudes

## We're in This Together: Intentional Design of Social Relationships with AIED Systems

Peer reviewed
Direct link

Walker, Erin; Ogan, Amy – International Journal of Artificial Intelligence in Education, 2016

Students' relationships with their peers, teachers, and communities influence the ways in which they approach learning activities and the degree to which they benefit from them. Learning technologies, ranging from humanoid robots to text-based prompts on a computer screen, have a similar social influence on students. We envision a future in which…

Descriptors: Artificial Intelligence, Technology Uses in Education, Educational Technology, Interpersonal Relationship

## Accumulation of Experience in a Vast Number of Cases: Enactivism as a Fit Framework for the Study of Spatial Reasoning in Mathematics Education

Peer reviewed

Direct link

Khan, Steven; Francis, Krista; Davis, Brent – ZDM: The International Journal on Mathematics Education, 2015

As we witness a push toward studying spatial reasoning as a principal component of mathematical competency and instruction in the twenty first century, we argue that enactivism, with its strong and explicit foci on the coupling of organism and environment, action as cognition, and sensory motor coordination provides an inclusive, expansive, apt,…

Descriptors: Mathematics Education, Spatial Ability, Psychomotor Skills, Cognitive Processes

## The Effect of 3D Virtual Learning Environment on Secondary School Third Grade Students' Attitudes toward Mathematics

Peer reviewed

Download full text

Simsek, Irfan – Turkish Online Journal of Educational Technology - TOJET, 2016

With this research, in Second Life environment which is a three dimensional online virtual world, it is aimed to reveal the effects of student attitudes toward mathematics courses and design activities which will enable the third grade students of secondary school (primary education seventh grade) to see the 3D objects in mathematics courses in a…

Descriptors: Secondary School Students, Mathematics Instruction, Student Attitudes, Technology Uses in Education

## Teen Experts Guide Makerspace Makeover

Peer reviewed

Direct link

Graves, Colleen – Knowledge Quest, 2014

A makerspace is a place where makers can envision a project, find an expert, and create something. Libraries have always held programming during which patrons were able to come in and create. The makerspace at the Lamar Middle School in Flower Mound, Texas, is available for students every day, so that they can daily create and play with innovative…

Descriptors: Middle Schools, School Libraries, Library Development, Space Utilization

## How Does Brain Activation Differ in Children with Unilateral Cerebral Palsy Compared to Typically Developing Children, during Active and Passive Movements, and Tactile Stimulation? An fMRI Study

Peer reviewed

Direct link

Van de Winckel, Ann; Klingels, Katrijn; Bruyninckx, Frans; Wenderoth, Nici; Peeters, Ron; Sunaert, Stefan; Van Hecke, Wim; De Cock, Paul; Eyssen, Maria; De Weerdt, Willy; Feys, Hilde – Research in Developmental Disabilities: A Multidisciplinary Journal, 2013

The aim of the functional magnetic resonance imaging (fMRI) study was to investigate brain activation associated with active and passive movements, and tactile stimulation in 17 children with right-sided unilateral cerebral palsy (CP), compared to 19 typically developing children (TD). The active movements consisted of repetitive opening and…

Descriptors: Brain, Stimulation, Cerebral Palsy, Comparative Analysis

## Influence of Scientific Stories on Students Ideas about Science and Scientists

Peer reviewed

Download full text

Erten, Sinan; Kiray, S. Ahmet; Sen-Gümüs, Betül – International Journal of Education in Mathematics, Science and Technology, 2013

This study was conducted to determine whether a lesson, in which context-based learning approach and scientific stories were used, changed students' (aged 11-12) stereotypical images of science and scientists. Data was collected from two separate sources: Interviews conducted with six students and Draw a Scientist Test (DAST) document that was…

Descriptors: Foreign Countries, Scientists, Work Environment, Elementary School Students

## Vitalizing Creative Learning in Science and Technology through an Extracurricular Club: A Perspective Based on Activity Theory

Peer reviewed

Direct link

Hong, Jon-Chao; Chen, Mei-Yung; Hwang, Ming-Yueh – Thinking Skills and Creativity, 2013

A case study was undertaken in a junior high school that had won the highest award of the National PowerTech Contest in Taiwan. In the contest, students were required to create their own wooden robot (mechatronics project) in the morning and compete in the afternoon, in order to better avoid the intervention of parents and teachers in the process.…

Descriptors: Learner Engagement, After School Programs, Foreign Countries, Clubs

## Collaborative Teamwork in Crossdisciplinarity

Peer reviewed

Download full text

Laberge, Renée-Pascale – Universal Journal of Educational Research, 2016

Polytechnique Montréal has integrated an approach of teamwork in its twelve engineering programs, in the bachelor's degree program since 2005. Students must take a compulsory 45 hours course on teamwork and are then accompanied with team coaching throughout the four years program, in all the engineering integration projects. These integration…

Descriptors: Teamwork, Cooperative Learning, Interdisciplinary Approach, Engineering Education

## Does Somatosensory Discrimination Activate Different Brain Areas in Children with Unilateral Cerebral Palsy Compared to Typically Developing Children? An fMRI Study

Peer reviewed

Direct link

Van de Winckel, Ann; Verheyden, Geert; Wenderoth, Nici; Peeters, Ron; Sunaert, Stefan; Van Hecke, Wim; De Cock, Paul; Desloovere, Kaat; Eyssen, Maria; Feys, Hilde – Research in Developmental Disabilities: A Multidisciplinary Journal, 2013

Aside from motor impairment, many children with unilateral cerebral palsy (CP) experience altered tactile, proprioceptive, and kinesthetic awareness. Sensory deficits are addressed in rehabilitation programs, which include somatosensory discrimination exercises. In contrast to adult stroke patients, data on brain activation, occurring during…

Descriptors: Brain, Cerebral Palsy, Human Body, Sensory Experience

## An Examination of the Characteristics Impacting Collaborative Tool Efficacy: The Uncanny Valley of Collaborative Tools

Peer reviewed

Direct link

Dishaw, Mark T.; Eierman, Michael A.; Iversen, Jacob H.; Philip, George – Journal of Information Technology Education: Research, 2013

As collaboration among teams that are distributed in time and space is becoming increasingly important, there is a need to understand the efficacy of tools available to support that collaboration. This study employs a combination of the Technology Acceptance Model (TAM) and the Task-Technology Fit (TTF) model to compare four different technologies…

Descriptors: Cooperation, Collaborative Writing, Electronic Publishing, Word Processing

## Contemporary Art and Citizenship Education: The Possibilities of Cross-Curricular Links on the Level of Content

Peer reviewed

Download full text

Kemperl, Metoda – Center for Educational Policy Studies Journal, 2013

Unlike the previous phenomenon of modern art, contemporary art strives to return to society and everyday life, while thematising the current issues that the individual faces here and now. One of its more frequent topics is that of sustainable development, and the accompanying issues of environment, values, relations to others, etc. All such topics…

Descriptors: Citizenship Education, Sustainable Development, Art Education, Elementary School Curriculum

## Integrating Touch-Enabled and Mobile Devices into Contemporary Mathematics Education

Peer reviewed

Direct link

Meletiou-Mavrotheris, Maria, Ed.; Mavrou, Katerina, Ed.; Paparistodemou, Efi, Ed. – IGI Global, 2015

Despite increased interest in mobile devices as learning tools, the amount of available primary research studies on their integration into mathematics teaching and learning is still relatively small due to the novelty of these technologies. "Integrating Touch-Enabled and Mobile Devices into Contemporary Mathematics Education" presents…

Descriptors: Mathematics Education, Handheld Devices, Technology Uses in Education, Technology Integration

## Robotics in the Early Childhood Classroom: Learning Outcomes from an 8-Week Robotics Curriculum in Pre-Kindergarten through Second Grade

 Peer reviewed
 Direct link

Sullivan, Amanda; Bers, Marina Umaschi – International Journal of Technology and Design Education, 2016

In recent years there has been an increasing focus on the missing "T" of technology and "E" of engineering in early childhood STEM (science, technology, engineering, mathematics) curricula. Robotics offers a playful and tangible way for children to engage with both T and E concepts during their foundational early childhood…

Descriptors: Robotics, Programming, Programming Languages, Engineering

## Effect of Robotics on Elementary Preservice Teachers' Self-Efficacy, Science Learning, and Computational Thinking

 Peer reviewed
 Direct link

Jaipal-Jamani, Kamini; Angeli, Charoula – Journal of Science Education and Technology, 2017

The current impetus for increasing STEM in K-12 education calls for an examination of how preservice teachers are being prepared to teach STEM. This paper reports on a study that examined elementary preservice teachers' (n = 21) self-efficacy, understanding of science concepts, and computational thinking as they engaged with robotics in a science…

Descriptors: STEM Education, Elementary Secondary Education, Preservice Teacher Education, Elementary School Teachers

## Educational Robotics as Mindtools

 Peer reviewed
 Download full text

Mikropoulos, Tassos A.; Bellou, Ioanna – Themes in Science and Technology Education, 2013

Although there are many studies on the constructionist use of educational robotics, they have certain limitations. Some of them refer to robotics education, rather than educational robotics. Others follow a constructionist approach, but give emphasis only to design skills, creativity and collaboration. Some studies use robotics as an educational…

Descriptors: Robotics, Educational Technology, Constructivism (Learning), Physics

## Effect of Robotics-Enhanced Inquiry-Based Learning in Elementary Science Education in South Korea

Peer reviewed

Direct link

Park, Jungho – Journal of Computers in Mathematics and Science Teaching, 2015

Much research has been conducted in educational robotics, a new instructional technology, for K-12 education. However, there are arguments on the effect of robotics and limited empirical evidence to investigate the impact of robotics in science learning. Also most robotics studies were carried in an informal educational setting. This study…

Descriptors: Robotics, Elementary School Science, Science Instruction, Inquiry

## Educational Robotics: Open Questions and New Challenges

Peer reviewed

Download full text

Alimisis, Dimitris – Themes in Science and Technology Education, 2013

This paper investigates the current situation in the field of educational robotics and identifies new challenges and trends focusing on the use of robotic technologies as a tool that will support creativity and other 21st-century learning skills. Finally, conclusions and proposals are presented for promoting cooperation and networking of…

Descriptors: Robotics, Educational Technology, Science Education, Creativity

## The Robotic Decathlon: Project-Based Learning Labs and Curriculum Design for an Introductory Robotics Course

Peer reviewed

Direct link

Cappelleri, D. J.; Vitoroulis, N. – IEEE Transactions on Education, 2013

This paper presents a series of novel project-based learning labs for an introductory robotics course that are developed into a semester-long Robotic Decathlon. The last three events of the Robotic Decathlon are used as three final one-week-long project tasks; these replace a previous course project that was a semester-long robotics competition.…

Descriptors: Robotics, Introductory Courses, Student Projects, Active Learning

## CALL Communities & Culture: Short Papers from EUROCALL 2016 (23rd, Limassol, Cyprus, August 24-27, 2016)

Peer reviewed

Download full text

Papadima-Sophocleous, Salomi, Ed.; Bradley, Linda, Ed.; Thouësny, Sylvie, Ed. – Research-publishing.net, 2016

The 23rd EUROCALL conference was held in Cyprus from the 24th to the 27th of August 2016. The theme of the conference this year was "CALL Communities and Culture." It offered a unique opportunity to hear from real-world CALL practitioners on how they practice CALL in their communities, and how the CALL culture has developed in local and…

Descriptors: Conference Papers, Computer Assisted Instruction, Second Language Instruction, English (Second Language)

## Comparison of the LEGO Mindstorms NXT and EV3 Robotics Education Platforms

Peer reviewed

Direct link

Sherrard, Ann; Rhodes, Amy – Journal of Extension, 2014

The release of the latest LEGO Mindstorms EV3 robotics platform in September 2013 has provided a dilemma for many youth robotics leaders. There is a need to understand the differences in the Mindstorms NXT and EV3 in order to make future robotics purchases. In this article the differences are identified regarding software, hardware, sensors, the…

Descriptors: Robotics, Comparative Analysis, Consumer Economics, Purchasing

## Girls, Boys, and Bots: Gender Differences in Young Children's Performance on Robotics and Programming Tasks

Peer reviewed

Direct link

Sullivan, Amanda; Bers, Marina Umaschi – Journal of Information Technology Education: Innovations in Practice, 2016

Prior work demonstrates the importance of introducing young children to programming and engineering content before gender stereotypes are fully developed and ingrained in later years. However, very little research on gender and early childhood technology interventions exist. This pilot study looks at N = 45 children in kindergarten through second…

Descriptors: Early Childhood Education, Kindergarten, Grade 1, Grade 2

## Robotic Cooperative Learning Promotes Student STEM Interest

Peer reviewed

Download full text

Mosley, Pauline; Ardito, Gerald; Scollins, Lauren – American Journal of Engineering Education, 2016

The principal purpose of this investigation is to study the effect of robotic cooperative learning methodologies on middle school students' critical thinking, and STEM interest. The semi-experimental inquiry consisted of ninety four six-grade students (forty nine students in the experimental group, forty five students in the control group), chosen…

Descriptors: Robotics, Cooperative Learning, Student Interests, STEM Education

## The Rediscovery of Teaching: On Robot Vacuum Cleaners, Non-Egological Education and the Limits of the Hermeneutical World View

Peer reviewed

Direct link

Biesta, Gert – Educational Philosophy and Theory, 2016

In this article, I seek to reclaim a place for teaching in face of the contemporary critique of so-called traditional teaching. While I agree with this critique to the extent to which it is levelled at an authoritarian conception of teaching as control, a conception in which the student can only exist as an object of the interventions of the…

Descriptors: Criticism, Teaching Methods, Intervention, Educational Philosophy

## Assessing the Impact of an Autonomous Robotics Competition for STEM Education

Peer reviewed
Direct link

Chung, C. J. ChanJin; Cartwright, Christopher; Cole, Matthew – Journal of STEM Education: Innovations and Research, 2014

Robotics competitions for K-12 students are popular, but are students really learning and improving their STEM scores through robotics competitions? If not, why not? If they are, how much more effective is learning through competitions than traditional classes? Is there room for improvement? What is the best robotics competition model to maximize…

Descriptors: STEM Education, Robotics, Competition, Teaching Methods

## A One-Year Introductory Robotics Curriculum for Computer Science Upperclassmen

Peer reviewed
Direct link

Correll, N.; Wing, R.; Coleman, D. – IEEE Transactions on Education, 2013

This paper describes a one-year introductory robotics course sequence focusing on computational aspects of robotics for third- and fourth-year students. The key challenges this curriculum addresses are "scalability," i.e., how to teach a robotics class with a limited amount of hardware to a large audience, "student assessment,"…

Descriptors: Introductory Courses, Robotics, Course Descriptions, Simulation

## The Early Years: Integrating Digital Tools

Peer reviewed
Direct link

Ashbrook, Peggy – Science and Children, 2017

This column discusses resources and science topics related to students in grades preK to 2. This month's issue discusses how digital media and robotics fit into the early childhood curriculum, and how time on devices supports learning goals and developmentally appropriate practice.

Descriptors: Early Childhood Education, Technology Uses in Education, Educational Technology, Technology Integration

## The Functionator 3000: Transforming Numbers and Children

Peer reviewed
Direct link

Fisher, Elaine Cerrato; Roy, George; Reeves, Charles – Teaching Children Mathematics, 2013

Mrs. Fisher's class was learning about arithmetic functions by pretending to operate real-world "function machines" (Reeves 2006). Functions are a unifying mathematics topic, and a great deal of emphasis is placed on understanding them in prekindergarten through grade 12 (Kilpatrick and Izsák 2008). In its Algebra Content Standard, the…

Descriptors: Arithmetic, Mathematics Instruction, Mathematical Concepts, Tables (Data)

## Spatial Ability Learning through Educational Robotics

Peer reviewed
Direct link

Julià, Carme; Antolí, Juan Òscar – International Journal of Technology and Design Education, 2016

Several authors insist on the importance of students' acquisition of spatial abilities and visualization in order to have academic success in areas such as science, technology or engineering. This paper proposes to discuss and analyse the use of educational robotics to develop spatial abilities in 12 year old students. First of all, a course to…

Descriptors: Spatial Ability, Robotics, Visualization, Academic Achievement

## A Project-Based Biologically-Inspired Robotics Module

Peer reviewed
Direct link

Crowder, R. M.; Zauner, K.-P. – IEEE Transactions on Education, 2013

The design of any robotic system requires input from engineers from a variety of technical fields. This paper describes a project-based module, "Biologically-Inspired Robotics," that is offered to Electronics and Computer Science students at the University of Southampton, U.K. The overall objective of the module is for student groups to…

Descriptors: Robotics, Engineering Education, Computer Science Education, Biology

## Robotic Construction Kits as Computational Manipulatives for Learning in the STEM Disciplines

Peer reviewed
Direct link

Sullivan, Florence R.; Heffernan, John – Journal of Research on Technology in Education, 2016

This article presents a systematic review of research related to the use of robotics construction kits (RCKs) in P-12 learning in the STEM disciplines for typically developing children. The purpose of this review is to configure primarily qualitative and mixed methods findings from studies meeting our selection and quality criterion to answer the…

Descriptors: Robotics, Manipulative Materials, STEM Education, Elementary Secondary Education

## Using Robotics and Game Design to Enhance Children's Self-Efficacy, STEM Attitudes, and Computational Thinking Skills

Peer reviewed
Direct link

Leonard, Jacqueline; Buss, Alan; Gamboa, Ruben; Mitchell, Monica; Fashola, Olatokunbo S.; Hubert, Tarcia; Almughyirah, Sultan – Journal of Science Education and Technology, 2016

This paper describes the findings of a pilot study that used robotics and game design to develop middle school students' computational thinking strategies. One hundred and twenty-four students engaged in LEGO® EV3 robotics and created games using Scalable Game Design software. The results of the study revealed students' pre-post self-efficacy…

Descriptors: Robotics, Design, Self Efficacy, Student Attitudes

## Master's in Autonomous Systems: An Overview of the Robotics Curriculum and Outcomes at ISEP, Portugal

Peer reviewed

Direct link

Silva, E.; Almeida, J.; Martins, A.; Baptista, J. P.; Campos Neves, B. – IEEE Transactions on Education, 2013

Robotics research in Portugal is increasing every year, but few students embrace it as one of their first choices for study. Until recently, job offers for engineers were plentiful, and those looking for a degree in science and technology would avoid areas considered to be demanding, like robotics. At the undergraduate level, robotics programs are…

Descriptors: Foreign Countries, Robotics, Engineering Education, Masters Programs

## Low-Cost Educational Robotics Applied to Physics Teaching in Brazil

Peer reviewed

Direct link

Souza, Marcos A. M.; Duarte, José R. R. – Physics Education, 2015

In this paper, we propose some of the strategies and methodologies for teaching high-school physics topics through an educational robotics show. This exhibition was part of a set of actions promoted by a Brazilian government program of incentive for teaching activities, whose primary focus is the training of teachers, the improvement of teaching…

Descriptors: Secondary School Science, Physics, Science Instruction, High Schools

## Experiential Learning of Electronics Subject Matter in Middle School Robotics Courses

Peer reviewed

Direct link

Rihtaršic, David; Avsec, Stanislav; Kocijancic, Slavko – International Journal of Technology and Design Education, 2016

The purpose of this paper is to investigate whether the experiential learning of electronics subject matter is effective in the middle school open learning of robotics. Electronics is often ignored in robotics courses. Since robotics courses are typically comprised of computer-related subjects, and mechanical and electrical engineering, these…

Descriptors: Experiential Learning, Middle School Students, Electronics, Robotics

## Implementing a Robotics Curriculum in an Early Childhood Montessori Classroom

Peer reviewed

Direct link

Elkin, Mollie; Sullivan, Amanda; Bers, Marina Umaschi – Journal of Information Technology Education: Innovations in Practice, 2014

This paper explores how robotics can be used as a new educational tool in a Montessori early education classroom. It presents a case study of one early educator's experience of designing and implementing a robotics curriculum integrated with a social science unit in her mixed-age classroom. This teacher had no prior experience using robotics in…

Descriptors: Robotics, Montessori Method, Case Studies, Curriculum Development

## Enacting Acts of Authentication in a Robotics Competition: An Interpretivist Study

 Peer reviewed
 Direct link

Verma, Geeta; Puvirajah, Anton; Webb, Horace – Journal of Research in Science Teaching, 2015

While the science classroom primarily remains a site for knowledge acquisition through teacher directed experiences, other sites exist outside of the classroom that allow for student generation of scientific knowledge. These sites provide opportunities for linguistic and social interactions to play a powerful role in situating students'…

Descriptors: Science Instruction, Robotics, Competition, Learning Experience

## Design and Development Issues for Educational Robotics Training Camps

 Peer reviewed
 Direct link

Ucgul, Memet; Cagiltay, Kursat – International Journal of Technology and Design Education, 2014

The aim of this study is to explore critical design issues for educational robotics training camps and to describe how these factors should be implemented in the development of such camps. For this purpose, two robotics training camps were organized for elementary school students. The first camp had 30 children attendees, and the second had 22. As…

Descriptors: Design, Robotics, Elementary School Students, Interviews

## Collaboration by Design: Using Robotics to Foster Social Interaction in Kindergarten

 Peer reviewed
 Direct link

Lee, Kenneth T. H.; Sullivan, Amanda; Bers, Marina U. – Computers in the Schools, 2013

Research shows the importance of social interaction between peers in child development. Although technology can foster peer interactions, teachers often struggle with teaching with technology. This study examined a sample of (n = 19) children participating in a kindergarten robotics summer workshop to determine the effect of teaching using a…

Descriptors: Social Networks, Robotics, Kindergarten, Child Development

## Examining Students' Proportional Reasoning Strategy Levels as Evidence of the Impact of an Integrated LEGO Robotics and Mathematics Learning Experience

Peer reviewed

Download full text

Martínez Ortiz, Araceli – Journal of Technology Education, 2015

The presented study used a problem-solving experience in engineering design with LEGO robotics materials as the real-world mathematics-learning context. The goals of the study were (a) to determine if a short but intensive extracurricular learning experience would lead to significant student learning of a particular academic topic and (b) to…

Descriptors: Engineering Education, Design, Problem Solving, Robotics

## Gender Differences in Kindergarteners' Robotics and Programming Achievement

Peer reviewed

Direct link

Sullivan, Amanda; Bers, Marina Umaschi – International Journal of Technology and Design Education, 2013

Early childhood is a critical period for introducing girls to traditionally masculine fields of science and technology before more extreme gender stereotypes surface in later years. This study looks at the TangibleK Robotics Program in order to determine whether kindergarten boys and girls were equally successful in a series of building and…

Descriptors: Programming, Kindergarten, Gender Differences, Robotics

## Diving beneath the Surface: Underwater Robotics Lessons Bring STEM to Life for Teachers in Guam

Peer reviewed

Direct link

Tweed, Anne; Arndt, Laura – Learning Professional, 2017

In spring 2014, education leaders from across Micronesia came together on the island of Guam to learn about underwater robotics and Marine Advanced Technology Education (MATE), a program based at Monterey Peninsula College in Monterey, California. Participants listened intently as they learned about building and participating in competitions with…

Descriptors: Robotics, STEM Education, Teaching Methods, Competition

## Teacher Self-Efficacy during the Implementation of a Problem-Based Science Curriculum

Peer reviewed

Direct link

Hodges, Charles B.; Gale, Jessica; Meng, Alicia – Contemporary Issues in Technology and Teacher Education (CITE Journal), 2016

This study was conducted to investigate eighth-grade science teachers' self-efficacy during the implementation of a new, problem-based science curriculum. The curriculum included applications of LEGO® robotics, a new technology for these teachers. Teachers' responded to structured journaling activities designed to collect information about their…

Descriptors: Problem Based Learning, Science Curriculum, Curriculum Implementation, Self Efficacy

## "STEMming" the Swell of Absenteeism in Urban Middle Grade Schools: Impacts of a Summer Robotics Program

Peer reviewed

Download full text

Mac Iver, Martha Abele; Mac Iver, Douglas J. – Society for Research on Educational Effectiveness, 2014

Attendance is probably the most fundamental behavioral indicator of student engagement with school. Though many students fall off-track to success for the first time in ninth grade, poor attendance patterns often begin increasing in middle school and become worse in high school. Missing school during the secondary grades can often be traced to low…

Descriptors: Attendance Patterns, Learner Engagement, Urban Schools, Middle School Students

## Digital Storytelling Teaching Robotics Basics

Peer reviewed

Download full text

Scandola, Michele; Fiorini, Paolo – Themes in Science and Technology Education, 2013

Digital Storytelling (DST) is a powerful tool for teaching complex concepts. DSTs are typically used in the humanities but several papers have shown that they are also a wonderful tool for the sciences because they are more involving, contextualized and can easily lead to deeper understanding. In the classical use of DST the story is the content,…

Descriptors: Robotics, Fundamental Concepts, Teaching Methods, Story Telling

## Teaching Robotics Software with the Open Hardware Mobile Manipulator

Peer reviewed

Direct link

Vona, M.; Shekar, N. H. – IEEE Transactions on Education, 2013

The "open hardware mobile manipulator" (OHMM) is a new open platform with a unique combination of features for teaching robotics software and algorithms. On-board low- and high-level processors support real-time embedded programming and motor control, as well as higher-level coding with contemporary libraries. Full hardware designs and…

Descriptors: Robotics, Computer Software, Open Source Technology, Internet

## Learning from the Periphery in a Collaborative Robotics Workshop for Girls

Peer reviewed

Download full text

Sullivan, Florence R.; Keith, Kevin; Wilson, Nicholas C. – Universal Journal of Educational Research, 2016

This study investigates how students who are peripherally positioned in computer science-based, collaborative group work meaningfully engage with the group activity in order to learn. Our research took place in the context of a one-day, all-girl robotics workshop, in which the participants were learning to program robotic devices. A total of 17…

Descriptors: Computer Science, Robotics, Females, Cooperative Learning

## A Bottom-Up Approach to Teaching Robotics and Mechatronics to Mechanical Engineers

Peer reviewed

Direct link

Shiller, Z. – IEEE Transactions on Education, 2013

This paper describes a multidisciplinary teaching program, designed to provide students with the broad knowledge and skills required to practice product development in robotics and mechatronics. The curriculum was designed to prepare students for the senior capstone design project, in which they design and build a working mechatronic/robotic…

Descriptors: Mechanical Skills, Robotics, Engineering Education, Instructional Innovation

## Ready for Robotics: Bringing Together the T and E of STEM in Early Childhood Teacher Education

Peer reviewed

Direct link

Bers, Marina Umaschi; Seddighin, Safoura; Sullivan, Amanda – Journal of Technology and Teacher Education, 2013

Prior work has shown that early childhood educators demonstrate a lack of knowledge and understanding about technology and engineering, and about developmentally appropriate pedagogical approaches to bring those disciplines into the classrooms. This paper reports a study in which 32 early childhood educators participated in an intensive three-day…

Descriptors: STEM Education, Early Childhood Education, Knowledge Base for Teaching, Developmentally Appropriate Practices

## An Analysis of Teacher-Student Interaction Patterns in a Robotics Course for Kindergarten Children: A Pilot Study

Peer reviewed

Download full text

Liu, Eric Zhi-Feng; Lin, Chun-Hung; Liou, Pey-Yan; Feng, Han-Chuan; Hou, Huei-Tse – Turkish Online Journal of Educational Technology - TOJET, 2013

Compared with other media, programmable bricks provide children with the opportunity to create their own product and, through this process, to express creative thinking. Studies have found that learning robotics or integrating programming bricks into courses can help to develop students' problem-solving abilities and enhance their learning…

Descriptors: Teaching Methods, Kindergarten, Interaction, Robotics

## Letting Artificial Intelligence in Education out of the Box: Educational Cobots and Smart Classrooms

Peer reviewed

Direct link

Timms, Michael J. – International Journal of Artificial Intelligence in Education, 2016

This paper proposes that the field of AIED is now mature enough to break away from being delivered mainly through computers and pads so that it can engage with students in new ways and help teachers to teach more effectively. Mostly, the intelligent systems that AIED has delivered so far have used computers and other devices that were essentially…

Descriptors: Artificial Intelligence, Educational Technology, Robotics, Intelligent Tutoring Systems

## Comparing Virtual and Physical Robotics Environments for Supporting Complex Systems and Computational Thinking

Peer reviewed

Direct link

Berland, Matthew; Wilensky, Uri – Journal of Science Education and Technology, 2015

Both complex systems methods (such as agent-based modeling) and computational methods (such as programming) provide powerful ways for students to understand new phenomena. To understand how to effectively teach complex systems and computational content to younger students, we conducted a study in four urban middle school classrooms comparing…

Descriptors: Robotics, Comparative Analysis, Computer Simulation, Systems Approach

## A Predictive Study of Learner Attitudes toward Open Learning in a Robotics Class

Peer reviewed

Direct link

Avsec, Stanislav; Rihtarsic, David; Kocijancic, Slavko – Journal of Science Education and Technology, 2014

Open learning (OL) strives to transform teaching and learning by applying learning science and emerging technologies to increase student success, improve learning productivity, and lower barriers to access. OL of robotics has a significant growth rate in secondary and/or high schools, but failures exist. Little is known about why many users stop…

Descriptors: Science Instruction, Educational Technology, Robotics, Technology Uses in Education

## Development of Hybrid Courses Utilizing Modules as an Objective in ATE Projects

Peer reviewed

Direct link

Payne, James E.; Murphy, Richard M.; Payne, Linda L. – Community College Journal of Research and Practice, 2017

Orangeburg-Calhoun Technical College (OCtech) has been awarded two National Science Foundation Advanced Technological Education (NSF-ATE) grants since 2011 that have the development of module-based hybrid courses in Engineering Technology and Mechatronics as objectives. In this article, the advantages and challenges associated with module-based…

Descriptors: Blended Learning, Educational Objectives, Learning Modules, Technology Education

## Passive Maple-Seed Robotic Fliers for Education, Research and Entrepreneurship

Peer reviewed

Download full text

Aslam, D. M.; Abu-Ageel, A.; Alfatlawi, M.; Varney, M. W.; Thompson, C. M.; Aslam, S. K. – Journal of Education and Training Studies, 2014

As inspirations from flora and fauna have led to many advances in modern technology, the concept of drawing ideas from nature for design should be reflected in engineering education. This paper focuses on a maple-seed robotic flier (MRF) with various complexities, a robotic platform modeled after the samaras of maple or ash trees, to teach STEM…

Descriptors: Robotics, Entrepreneurship, Engineering Education, Science Instruction

## Drone Class: Keeping Coursework Current as Technology Advances

Peer reviewed

Direct link

Hanssen, Sarah – Community College Journal of Research and Practice, 2016

Today's students prioritize employment; they want to be sure that there will be work for them upon graduation. Film and media students, in particular, need a long list of computer software and film equipment skills on their resumes, especially newer technologies that professionals in the workforce have not yet mastered. Consider, in this regard,…

Descriptors: Technological Advancement, Skill Development, Educational Needs, Capacity Building

## Using Robotics to Improve Retention and Increase Comprehension in Introductory Programming Courses

Peer reviewed

Direct link

Pullan, Marie – Journal of Educational Technology Systems, 2013

Several college majors, outside of computer science, require students to learn computer programming. Many students have difficulty getting through the programming sequence and ultimately change majors or drop out of college. To deal with this problem, active learning techniques were developed and implemented in a freshman programming logic and…

Descriptors: Robotics, Introductory Courses, Programming, Computer Science Education

## Examining Fidelity of Program Implementation in a STEM-Oriented Out-of-School Setting

Peer reviewed

Direct link

Barker, Bradley S.; Nugent, Gwen; Grandgenett, Neal F. – International Journal of Technology and Design Education, 2014

In the United States and many other countries there is a growing emphasis on science, technology, engineering and mathematics (STEM) education that is expanding the number of both in-school and out-of-school instructional programs targeting important STEM outcomes. As instructional leaders increasingly train teachers and facilitators to undertake…

Descriptors: Fidelity, Program Implementation, STEM Education, Alignment (Education)

## Innovative Technology-Based Interventions for Autism Spectrum Disorders: A Meta-Analysis

Peer reviewed

Direct link

Grynszpan, Ouriel; Weiss, Patrice L.; Perez-Diaz, Fernando; Gal, Eynat – Autism: The International Journal of Research and Practice, 2014

This article reports the results of a meta-analysis of technology-based intervention studies for children with autism spectrum disorders. We conducted a systematic review of research that used a pre-post design to assess innovative technology interventions, including computer programs, virtual reality, and robotics. The selected studies provided…

Descriptors: Autism, Pervasive Developmental Disorders, Intervention, Technology Uses in Education

## Deepening Learning through Learning-by-Inventing

Peer reviewed

Direct link

Apiola, Mikko; Tedre, Matti – Journal of Information Technology Education: Innovations in Practice, 2013

It has been shown that deep approaches to learning, intrinsic motivation, and self-regulated learning have strong positive effects on learning. How those pedagogical theories can be integrated in computing curricula is, however, still lacking empirically grounded analyses. In a more general level, it has been widely acknowledged that in…

Descriptors: Computer Science Education, Creativity, Robotics, Problem Based Learning

## Using Control Heuristics as a Means to Explore the Educational Potential of Robotics Kits

Peer reviewed

Download full text

Gaudiello, Ilaria; Zibetti, Elisabetta – Themes in Science and Technology Education, 2013

The educational potential of robotics kits as a form of control technology will remain undervalued until meaningful observation parameters are identified to enable a better understanding of children?s control strategies. For this reason, this paper aims primarily to identify and classify the heuristics spontaneously applied by 6-10 year old…

Descriptors: Robotics, Learning Modules, Educational Opportunities, Heuristics

## An Effective Educational Tool: Construction Kits for Fun and Meaningful Learning

Peer reviewed

Direct link

Somyürek, Sibel – International Journal of Technology and Design Education, 2015

The integration of robotics in education is still relatively new and represents an important advance in education practices. So, this paper aims to share the results from the perspectives of both students and trainers in an experimental case research in which LEGO Mindstorms construction kits were used. Sixty-two students between the ages of 8 and…

Descriptors: Robotics, Construction (Process), Constructivism (Learning), Active Learning

## A Case Study of Increasing Vocational High School Teachers Practices in Designing Interdisciplinary Use of Scientific Inquiry in Curriculum Design

Peer reviewed
Direct link

Chang, Yu-Liang; Wu, Huan-Hung – EURASIA Journal of Mathematics, Science & Technology Education, 2015

The primary objective of this study was to determine how experience in learning to teach scientific inquiry using a practical approach affected teacher's attitudes, evaluations of use of inquiry and their actual design of inquiry based instruction. The methodology included the use an approach incorporating inquiry methodology combined with a…

Descriptors: Vocational High Schools, Secondary School Teachers, Science Teachers, Secondary School Science

## Comment on Technology-Based Intervention Research for Individuals on the Autism Spectrum

Peer reviewed
Direct link

McCleery, Joseph P. – Journal of Autism and Developmental Disorders, 2015

The purpose of this letter to the editor is to comment on several review papers recently published in the current "Journal of Autism and Developmental Disorders, Special Issue on Technology: Software, Robotics, and Translational Science." These reviews address a variety of aspects relating to technology-aided intervention and instruction…

Descriptors: Autism, Pervasive Developmental Disorders, Assistive Technology, Intervention

## Bringing in the Tech: Using Outside Expertise to Enhance Technology Learning in Youth Programs

Peer reviewed
Download full text

Akiva, Thomas; Povis, Kaleen Tison; Martinez, Ani – Afterschool Matters, 2015

Afterschool continues to be promoted as a complementary setting to school for strengthening science, technology, engineering, and math (STEM) education (for example, Krishnamurthi, Bevan, Rinehart, & Coulon, 2013). This is a reasonable idea: 10.2 million children and youth in the U.S. participate in structured afterschool programs (Afterschool…

Descriptors: After School Programs, STEM Education, Educational Innovation, Technology Uses in Education

## A Proposed Astronomy Learning Progression for Remote Telescope Observation

Peer reviewed
Direct link

Slater, Timothy F.; Burrows, Andrea C.; French, Debbie A.; Sanchez, Richard A.; Tatge, Coty B. – Journal of College Teaching & Learning, 2014

Providing meaningful telescope observing experiences for students who are deeply urban or distantly rural place-bound--or even daylight time-bound--has consistently presented a formidable challenge for astronomy educators. For nearly 2 decades, the Internet has promised unfettered access for large numbers of students to conduct remote telescope…

Descriptors: Astronomy, Science Equipment, Observation, Science Instruction

## The Store Challenge

Peer reviewed
Direct link

Roman, Harry T. – Technology and Engineering Teacher, 2014

Biomedical and robotic technologies are merging to present a wonderful opportunity to develop artificial limbs and prosthetic devices for humans injured on the job, in the military, or due to disease. In this challenge, students will have the opportunity to design a store or online service that specifically dedicates itself to amputees. Described…

Descriptors: Engineering Education, Robotics, Biomedicine, Online Vendors

## Enrichment and Strengthening of Indian Biotechnology Industry along with Academic Interface

Peer reviewed
Download full text

Singh, Shalini – International Journal of Educational Administration and Policy Studies, 2014

For many years, humankind has been incorporating biosciences in different places--from agriculture to food and medicine. Today, the nomenclature of biology has been recoined as Biotechnology, a technological science with a perfect blend of sophisticated techniques, manuals and application of fast delivery equipment and vehicles. It encompasses…

Descriptors: Foreign Countries, Biotechnology, Industry, Educational Change

## Coding & Robotics for Young Children? You Bet!

Peer reviewed
Direct link

Gadzikowski, Ann – Parenting for High Potential, 2016

In 2012, the National Association for the Education of Young Children (NAEYC) revised its position statement regarding the appropriate use of technology in early childhood classrooms. The increased accessibility of touch screens on tablets and smart phones led to this revision, which moves the conversation from the question of "When shall we…

Descriptors: Coding, Robotics, Young Children, Appropriate Technology

## Face-to-Face Interaction with Pedagogical Agents, Twenty Years Later

Peer reviewed
Direct link

Johnson, W. Lewis; Lester, James C. – International Journal of Artificial Intelligence in Education, 2016

Johnson et al. ("International Journal of Artificial Intelligence in Education," 11, 47-78, 2000) introduced and surveyed a new paradigm for interactive learning environments: animated pedagogical agents. The article argued for combining animated interface agent technologies with intelligent learning environments, yielding intelligent…

Descriptors: Teaching Methods, Intelligent Tutoring Systems, Outcomes of Education, Computer Assisted Instruction

## An Empirical Study of Graduate Student Mobility Underpinning Research Universities

Peer reviewed
Direct link

Furukawa, Takao; Shirakawa, Nobuyuki; Okuwada, Kumi – Higher Education: The International Journal of Higher Education and Educational Planning, 2013

The issue of international student mobility has had a profound effect on policy decision-making in the higher education system of essentially every country; however, the statistical data on this subject are insufficient, especially for graduate students. The purposes of this study are to substantiate the state of international mobility among…

Descriptors: Higher Education, Research Universities, Graduate Students, Student Mobility

## "Some Explanation Here": A Case Study of Learning Opportunities and Tensions in an Informal Science Learning Environment

Peer reviewed
Direct link

Stewart, Olivia G.; Jordan, Michelle E. – Instructional Science: An International Journal of the Learning Sciences, 2017

Recent scholarship highlights the wealth of varied and interconnected opportunities for learning science that informal environments can provide; yet, participants with different experiences, knowledge, and backgrounds do not all learn in the same ways. Thus, studies are needed that examine how particular participants take up learning opportunities…

Descriptors: Case Studies, Educational Environment, Science Education, STEM Education

## Cognitive Demand of Model Tracing Tutor Tasks: Conceptualizing and Predicting How Deeply Students Engage

Peer reviewed
Direct link

Kessler, Aaron M.; Stein, Mary Kay; Schunn, Christian D. – Technology, Knowledge and Learning, 2015

Model tracing tutors represent a technology designed to mimic key elements of one-on-one human tutoring. We examine the situations in which such supportive computer technologies may devolve into mindless student work with little conceptual understanding or student development. To analyze the support of student intellectual work in the model…

Descriptors: Learner Engagement, Cognitive Processes, Difficulty Level, Intelligent Tutoring Systems

## Alignment of Hands-On STEM Engagement Activities with Positive STEM Dispositions in Secondary School Students

Peer reviewed
Direct link

Christensen, Rhonda; Knezek, Gerald; Tyler-Wood, Tandra – Journal of Science Education and Technology, 2015

This study examines positive dispositions reported by middle school and high school students participating in programs that feature STEM-related activities. Middle school students participating in school-to-home hands-on energy monitoring activities are compared to middle school and high school students in a different project taking part in…

Descriptors: Middle School Students, High School Students, STEM Education, Student Attitudes

## The Uses of Cognitive Training Technologies in the Treatment of Autism Spectrum Disorders

Peer reviewed

Direct link

Wass, Sam V.; Porayska-Pomsta, Kaska – Autism: The International Journal of Research and Practice, 2014

In this review, we focus on research that has used technology to provide cognitive training--i.e. to improve performance on some measurable aspect of behaviour--in individuals with autism spectrum disorders. We review technology-enhanced interventions that target three different cognitive domains: (a) emotion and face recognition, (b) language and…

Descriptors: Pervasive Developmental Disorders, Autism, Technology Uses in Education, Cognitive Processes

## Haptic Paddle Enhancements and a Formal Assessment of Student Learning in System Dynamics

Peer reviewed

Download full text

Gorlewicz, Jenna L.; Kratchman, Louis B.; Webster, Robert J., III – Advances in Engineering Education, 2014

The haptic paddle is a force-feedback joystick used at several universities in teaching System Dynamics, a core mechanical engineering undergraduate course where students learn to model dynamic systems in several domains. A second goal of the haptic paddle is to increase the accessibility of robotics and haptics by providing a low-cost device for…

Descriptors: College Instruction, Laboratory Equipment, Undergraduate Students, Engineering Education

## Communication Tasks Using Intelligent Agents in Second Life

Peer reviewed

Direct link

Ishizuka, Hiroki; Kiyoshi, Akama – International Journal on E-Learning, 2014

Numerous attempts have been made to use Second Life (SL) as a platform for language teaching. As a result, the possibility of SL as a means to promote conversational interactions has been reported. However, research has thus far largely focused on simply using SL without further augmentations for communication between learners or between teachers…

Descriptors: Computer Simulation, Internet, Computer Mediated Communication, Second Language Learning

## Robotics and Design: An Interdisciplinary Crash Course

Peer reviewed

Direct link

Bonarini, A.; Romero, M. – IEEE Transactions on Education, 2013

The authors designed and ran a crash course on emotional robotics involving students from both the Information Engineering School and the Design School of Politecnico di Milano, Milan, Italy. The course consisted of two intensive days of short introductory lessons and lab activity, done in interdisciplinary groups and supported by a well-equipped…

Descriptors: Robotics, Design, Interdisciplinary Approach, Teamwork

## Channeling Your Inner Entomologist

Peer reviewed
Direct link

Bell, Tara C.; McGill, Tara A. W. – Science and Children, 2014

The lesson described herein is the result of a partnership between a teacher and an entomologist brought together by a National Science Foundation (NSF)-funded grant that paired teachers and researchers to impact K-12 STEM education through partnership and innovation. This collaboration resulted in five lessons featuring live insects such as…

Descriptors: Entomology, Partnerships in Education, Lesson Plans, Safety Education

## "The Intimate Machine"--30 Years On

Peer reviewed
Direct link

Frude, Neil; Jandric, Petar – E-Learning and Digital Media, 2015

This conversation focuses on a book published in 1983 that examined "animism," the tendency to regard non-living entities as living and sentient. "The Intimate Machine" suggested that animism will be fully exploited by artificial intelligence (AI) and robotics, generating artefacts that will engage the user in…

Descriptors: Artificial Intelligence, Robotics, Books, Interpersonal Relationship

## An Arduino-Controlled Photogate

Peer reviewed
Direct link

Galeriu, Calin – Physics Teacher, 2013

It is hard to imagine teaching physics without doing experimental measurements of position as a function of time. These measurements, needed for the determination of velocity and acceleration, are most easily performed with the help of photogates. Unfortunately, commercial photogates are rather expensive. Many require the purchase of an additional…

Descriptors: Physics, Measurement, Time, Electronics

## Engineering Encounters: The Tightrope Challenge

Peer reviewed
Direct link

Burton, Bill – Science and Children, 2014

In order to prepare students to become the next innovators, teachers need to provide real-world challenges that allow children to exercise their innovation muscles. Innovation starts with a problem and innovators work to solve a problem by planning, creating, and testing. The real-world innovation process does not happen on a worksheet, and it…

Descriptors: Science Instruction, Engineering, Robotics, Elementary School Science

## An Arduino Investigation of Simple Harmonic Motion

Peer reviewed

Direct link

Galeriu, Calin; Edwards, Scott; Esper, Geoffrey – Physics Teacher, 2014

We cannot hope for a new generation of scientists and engineers if we don't let our young students take ownership of their scientific and engineering explorations, if we don't let them enjoy the hands-on cycle of design and production, and if we don't let them implant their creativity into a technologically friendly environment.…

Descriptors: Science Instruction, Scientific Principles, Motion, Hands on Science

## Practicalities of Using a Modified Version of the Cochrane Collaboration Risk of Bias Tool for Randomised and Non-Randomised Study Designs Applied in a Health Technology Assessment Setting

Peer reviewed

Direct link

Robertson, Clare; Ramsay, Craig; Gurung, Tara; Mowatt, Graham; Pickard, Robert; Sharma, Pawana – Research Synthesis Methods, 2014

We describe our experience of using a modified version of the Cochrane risk of bias (RoB) tool for randomised and non-randomised comparative studies. Objectives: (1) To assess time to complete RoB assessment; (2) To assess inter-rater agreement; and (3) To explore the association between RoB and treatment effect size. Methods: Cochrane risk of…

Descriptors: Risk, Randomized Controlled Trials, Research Design, Comparative Analysis

## Interdisciplinary Robotics Project for First-Year Engineering Degree Students

Peer reviewed

Download full text

Aznar, Mercedes; Zacarés, José; López, Jaime; Sánchez, Rafael; Pastor, José M.; Llorca, Jaume – Journal of Technology and Science Education, 2015

The acquisition of both transversal and specific competences cannot be achieved using conventional methodologies. New methodologies must be applied that promote the necessary competences for proper professional development. Interdisciplinary projects can be a suitable tool for competence-based learning. A priori, this might be complicated, as…

Descriptors: Interdisciplinary Approach, Engineering Education, Automation, Industry

## Engineering Design EDUCATION: When, What, and HOW

Peer reviewed

Download full text

Khalaf, Kinda; Balawi, Shadi; Hitt, George Wesley; Radaideh, Ahmad – Advances in Engineering Education, 2013

This paper presents an innovative, interdisciplinary, design-and-build course created to improve placement, content, and pedagogy for introductory engineering design education. Infused at the freshman level, the course aims to promote expert design thinking by using problem-based learning (PBL) as the mode of delivery. The course is structured to…

Descriptors: Foreign Countries, Engineering, Engineering Education, Design

## Pattern of Task Interpretation and Self-Regulated Learning Strategies of High School Students and College Freshmen during an Engineering Design Project

Peer reviewed

Direct link

Lawanto, Oenardi; Butler, Deborah; Cartier, Sylvie C.; Santoso, Harry B.; Goodridge, Wade; Lawanto, Kevin N.; Clark, David – Journal of STEM Education: Innovations and Research, 2013

The objective of this exploratory study was to describe patterns in self-regulated learning (SRL) for both high school students and college freshmen while engaged in a design activity. The main research question guiding this study was: How did high school and first-year college students self-regulate their approaches to learning when engaged in an…

Descriptors: Comparative Analysis, Metacognition, High School Students, College Freshmen

## Promoting Global Literacy Skills through Technology- Infused Teaching and Learning

Peer reviewed

Direct link

Keengwe, Jared, Ed.; Mbae, Justus G., Ed.; Ngigi, Simon K., Ed. – IGI Global, 2015

The increasing internationalization of today's classrooms calls for learning institutions to prepare students for success in an interdependent and technologically-advanced world. Faculty who are competent in multiple 21st century skills are best equipped to engage students in curricula that are relevant, transformative, and engaging across content…

Descriptors: Global Approach, Literacy, Technology Uses in Education, Educational Technology

## Beyond Robotic Wastelands of Time: Abandoned Pedagogical Agents and "New" Pedalled Pedagogies

Peer reviewed

Direct link

Savin-Baden, Maggi; Tombs, Gemma; Bhakta, Roy – E-Learning and Digital Media, 2015

Chatbots, known as pedagogical agents in educational settings, have a long history of use, beginning with Alan Turing's work. Since then online chatbots have become embedded into the fabric of technology. Yet understandings of these technologies are inchoate and often untheorised. Integration of chatbots into educational settings over the past…

Descriptors: Technology Uses in Education, Electronic Learning, Ethics, Emotional Experience

## Possibilities and Determinants of Using Low-Cost Devices in Virtual Education Applications

Peer reviewed
Direct link

Bun, Pawel Kazimierz; Wichniarek, Radoslaw; Górski, Filip; Grajewski, Damian; Zawadzki, Przemyslaw; Hamrol, Adam – EURASIA Journal of Mathematics, Science & Technology Education, 2017

Virtual reality (VR) may be used as an innovative educational tool. However, in order to fully exploit its potential, it is essential to achieve the effect of immersion. To more completely submerge the user in a virtual environment, it is necessary to ensure that the user's actions are directly translated into the image generated by the…

Descriptors: Simulated Environment, Educational Technology, Technology Uses in Education, Equipment

## Control Engineering as a Part of Undergraduate Curriculum for Mechanical Engineering in India

Peer reviewed
Direct link

Akhtar, Shagil; Iqbal, Syed Muneeb; Bajpai, Shrish – Comparative Professional Pedagogy, 2016

In this present study we have traced the genesis of control engineering in the scope of mechanical engineering and then some analysis on its recent developments, their increasing need and how this particular subject has evolved machines functioning nowadays specifically its standard of education in India. We have probed this field right from its…

Descriptors: Foreign Countries, Engineering Education, Equipment, Information Technology

## Accelerating Technologies: Consequences for the Future Wellbeing of Students

Peer reviewed
Download full text

Saltinski, Ronald – Journal of Instructional Pedagogies, 2015

Today's students, K-12 and beyond, will face an ominous future unless educators quickly invest in preparing student perspectives for the accelerating technologies that will have global implications for the wellbeing of all humanity. Accelerating technologies are quietly, almost insidiously, transforming the world with little fanfare and certainly…

Descriptors: Well Being, Technological Advancement, Influence of Technology, Science and Society

## Friction and the Intuition-Outcome Disparity

Peer reviewed
Direct link

Kalajian, Peter; Makarova, Maria – Physics Teacher, 2014

Humans have evolved to follow their intuition, but as any high school physics teacher knows, relying on intuition often leads students to predict outcomes that are at odds with evidence. Over the years, we have attempted to make this intuition-outcome disparity a central theme running throughout our physics classes, with limited success. Part of…

Descriptors: Science Instruction, Physics, Secondary School Science, High Schools

## Promote or Perish

Peer reviewed

Direct link

Caccavale, Frank – Technology and Engineering Teacher, 2016

Any parent, teacher, or coach who works with students today will admit there is a lot of competition for a student's time and attention. After school dismisses, video games, homework, sports, extracurricular activities, and more occupy students' time. It is equally as challenging to compete for their attention during the school day. New electives…

Descriptors: STEM Education, Technology Education, Engineering Education, Learner Engagement

## Project-Based Learning to Enhance Teaching Embedded Systems

Peer reviewed

Direct link

Sababha, Belal H.; Alqudah, Yazan A.; Abualbasal, Abdelraheem; AlQaralleh, Esam A. – EURASIA Journal of Mathematics, Science & Technology Education, 2016

Exposing engineering students during their education to real-world problems and giving them the chance to apply what they learn in the classroom is a vital element of engineering education. The Embedded Systems course at Princess Sumaya University for Technology (PSUT) is one of the main courses that bridge the gap between theoretical electrical…

Descriptors: Active Learning, Student Projects, Engineering Education, Foreign Countries

## Investigating the Role of Minecraft in Educational Learning Environments

Peer reviewed

Direct link

Callaghan, Noelene – Educational Media International, 2016

This research paper identifies the way in which Minecraft Edu can be used to contribute to the teaching and learning of secondary students via a multiple case research study. Minecraft Edu is recognised as a gamification tool that enables its users to create and evaluate project-based learning activities within a classroom context. Learning…

Descriptors: Robotics, Information Technology, Electronic Learning, Educational Games

## Themed Learning with Music and Technology

Peer reviewed

Download full text

Smarkusky, Debra L.; Toman, Sharon A. – Information Systems Education Journal, 2016

Interdisciplinary teaching and interpretation of technology for various applications provides a challenging and engaging environment for students to enhance their creativity, critical thinking and problem-solving skills. This paper presents results of a joint effort between faculty in the Department of Information Sciences and Technology and the…

Descriptors: Interdisciplinary Approach, Music Education, Information Science, Teaching Methods

## Visualizing Compound Rotations with Virtual Reality

Peer reviewed

Direct link

Flanders, Megan; Kavanagh, Richard C. – Engineering Design Graphics Journal, 2013

Mental rotations are among the most difficult of all spatial tasks to perform, and even those with high levels of spatial ability can struggle to visualize the result of compound rotations. This pilot study investigates the use of the virtual reality-based Rotation Tool, created using the Virtual Reality Modeling Language (VRML) together with…

Descriptors: Visualization, Spatial Ability, Computer Simulation, Engineering Education

## Geotechnical Engineering in US Elementary Schools

Peer reviewed

Direct link

Suescun-Florez, Eduardo; Iskander, Magued; Kapila, Vikram; Cain, Ryan – European Journal of Engineering Education, 2013

This paper reports on the results of several geotechnical engineering-related science activities conducted with elementary-school students. Activities presented include soil permeability, contact stress, soil stratigraphy, shallow and deep foundations, and erosion in rivers. The permeability activity employed the LEGO NXT platform for data…

Descriptors: Science Education, Engineering Education, Science Activities, Elementary School Science

## The Use of Video-Gaming Devices as a Motivation for Learning Embedded Systems Programming

Peer reviewed

Direct link

Gonzalez, J.; Pomares, H.; Damas, M.; Garcia-Sanchez,P.; Rodriguez-Alvarez, M.; Palomares, J. M. – IEEE Transactions on Education, 2013

As embedded systems are becoming prevalent in everyday life, many universities are incorporating embedded systems-related courses in their undergraduate curricula. However, it is not easy to motivate students in such courses since they conceive of embedded systems as bizarre computing elements, different from the personal computers with which they…

Descriptors: Video Games, Video Equipment, Programming, Undergraduate Students

## Developing and Testing a Mobile Learning Games Framework

Peer reviewed

Download full text

Busch, Carsten; Claßnitz, Sabine; Selmanagic,, André; Steinicke, Martin – Electronic Journal of e-Learning, 2015

In 2010 1.1 million pupils took private lessons in Germany, with 25% of all German children by the age of 17 having attended paid private lessons at some point in their school career (Klemm & Klemm, 2010). The high demand for support for learning curricular content led us to consider an integrated solution that speeds up both the design of…

Descriptors: Foreign Countries, Educational Games, Educational Technology, Telecommunications

## Changes in Teachers' Adaptive Expertise in an Engineering Professional Development Course

Peer reviewed
Direct link

Martin, Taylor; Peacock, Stephanie Baker; Ko, Pat; Rudolph, Jennifer J. – Journal of Pre-College Engineering Education Research, 2015

Although the consensus seems to be that high-school-level introductory engineering courses should focus on design, this creates a problem for teacher training. Traditionally, math and science teachers are trained to teach and assess factual knowledge and closed-ended problem-solving techniques specific to a particular discipline, which is unsuited…

Descriptors: Teacher Education, Faculty Development, Engineering, Engineering Education

## A Mixed-Methods Exploration of an Environment for Learning Computer Programming

Peer reviewed
Direct link

Mather, Richard – Research in Learning Technology, 2015

A mixed-methods approach is evaluated for exploring collaborative behaviour, acceptance and progress surrounding an interactive technology for learning computer programming. A review of literature reveals a compelling case for using mixed-methods approaches when evaluating technology-enhanced-learning environments. Here, ethnographic approaches…

Descriptors: Mixed Methods Research, Programming, Cooperative Learning, Technology Uses in Education

## Beyond Blackboards: Engaging Underserved Middle School Students in Engineering

Peer reviewed
Direct link

Blanchard, Sarah; Judy, Justina; Muller, Chandra; Crawford, Richard H.; Petrosino, Anthony J.; Christina K. White,; Lin, Fu-An; Wood, Kristin L. – Journal of Pre-College Engineering Education Research, 2015

"Beyond Blackboards" is an inquiry-centered, after-school program designed to enhance middle school students' engagement with engineering through design-based experiences focused on the 21st Century Engineering Challenges. Set within a predominantly lowincome, majority-minority community, our study aims to investigate the impact of…

Descriptors: Engineering, Engineering Education, Learner Engagement, Disproportionate Representation

## Curriculum and Professional Development for OST Science Education: Lessons Learned from California 4-H

Peer reviewed
Download full text

Worker, Steven M.; Smith, Martin H. – Afterschool Matters, 2014

A wide variety of out-of-school time (OST) programs across the U.S. offer science education opportunities that cover many scientific disciplines and use diverse pedagogical practices (National Research Council [NRC], 2009). However, to improve youth's scientific literacy, OST educators need to "have the disposition and repertoire of practices…

Descriptors: After School Programs, Science Education, Science Process Skills, Skill Development

## Fitting the Framework: The STEM Institute and the 4-H Essential Elements

Peer reviewed
Direct link

Sallee, Jeff; Peek, Gina G. – Journal of Extension, 2014

Extension and 4-H youth development programs are addressing a shortage of scientists, engineers, and other related professionals by promoting science, technology, engineering, and math (STEM). This case study illustrates how the Oklahoma 4-H Youth Development program trained youth-adult teams to design and implement STEM projects. The STEM…

Descriptors: Extension Education, STEM Education, Case Studies, Youth Programs

## Learning Programming with IPRO: The Effects of a Mobile, Social Programming Environment

Peer reviewed
Direct link

Martin, Taylor; Berland, Matthew; Benton, Tom; Smith, Carmen Petrick – Journal of Interactive Learning Research, 2013

In this paper, we present two studies examining how high school students learn to program in a mobile, social programming environment that we have developed and deployed ("IPRO"). IPRO is delivered, with an associated curriculum, as an iPod Touch app and is freely and publicly available. We find that the affordances of mobility and…

Descriptors: High School Students, Programming, Cooperation, Mobility

## Distance Learning and Skill Acquisition in Engineering Sciences: Present State and Prospects

Peer reviewed
Direct link

Potkonjak, Veljko; Jovanovic, Kosta; Holland, Owen; Uhomoibhi, James – Multicultural Education & Technology Journal, 2013

Purpose: The purpose of this paper is to present an improved concept of software-based laboratory exercises, namely a Virtual Laboratory for Engineering Sciences (VLES). Design/methodology/approach: The implementation of distance learning and e-learning in engineering sciences (such as Mechanical and Electrical Engineering) is still far behind…

Descriptors: Electronic Learning, Distance Education, Computer Simulation, Skill Development

## Straw Rockets Are out of This World

Peer reviewed
Direct link

Gillman, Joan – Science and Children, 2013

To capture students' excitement and engage their interest in rocketships and visiting planets in the solar system, the author designed lessons that give students the opportunity to experience the joys and challenges of developing straw rockets, and then observing which design can travel the longest distance. The lessons are appropriate for…

Descriptors: Astronomy, Lesson Plans, Grade 4, Grade 5

## STEM Education: A Review of the Contribution of the Disciplines of Science, Technology, Engineering and Mathematics

Peer reviewed

Download full text

McDonald, Christine V. – Science Education International, 2016

Recent global educational initiatives and reforms have focused on increasing the number of students pursuing STEM subjects, and ensuring students are well-prepared, and suitably qualified to engage in STEM careers. This paper examines the contributions of the four disciplines--Science, Technology, Engineering and Mathematics--to the field of STEM…

Descriptors: STEM Education, Student Interests, Teaching Methods, Scientific Literacy

## Playful Talk: Negotiating Opportunities to Learn in Collaborative Groups

Peer reviewed

Direct link

Sullivan, Florence R.; Wilson, Nicholas C. – Journal of the Learning Sciences, 2015

This case study examines the role of playful talk in negotiating the "how" of collaborative group work in a 6th-grade science classroom. Here we develop and test a Vygotsky-derived hypothesis that postulates playful talk as a mechanism for identity exploration and group status negotiation. Our findings indicate that students utilized the…

Descriptors: Case Studies, Cooperative Learning, Grade 6, Science Instruction

## STEM Related After-School Program Activities and Associated Outcomes on Student Learning

Peer reviewed

Download full text

Sahin, Alpaslan; Ayar, Mehmet C.; Adiguzel, Tufan – Educational Sciences: Theory and Practice, 2014

This study explores the characteristics of after-school program activities at a charter school in the Southeast US highlighting students' experiences with and gains from these after-school program activities. A qualitative case study design was employed to understand students' views and opinions regarding the activities and their learning…

Descriptors: After School Programs, Charter Schools, Program Effectiveness, Qualitative Research

# ii. COLLABORATIVE LEARNING

## Search methodology

We chose to make a SCOPUS search only on “collaborative learning”, which gave far too many results: 11,327. An analysis of the search results shows that the range of publication years span from 1975-2017. Looking at the statistic again, the year range with the absolute highest amount of publications is from 2009-2016. We therefore choose 2009 as the right publication year.

We searched SCOPUS for “collaborative learning theory”. The statistic shows only 6 out of 30 articles were published before 2007, the earliest publication is from 1994, in 2007 4 articles were published. 8 Articles were published after 2014. And in the year 2014 5 articles were published. The wrong time of publication could be before 2007 or before 2014.

We looked through the abstracts, and 7 out of 30 publications seemed relevant for REELER. For example because some relevant hits combine collaborative learning theory with technology (one finding is described underneath), one study includes engineering and the building of a user model. Another article is concerning software development based on collaborative learning theories. And another article concerns interprofessional learning in healthcare practice. But overall the field is mainly educational research concerned with learning in schools.

We proceeded to search for the combination of “collaborative learning theory” and “engineering”, which gave me 6 results, in the year range from 1995-2014. There was only one publication in the years from 1995-2007. The rest was published from 2007-2014.

Looking through the abstracts, two papers seemed most relevant for REELER. Because one paper for example discusses the collaborative learning theories and environmental requirements in computer-assisted distance learning. Another relevant paper (the one underneath), places the collaborative approach in engineering education. Two articles which at first seemed relevant, can be excluded because they focused on how to construct a web design with a collaborative learning environment.

We searched the AAA database AnthroSource for the term ”collaborative learning” and returned 46 results. I performed additional searches including other terms relevant to REELER. I ultimately examined the abstracts of all 46 (and the full texts of some) to determine relevance and found no relevance to REELER’s context.

Of the 46 results for “collaborative learning”, the oldest result was from 1992, the newest from 2016. The term was mentioned consistently, but rarely: 0-5 times per year (out of roughly 1000-1500 documents for each year). None of the results mentioned “collaborative learning” in the title, suggesting that the research focus of these texts would not involve collaborative learning. Indeed, none of the results were particularly relevant to REELER. The texts loosely mentioned the search terms but did not involve “collaborative learning” as a concept or collaboration in relation to machines or non-human actors.

One significant finding is that “collaborative learning” is thus far not a subject of anthropology. Because “collaborative learning” is an education/sociology topic, perhaps Stine’s search of ERIC and SCOPUS will prove more useful in finding a research context that involves collaborative learning in a way that is relevant to REELER.

**Wrong scope / research fields not relevant**: Chemistry, Biochemistry, Agricultural, Mathematics, Decision Sciences, Business

**Right scope / research fields relevant**: Social sciences, Computer Science, Engineering, Arts and Humanities, Business,

**Wrong time of publication**: Before 2007, 2009, or Before 2014

**Right time of publication**: After 2007, 2009, or after 2014

## Database queries

| Search term combinations | SCOPUS | ERIC |
|---|---|---|
| Collaborative learning theory | 30 | 3 |
| Collaborative learning theory + Robotics | 0 | 0 |
| Collaborative learning theory + Robots | 0 | 0 |
| Collaborative learning theory + Engineering | 6 | 0 |
| Collaborative learning theories | 30 | 6 |
| Collaborative learning | 11,327 | 2,712 |
| Collaborative learning + robot | 103 | 2 |
| Collaborative learning + robotics | 78 | 7 |
| Collaborative learning + robot + work place collaboration | 0 | 0 |
| Work place collaboration | 1 | 0 |
| Collaborative learning + Robot + Work | 17 | 0 |
| Collaborative learning + Technology | 3,502 | 1,058 |
| Collaborative learning + Technology + Industry | 108 | 11 |
| Collaborative learning + Technology + Engineering | 851 | 42 |
| Collaborative learning + Technology + Engineering + Ethics | 9 | 2 |
| Collaborative learning + Technology + Health | 106 | 14 |
| Collaborative learning + Technology + Health + Rehabilitation | 1 | 0 |
| Collaborative learning + Technology + Health + Psychology | 4 | 0 |
| Collaborative learning + Technology + Psychology | 42 | 26 |
| Collaborative learning + Health | 465 | 55 |
| Collaborative learning + Rehabilitation | 14 | 4 |
| Collaborative learning + Obstacles | 67 | 16 |
| Collaborative learning + Ethics | 61 | 22 |
| Collaborative learning + Psychology + Technology | 42 | 26 |
| Common knowledge + Technology + Work place + Collaboration | 0 | 0 |
| Common knowledge + Technology | 290 | 10 |
| Ethics + Technology + Development | 3,675 | 258 |
| Ethics + Technology + Development + Learning | 318 | 119 |
| Ethics + Technology + Development + Learning + Social science | 10 | 0 |
| Ethics + Interdisciplinary + Industry + Psychology | 7 | 0 |
| Ethics + Interdisciplinary + Technology + Psychology | 38 | 2 |
| Ethics + Robot + Development | 123 | 0 |
| Collaborative learning + Ethics + Robot + Development | 0 | 0 |
| Ethics + Robot + Learning | 35 | 0 |

| Search Queries in AnthroSource | Number of hits |
|---|---|
| **“collaborative learning”** | **46** |
| “collaborative learning” AND “technology” | 21 |
| “collaborative learning” AND “piaget” | 1 |
| “collaborative learning” AND “vygotsky” | 9 |

| | |
|---|---|
| “collaborative learning” AND “robot” | 0 |
| “collaborative learning” AND “robotics” | 0 |
| “collaborative learning” AND “machine” | 8 |
| “collaborative learning” AND “machine learning” | 0 |
| “collaborative learning” AND “HRI” | 0 |
| “collaborative learning” AND “STS” | 0 |
| “collaborative learning” AND “science and technology” | 1 |
| “collaborative learning” AND “labour” | 11 |
| “collaborative learning” AND “labor” | 11 |
| “collaborative learning” AND “work” | 46 |
| “collaborative learning” AND “ethics” | 5 |
| “collaborative learning” AND “gender” | 13 |
| “collaborative learning” AND “design” | 33 |
| “collaborative learning” AND “human” | 37 |
| | |

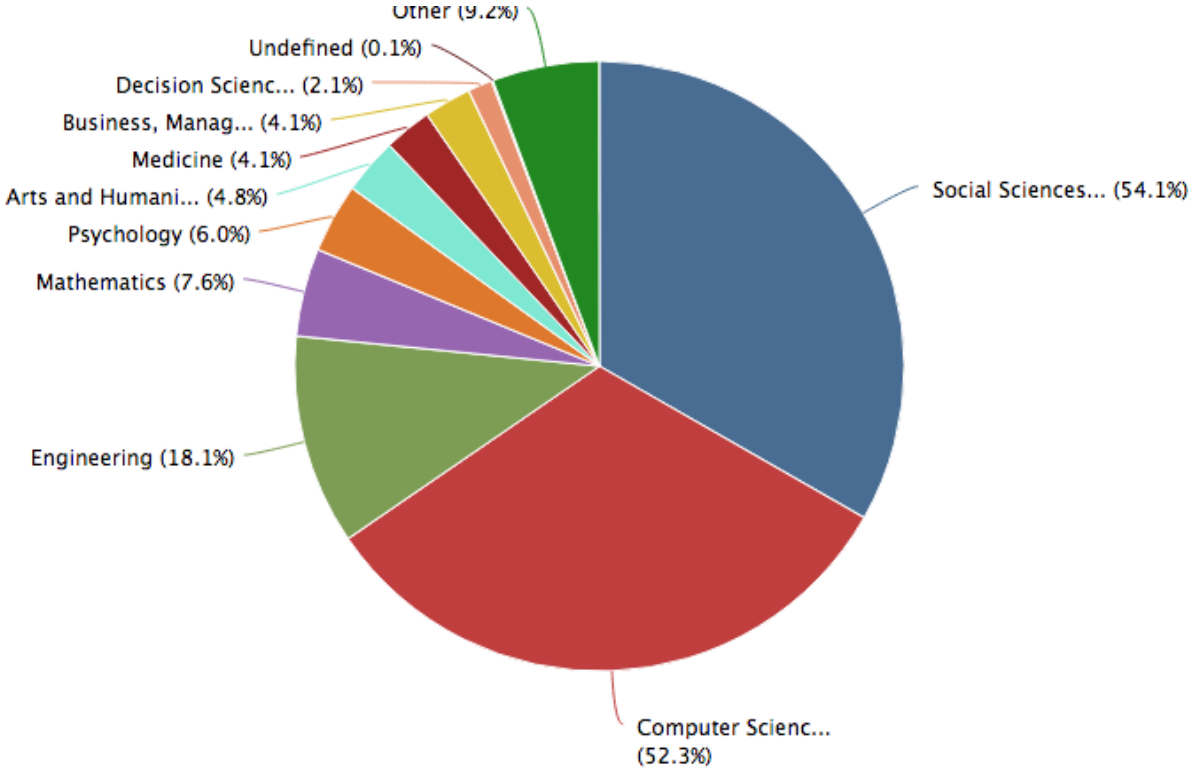
The high number of results demonstrates how common these additional search terms are: labor, work, gender, design, human. It should be a consideration when performing further searches. Not all search terms increase relevance, particularly when the terms are ambiguous or part of common speech.

## Charts and trends

**“collaborative learning”**

| | |
|---|---|
| Conference Paper | 5012 |
| Article | 4909 |
| Book Chapter | 558 |
| Review | 333 |
| Conference Review | 267 |
| Article in Press | 137 |
| Book | 61 |
| Editorial | 24 |
| Short Survey | 9 |
| Note | 8 |
| Erratum | 5 |

| | |
|---|---|
| Letter | 4 |



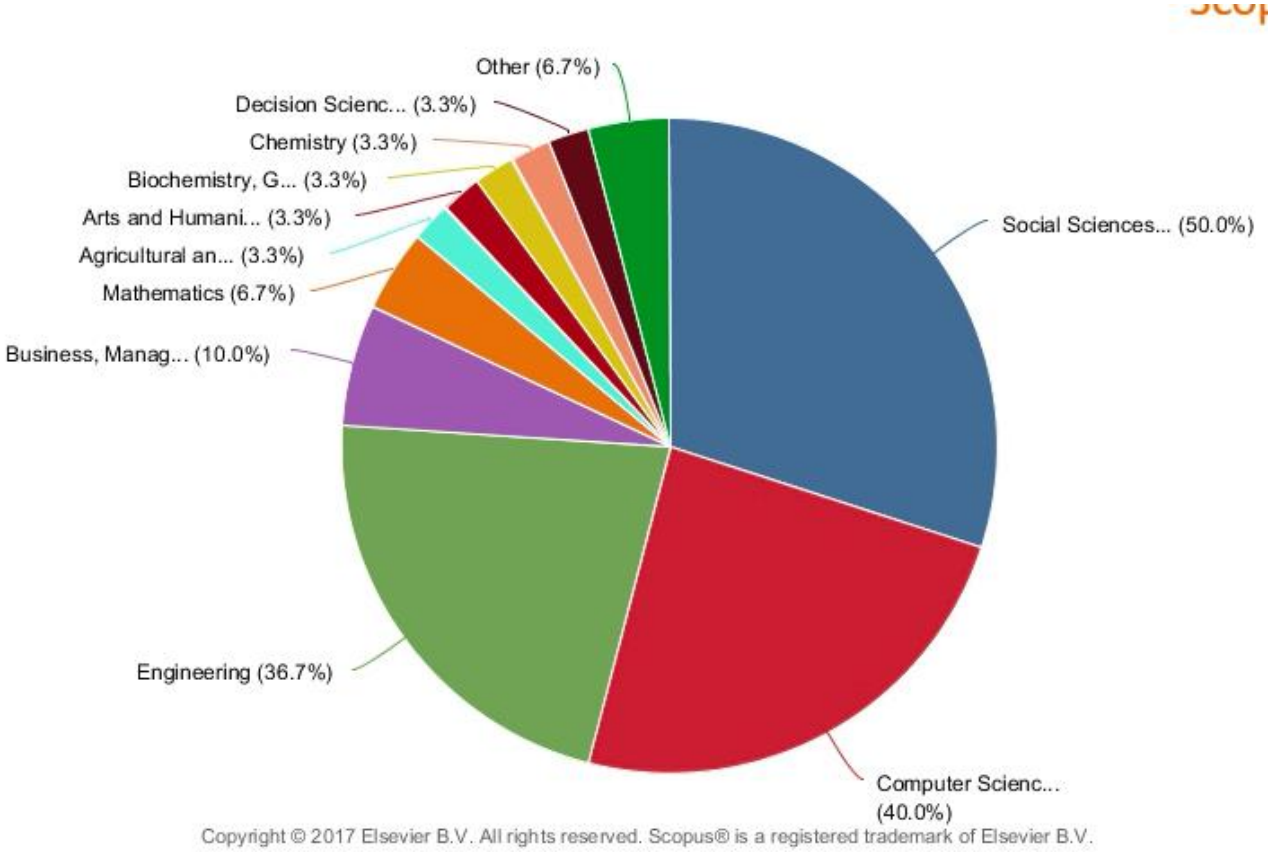

**“collaborative learning theory”**

The statistic shows only 6 out of 30 articles were published before 2007, the earliest publication is from 1994, in 2007 4 articles were published. 8 Articles were published after 2014. And in the year 2014 5 articles were published. The wrong time of publication could be before 2007 or before 2014.

The document types:

| | |
|---|---|
| Conference Paper | 16 |

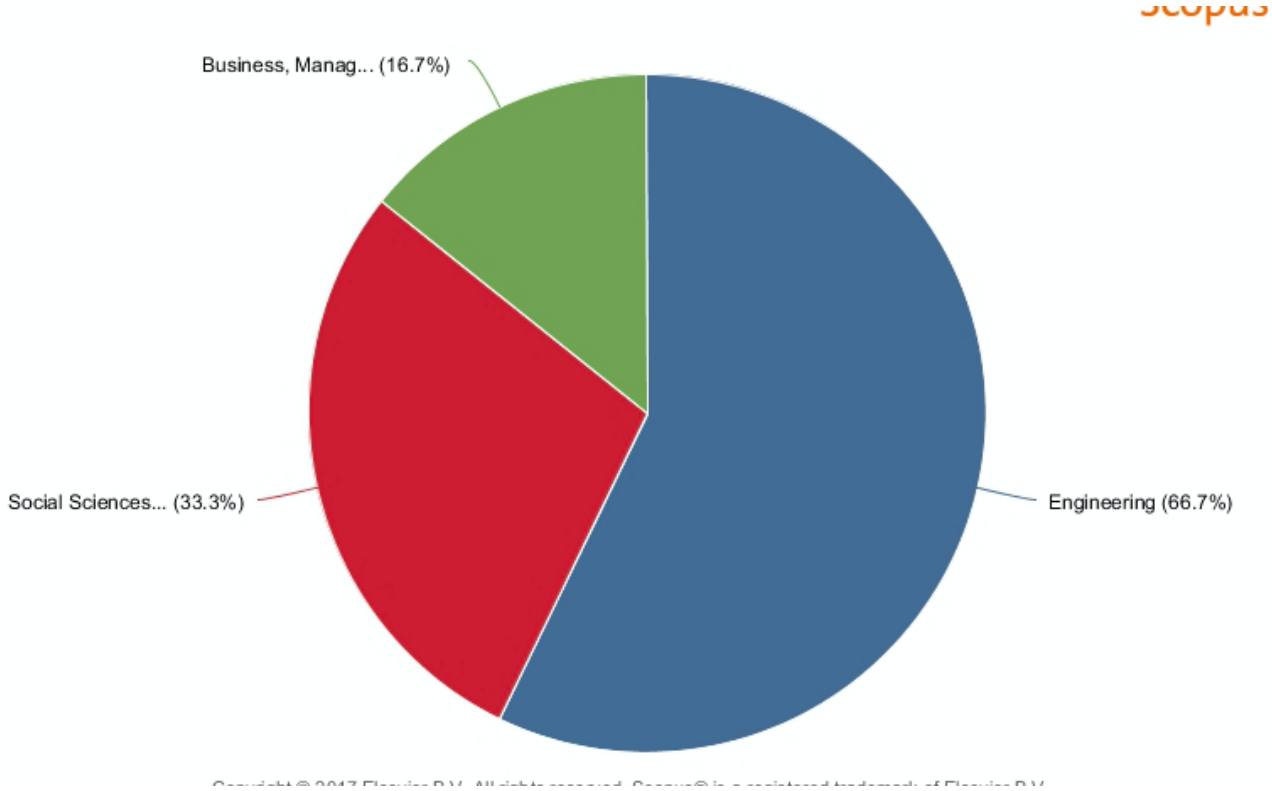
| | |
|---|---|
| Article | 12 |
| Book | 1 |
| Book Chapter | 1 |




**“collaborative learning theory” + “engingeering”**

Document types:

| | |
|---|---|
| Conference Paper | 5 |
| Article | 1 |
| Total | 6 |




## Selected literature

**Book:** Rutherford, S. 2014. "Collaborative Learning: Theory, Strategies and Educational Benefits." In *Collaborative Learning: Theory, Strategies and Educational Benefits*, 1-297.

Link: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84953383149&partnerID=40&md5=62085d047e85d2cefcd83a51ede42904

**ISBN:** 978-163321790-4;978-163321756-0 **Original language:** English

**Document Type:** Book

**Publisher:** Nova Science Publishers, Inc.

*[This book combines the collaborative learning theory with technology, it introduces the term 'collaborative technologies', research field: classrooms but also outside. The studies are examples of good practice – beneficial to a wide variety of educational practitioners.]*

**Abstract:**

There is strong evidence that **collaborative learning** is beneficial to educational development. By engaging in collaborative activity, learners utilise each other's perspectives and experiences to solve problems and develop a shared understanding of meanings. Through dialogue and social interaction, learners are empowered to perform outside of their own individual capabilities. **Collaborative learning** has the potential to benefit learners of all levels of experience and in a variety of situations. This edited volume showcases a series of studies of theory and case-studies of practice. The book highlights the benefits and challenges of collaborative inquiry, and how these are best managed in practice. The contributors to this volume are comprised of educators from around the world, and collaborative approaches for learners across a broad range of stages of development are discussed. The authors highlight the rich diversity of approaches to learning through collaborative activity, and provide examples of good practice. **It also addresses the increasing significance of technology in the support collaborative learning. The benefits technology can bring to collaborative activity have been recognised for several years, and many of the contributions to this volume**

**demonstrate how the impact and scope of collaborative learning may be enhanced by the use of collaborative technologies, social media and Web 2.0 interactive platforms. The examples presented in this edited work illustrate that through technology, collaborative activities no longer need to be confined to the classroom, but may occur across geographical, cultural, and language barriers. Often overcoming these barriers within a collaborative environment proves to be of great benefit to the learners in addition to the knowledge gains offered. The studies presented in this volume will act as examples of good practice that will be beneficial to a wide variety of educational practitioners.** Moreover, the studies highlight the key principles for the organisation and management of these collaborative activities by the teacher. The considerations that the teacher needs to address, in order for the collaborative activities to be rich and effective, are brought to the fore. The scaffolding required for **collaborative learning** to have its maximal impact needs to be carefully considered, and this volume highlights those challenges. This book presents complementary examples of practice that demonstrate the advantages of collaborative activity for learning. Collaborative inquiry can enrich teaching practice and enhance the impact and depth of the learning experience for student and teacher alike.

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**Article:** Moreno, L., C. Gonzalez, I. Castilla, E. Gonzalez, and J. Sigut. 2007. "Applying a Constructivist and Collaborative Methodological Approach in Engineering Education." *Computers and Education* 49 (3): 891-915. doi:10.1016/j.compedu.2005.12.004.

**ISSN:** 03601315 **CODEN:** COMED **Source Type:** Journal **Original language:** English

**DOI:** 10.1016/j.compedu.2005.12.004 **Document Type:** Article

**Indexed keywords: Engineering controlled terms:** Computer architecture; Computer simulation; Computer supported cooperative work; E-**learning**; **Learning** systems; Program processors **Engineering uncontrolled terms: Collaborative learning**; Educational technology; Instruction Level Parallelism (ILP) **Engineering main heading: Engineering** education

**Abstract:**

**In this paper, a methodological educational proposal based on constructivism and collaborative learning theories is described. The suggested approach has been successfully applied to a subject entitled "Computer Architecture and Engineering" in a Computer Science degree in the University of La Laguna in Spain.** This methodology is supported by two tools: the Moodle platform as a collaboration framework among students and teachers and a free Instruction Level Parallelism (ILP) processor simulator called SIMDE, developed by the authors to promote the experience and help the understanding of superscalar and VLIW processors. This work is described showing how the constructivist and collaborative approaches have been applied and how the activities have been structured temporarily in phases. This educational proposal has been validated and improved with the feedback of the students during two academic years. Furthermore, the methodological procedure is also suitable to be used not only in subjects with contents which require the understanding of dynamic situations but also in subjects with other requirements. 

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**Article:** Sinha, V., A. Merchant, N. Dangar, P. Agal, and P. Sharma. 2015. "Comparative Study on Workplace Collaboration Across the Leading Global Organizations in IT Sector." *International Journal of Human Capital and Information Technology Professionals* 6 (2): 14-32. doi:10.4018/IJHCITP.2015040102

**SSN:** 19473478**Source Type:** Journal **Original language:** English

**DOI:** 10.4018/IJHCITP.2015040102**Document Type:** Article

**Publisher:** IGI Global

**Author keywords: Collaboration**; Global; IT; Organization; Sector; Workplace

**Abstract:**

 The significant role of **work place collaboration** has been widely felt across the globe due to diversity and highly changing organizational dynamics. Six components emerged from the relevant management and organizational behaviour regarding how managers built unity through collaboration and create a conducive environment for work and productivity. They are known as -teaming, motivating subordinate, career counselling, communicating with subordinate, professional relationships, issues related to morale and quality of work life. The present piece of work is a study of **work place collaboration** on 60 employees belonging from 6 different organizations. Self-assessment inventory on **work place collaboration** have been used to assess those six factors. The

results revealed that there is a significant gap between "what is" and "what should be" across all the six components of **work place collaboration**. Correlation values also suggest the differential degree of correlation between the six factors for each organization. The findings have been discussed in terms of the organizational & IT Sector's perspectives.

## ANTHROSOURCE

Guberman, S. R., Rahm, J. and Menk, D. W. (1998), Transforming Cultural Practices: Illustrations from Children's Game Play. *Anthropology & Education Quarterly*, 29: 419–445. doi:10.1525/aeq.1998.29.4.419

*[This excerpt references Piaget, Vygotsky, and collaborative learning but doesn't seem significant to REELER.]*

EXCERPT "As **Piaget** (1965) noted in his discussion of children playing marbles, peer groups provide greater opportunities for children to negotiate and jointly construct the character of their activities than do adult-child interactions. In addition to transformations that come about as a result of assistance, participants often transform activities unintentionally. For in-stance, in a study of college students, Holland and Reeves (1994) found that computer programming teams from a single class differed in their motives for engaging in an assigned project and, as a result, varied in their accomplishments. Forman and Larreamendy-Joerns (1995) found comparable results among fourth- and seventh-grade children working collaboratively on a projection-of-shadows task. Similar to Engestrom(1993) and **Vygotsky** (1978,1984), Forman and Larreamendy-Joerns concluded that "the context of a **collaborative learning** situation is not static but is constantly being recreated by the participants in the group"(1995:550)."

Jocson, K. M. (2016), Ripples and Breaks: Reflecting on Learning Ecologies in Career and Technical Education. *Anthropology & Education Quarterly*, 47: 444–455. doi:10.1111/aeq.121702053

*[This paper has no relevance to REELER despite mentioning "Vygotsky" in the reference section, "collaborative learning" in the text, and "technical education" in the title.]*

EXCERPT "At first glance, this multimedia communications classroom within CTE wasunlike anything I had ever seen. The classroom included a main classroom space with 12iMac computer stations with high stools, an iMac computer station placed on a cart(typically used by the teacher), and a projector screen hanging from a ceiling on the backwall with glass windows separating the main room from an enclosed equipment room(doubly serving as a space for related activities that require less ambient noise).Rectangular tables, low stools, and chairs occupied the center of the room. It took no time to notice that this multimedia communications classroom had been spatially designed for individual and **collaborative learning**. Media and curriculum-based posters accentuated the walls along the perimeter. Overhead fluorescent lighting ran across the room parallel to a heating vent. To the right of the back wall (pictured with arrow) was a door leading to the classroom television station located in the adjacent room that, upon entering the classroom, seemed hidden from view."

ABSTRACT "In this paper, the author reflects on a year-long ethnography to point out contextual factors situated in career and **technical education** (CTE) and specifically how a CTE teacher and a university researcher shaped learning opportunities to support students' interests in the arts, technology, and multimedia communications. The discussion arched by a metaphor of ripples and breaks suggests the value of seeing dynamic forms of mobility and learning ecologies within classrooms and other educational settings."

Stout, D. 2008. "Technology and Human Brain Evolution." *General Anthropology*, 15: 1–5. doi:10.1111/j.1939-3466.2008.00008.x

*[Interesting, but doesn't involve our concept. The "collaborative learning" search term was mentioned in another article presented in the same news bulletin.]*

EXCERPT "Ongoing research continues to sup-port long-held intuitions regarding the tight links between **technology**, language, and culture in **human** brain evolution, while adding a great deal to our under-standing of context, timing, and mechanism. However, the very tightness of these evolutionary relationships makes it difficult to distinguish cause from con-sequence. Fossil evidence has pretty decisively supported Engels' supposition that bipedalism and the hand came first, but did toolmaking lead to language or vice versa?

Turin, M. 2015. "Devil in The Digital: Ambivalent Results in an Object-Based Teaching Course." *Museum Anthropology*, 38: 123–132. doi:10.1111/muan.12088

*["collaborative learning" + "design" still not relevant]*

EXCERPT "These were some of the questions that motivated me to pilot a new course in the fall of 2013 at Yale University. During my three years in New Haven, I had been surprised by two features of the institutional landscape in which I was working. First, while students were on the whole extremely motivated and driven, they were quite traditional in their expectations of learning outcomes and classroom hierarchy. Analytical and discursive writing assignments were still the norm and were generated for an instructor to review and evaluate. It seemed a shame that such effort was destined solely for my inbox, and I wanted to experiment with creating a more connective, longer-lasting, and less text-driven classroom. I had been inspired by recent work that focused on emergent pedagogies in the digital humanities (see Hirsch 2012) and the opportunities provided by digitally mediated and more **collaborative learning** environments."

ABSTRACT "In 2013, I piloted a course in which students used Web-based tools to explore underdocumented collections of Himalayan materials at Yale University. Through class-based research and contextualization, I set students the goal of augmenting existing metadata and **design**ing media-rich, virtual tours of the collections that could be incorporated into the sparse catalogue holdings held within the library system. The process was experimental and had mixed results, as this article documents. The class provided an opportunity for undergraduate students from any discipline to work with objects and primary materials, requiring them to evaluate different sources of information, value, and legitimacy. Learning outcomes were nontraditional and intentionally underscripted. The **collaborative** and hands-on approaches toward digitization that de-emphasized the authority of the instructor were unsettling to some students. [digital humanities, mobile classroom, critical pedagogy, material culture, Himalaya]"

Rose, M. 1999. "Our Hands Will Know: The Development of Tactile Diagnostic Skill—Teaching, Learning, and Situated Cognition in a Physical Therapy Program." *Anthropology & Education Quarterly*, 30: 133–160. doi:10.1525/aeq.1999.30.2.133

*[I could not find our search terms within the text]*

ABSTRACT "Relying on observational and interview data from a clinical practice class in a graduate physical therapy program, I examine, within a situated cognition framework, the teaching and learning of a concept in biomechanics, the manual techniques and tactile discrimination skills that accompany it, and the diagnostic frame of mind that informs concept, technique, and skill. In examining this complex set of practices, I hope to add to and qualify the literature on working knowledge, participation and competence, and situated **learning** and pedagogy."

# iii. HUMAN PROXIMITY

## Search methodology

First, we searched for "human-robot proximity". A single result was returned, suggesting that this concept or phrasing may be unique to REELER. A wider search for "human proximity" returned 99 results which were largely irrelevant – relating to zoology and other subjects and referring quite generally to the spatial distance between humans and some *other.* So, we narrowed the search to "human proximity" AND "robot", which returned just 6 results.

A broader search was performed to seek results that don't use our exact phrasing but perhaps discuss the proximity of robots to humans. This secondary search returned 140 results, nearly all from the technical sciences (journals and conferences related to engineering and robotics). A breakdown by date revealed a rise in usage after 2003, so we set inclusion criteria to texts published after 2003. Of the remaining 127 texts, 105 were relevant for review.

We reviewed each text and noted the focus on proximity and the purpose of the study. The primary focus in these papers was the spatial proximity of robot to human with a regard for the robot's functionality and for the human's physical safety.

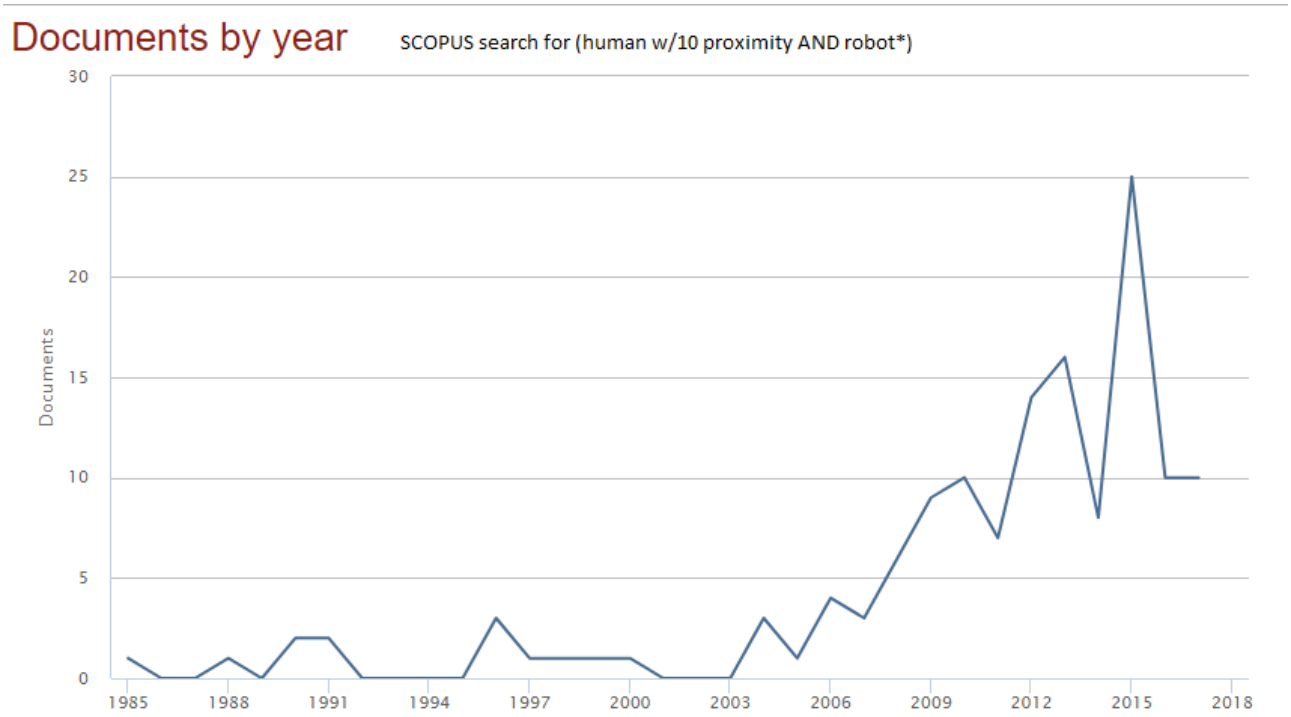
From the review of the initial and broad searches, we identified the relevant term *proxemics* which refers to the study of interpersonal distances. In psychology, proxemics refers to physical and psychological distances between humans; in robotics, this meaning is extended to address human-robot physical proximity with concern for appropriate social distances. We also identified the subtopic pHRI (physical human-robot interaction), which is concerned with physical interactions/contact between the robot and human.

## Database queries

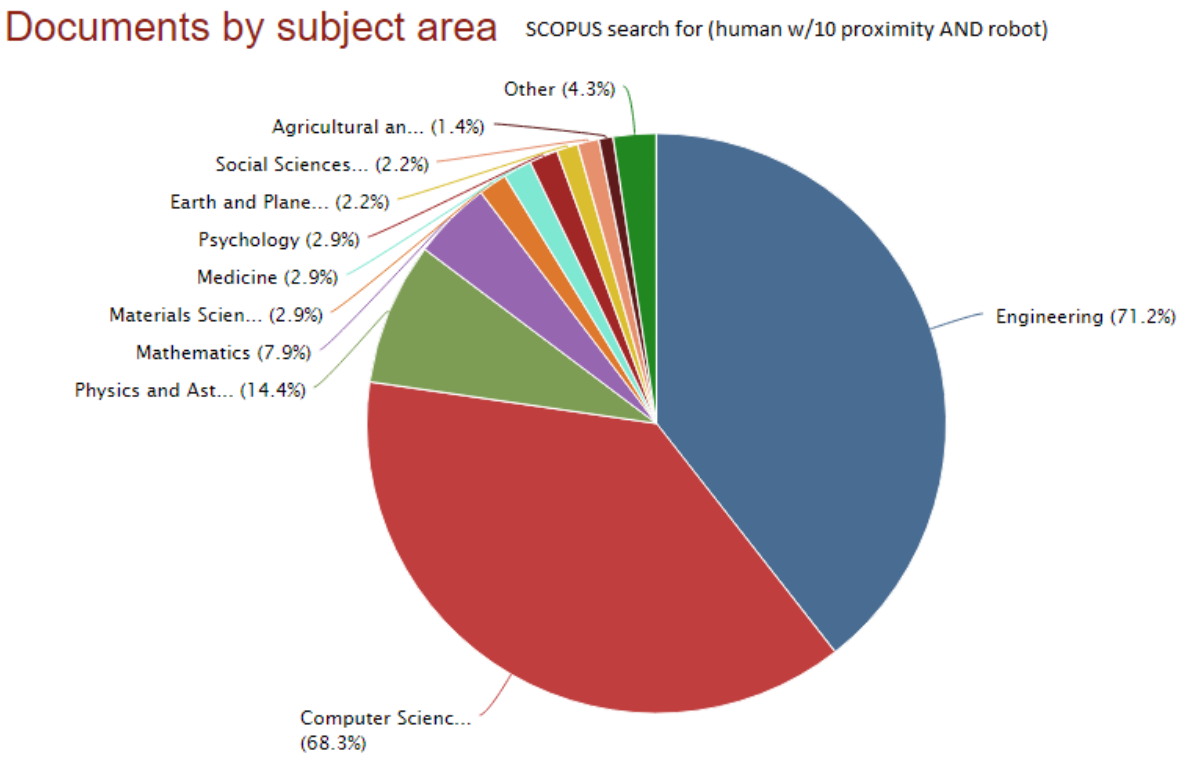
| Search Queries in SCOPUS | Number of hits | Texts selected |
|---|---|---|
| **human-robot proximity** | **1** | **1*** |
| **human proximity** | **99** | **---** |
| human proximity AND robot* | 6 | 6 |
| **human w/10 proximity AND robot*** | **140** | **---** |
| human w/10 proximity AND robot*; PUBYEAR>2003 | 127 | 105 |
| human w/10 proximity AND robot*; SUBJAREA=PSYC, SOCI, ARTS | 5 | 5 |
| **proxemics** | **450** | **---** |
| proxemics AND robot* | 104 | 23* |
| | | ***included in the results from human w/10 proximity AND robot** |

## Charts and trends

The broader search for "human" within 10 words' distance from "proximity" combined with variations of the term "robot" showed an increase in mention after the millennial turn, consistent with rises for mentions of robot in general.




Most of the results were from engineering and the computer sciences.




## Selected literature

**SCOPUS search for: TITLE-ABS-KEY ("human proximity" AND "robot") (6)**

The opening search query for the concept 'human proximity' returned the following 6 results, all reflecting a technical perspective to proximity and human-robot interaction. The following abstracts demonstrate the focus on spatial proximity, robot functionality, and human physical safety. Subsequent searches were performed to broaden the way human-robot proximity might be phrased.

**Abstract results for the search query:** TITLE-ABS-KEY ("human proximity" AND "robot")

Papadakis, P. & Rives, P. 2016. "Binding human spatial interactions with mapping for enhanced mobility in dynamic environments." *Autonomous Robots*, 1-13. Article in Press. DOI: 10.1007/s10514-016-9581-1

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84975112363&doi=10.1007%2fs10514-016-9581-1&partnerID=40&md5=f4c45ecf6f22628065574f4378ba6030

[*This texts addresses a mobile robot's use of human movement patterns to map its own movements in close* ***physical proximity*** *to humans.]*

ABSTRACT: For mobile robots to operate in compliance with human presence, interpreting the impact of human activities and responding constructively is a challenging goal. In this paper, we propose a generative approach for enhancing robot mapping and mobility in the presence of humans through a joint, probabilistic treatment of static and dynamic characteristics of indoor environments. Human spatial activity is explicitly exploited for the purpose of passage detection and space occupancy prediction while effectively discarding false positive human detections using prior map information. In turn, this allows the execution of plan trajectories within unexplored areas by using human presence for resolving the uncertainty or ambiguity that is due to dynamic events. A series of experiments with an indoor **robot navigating in close human proximity** within a multi-floor building demonstrate the effectiveness of our approach in realistic conditions.

Huber, J. & Straub, J. 2013. "Validating an artificial intelligence human proximity operations system with test cases." *Proceedings of SPIE - The International Society for Optical Engineering*, 8752, art. no. 875206. DOI: 10.1117/12.2013647

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84881087530&doi=10.1117%2f12.2013647&partnerID=40&md5=633633abc1da4d60ee753980b350f9a7

*[This text addresses the **physical proximity** of robots to humans and the simulation of these human movements to improve the robot's AI.]*

ABSTRACT: An artificial intelligence-controlled **robot (AICR) operating in close proximity to humans** poses risk to these humans. Validating the performance of an AICR is an ill posed problem, due to the complexity introduced by the erratic (noncomputer) actors. In order to prove the AICR's usefulness, test cases must be generated to simulate the actions of these actors. This paper discusses AICR's performance validation in the context of a common human activity, moving through a crowded corridor, using test cases created by an AI use case producer. This test is a two-dimensional simplification relevant to autonomous UAV navigation in the national airspace.

Diamond, A., Knight, R., Devereux, D., & Holland, O. 2012. "Anthropomimetic robots: Concept, construction and modelling." *International Journal of Advanced Robotic Systems*, 9. DOI: 10.5772/52421

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84870452073&doi=10.5772%2f52421&partnerID=40&md5=e4c184d0e153bebfe5be11467c3468df

*[This text describes progress in building anthropomimetic robot torsos, describing their structure as safe for **physical human proximity** and contact.]*

ABSTRACT: An anthropomimetic robot is one that closely copies the mechanics of the human body by having a human-like jointed skeleton moved by compliant musclelike actuators. This paper describes the progress achieved in building anthropomimetic torsos in two projects, CRONOS and ECCEROBOT. In each, the bones were hand-moulded in a thermoplastic and the muscles were implemented by DC motors shortening and extending elastic tendons. Anthropomimetic robots differ from conventionally engineered robots by having complex joints and compliant tendon driven actuation that can cross more than one joint. Taken together, these characteristics make the robots unsuitable for control by standard methods, and so the ability to model them is important for developing heuristic methods of control and also for providing forward models. The robots were modelled using physics-based techniques which enable the study of the generation of movements and also of interactions with arbitrary objects. The lightweight and compliant structure of the **robots was found to be safe for human proximity and contact**.

Pandey, A.K. & Alami, R. 2010. "A framework towards a socially aware mobile robot motion in human-centered dynamic environment." *IEEE/RSJ 2010 International Conference on Intelligent Robots and Systems, IROS 2010 - Conference Proceedings*, art. no. 5649688, pp. 5855-5860. DOI: 10.1109/IROS.2010.5649688

https://www.scopus.com/inward/record.uri?eid=2-s2.0-78651521318&doi=10.1109%2fIROS.2010.5649688&partnerID=40&md5=dca21ec77ce40031a19b47e879464f6d

*[This text considers robot movement in a "human-centered" environment with regard for **physical human proximity guidelines** but also considering **social conventions.**]*

ABSTRACT: For a Mobile **Robot to navigate in the Human-Centered environment** without imposing alien like impression by its motion, it should be able to reason about various criteria ranging from clearance, environment structure, unknown objects, social conventions, proximity constraints, presence of an individual or group of peoples, etc. Also the robot should neither be over-reactive nor be simple wait and move machine. We have adapted a Voronoi diagram based approach for the analysis of local clearance and environment structure. We also propose to treat human differently from other obstacles for which the robot constructs different sets of regions around human and iteratively converges to a set of points (milestones), **using social conventions, human proximity guidelines and clearance constraints to generate and modify its path smoothly**. Once equipped with such capabilities, robot is able to do higher-level reasoning for dynamic and selective adaptation of social convention depending upon the environment segment. It also leads the robot to be aware about its own motion behavior.

Pandey, A.K. & Alami, R. 2009. "A framework for adapting social conventions in a mobile robot motion in human-centered environment." *International Conference on Advanced Robotics, ICAR 2009*, art. no. 5174708.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-70449420097&partnerID=40&md5=8923192c8921c2e0e3610cada8e2f73d

*[This text focuses on the variable appropriate **physical proximity** of robot to human with consideration for **social rules.]***

ABSTRACT: Interestingly in different situations, human not only plans differently for approaching, accompanying, passing by and avoiding another person, but also smoothly maintains an appropriate distance. But for a mobile robot it is not trivial at all, while also maintaining its goal. In this paper we present a generic framework of mobile robot path planning for adapting social rules at different states of execution, which apart from assuring safety, also respects the comfort and expectations of human, and convey its intention to human well in advance. In our approach for treating human explicitly robot constructs different sets of regions around human and iteratively converges to a set of points (milestones), **using social rules, human proximity rules and task oriented rules to generate a smooth path.** We have compared our results with the case, when robot is purely reactive.

Buller, W. & Wilson, B. 2006. "Measurement and modeling mutual capacitance of electrical wiring and humans." *IEEE Transactions on Instrumentation and Measurement*, 55 (5): 1519-1522. DOI: 10.1109/TIM.2006.880293

https://www.scopus.com/inward/record.uri?eid=2-s2.0-33749344205&doi=10.1109%2fTIM.2006.880293&partnerID=40&md5=fcf8d0338650c5250f43a36c9a501775

*[This article demonstrates the more generic way the term* human proximity *has been used in the literature reviewed – to indicate the closeness of a human with regard for the technology's function, not with regard for the human's well-being.]*

ABSTRACT: In a recent series of electric field sensing experiments, a theremin was used to measure the mutual capacitance between a human being and a length of electrical wiring. The instrument, based on the LM555 circuit, measures the deflections in capacitance due to the proximity of a human. The measurements are repeatable, and the difference in capacitance for a person at 0.5 m with a person at 1 m is consistent with the difference computed, assuming the human acts as a ground plane for the wiring. Much of the current literature in electric field sensing focuses on measures and models of mutual capacitance for humans interacting with plate conductors [J. R. Smith, Electric field imaging, Ph.D. dissertation, Mass. Inst. Technol., Cambridge, MA, 1999; N. Karlsson and J. O. Jarrhed, A capacitive sensor for the detection of humans in a robot cell, in Proc. IEEE IMTC Rec., May 18-20, 1993 pp. 164-166.], especially fingers near touch screens [D. Wiebe, A. Machynia, K. Mazur, and J. Epp, Human-computer interface device based on electric field sensing, Ph.D. dissertation, Univ. Manitoba, Winnipeg, MB, Canada, 2004]. The present investigation considers conducting wires to allow the development of portable rapidly deployable **human proximity** sensing systems that exploit existing electrical infrastructure in buildings. The experiment described here demonstrates that sensing with wires is possible at ranges on the order of a meter and provides evidence that modeling the person as a ground plane of finite extent provides a rough estimate of the change in mutual capacitance.

**SCOPUS search for: TITLE-ABS-KEY ((human w/10 proximity) AND robot*) within social sciences (5)**

The secondary search of SCOPUS for "human" within 10 words of "proximity" coupled with a search of "robot*" returned 140 results. This search allows for articles which might not mention the phrases "human proximity" or "human-robot proximity" but might include the sentence "when the robot is within close proximity to the human…". In this way the search is broader and *might* (or might not) encompass some of the ways REELER has handled human-robot proximity. When limited to texts from the social sciences, psychology, and arts & humanities, 5 results were returned. All of the results were from technical perspectives and mostly from technical sources. The use of 'proximity' remained focused on spatial proximity and robot functionality.

**Abstract results for the search query:** TITLE-ABS-KEY ( ( human W/10 proximity ) AND robot*) AND ( LIMIT-TO ( SUBJAREA , "PSYC" ) OR LIMIT-TO ( SUBJAREA , "SOCI" ) OR LIMIT-TO ( SUBJAREA , "ARTS" ) )

Obaid, M., Sandoval, E.B., Zlotowski, J., Moltchanova, E., Basedow, C.A., & Bartneck, C. 2016. "Stop! That is close enough. How body postures influence human-robot proximity." *25th IEEE International Symposium on Robot and Human Interactive Communication, RO-MAN 2016*, art. no. 7745155, pp. 354-361. DOI: 10.1109/ROMAN.2016.7745155

https://www.scopus.com/inward/record.uri?eid=2-s2.0-85002676945&doi=10.1109%2fROMAN.2016.7745155&partnerID=40&md5=0ea4d8f4eb88b4019e3c1cda86765f7a

*[This was the single result in SCOPUS for "human-robot proximity"]*

ABSTRACT: In this paper we present a study that investigates human-robot interpersonal distances and the influence of posture, either sitting or standing on the interpersonal distances. The study is based on a human approaching a robot and a robot approaching a human, in which the human/robot maintain either a sitting or standing posture while being approached. We collected and analysed data from twenty-two participants and the results revealed that **robot posture has a significant impact on the interpersonal distances in human-robot interactions**. Previous interactions with a robot, and lower negative attitudes towards robots also impacted interpersonal distances. Although the effects of gender, height and age did not yield significant results, we discuss their influence on the interpersonal distances between humans and robots and how they are of interest for future research. We present design implications for human-robot interaction research and humanoid robot design.

Scheunemann, M.M., Dautenhahn, K., Salem, M., & Robins, B. 2016. "Utilizing Bluetooth Low Energy to recognize proximity, touch and humans." *25th IEEE International Symposium on Robot and Human Interactive Communication, RO-MAN 2016*, art. no. 7745156, pp. 362-367. DOI: 10.1109/ROMAN.2016.7745156

https://www.scopus.com/inward/record.uri?eid=2-s2.0-85002560694&doi=10.1109%2fROMAN.2016.7745156&partnerID=40&md5=6bd99ab93161ad0eb299fb64db188070

*[This text focuses on improving the functionality of a robot when in contact with humans.]*

ABSTRACT: **Interacting with humans is one of the main challenges for mobile robots in a human inhabited environment**. To enable adaptive behavior, a robot needs to recognize touch gestures and/or the proximity to interacting individuals. Moreover, a robot interacting with two or more humans usually needs to distinguish between them. However, this remains both a configuration and cost intensive task. In this paper we utilize inexpensive Bluetooth Low Energy (BLE) devices and propose an easy and configurable technique to **enhance the robot's capabilities to interact with surrounding people**. In a noisy laboratory setting, a mobile spherical robot is utilized in three proof-of-concept experiments of the proposed system architecture. Firstly, we enhance the robot with proximity information about the individuals in the surrounding environment. Secondly, we exploit BLE to utilize it as a touch sensor. And lastly, we use BLE to distinguish between interacting individuals. Results show that observing the raw received signal strength (RSS) between BLE devices already enhances the robot's interaction capabilities and that the provided infrastructure can be facilitated to enable adaptive behavior in the future. We show one and the same sensor system can be used to detect different types of information relevant in human-robot interaction (HRI) experiments.

Lasota, P.A. & Shah, J.A. 2015. "Analyzing the effects of human-aware motion planning on close-proximity human-robot collaboration." *Human Factors*, 57 (1): 21-33. DOI: 10.1177/0018720814565188

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84922507239&doi=10.1177%2f0018720814565188&partnerID=40&md5=e994ebf4993709daa7605a66a5678b12

*[Measures **user acceptance** of robots with different navigation planning: shortest-path and human-aware.]*

ABSTRACT: Objective: The objective of this work was to examine human response to motion-level robot adaptation to determine its effect on team fluency, human satisfaction, and perceived safety and comfort. Background: The evaluation of human response to adaptive robotic assistants has been limited, particularly in the realm of motion-level adaptation. The lack of true **human-in-the-loop** evaluation has made it impossible to determine whether such adaptation would lead to efficient and satisfying human-robot interaction. Method: We conducted an experiment in which participants worked with a robot to perform a collaborative task. Participants worked with an adaptive robot incorporating human-aware motion planning and with a baseline robot using shortest-path motions. Team fluency was evaluated through a set of quantitative metrics, and human satisfaction and perceived safety and comfort were evaluated through questionnaires. Results: When working with the adaptive robot, participants completed the task 5.57% faster, with 19.9% more concurrent motion, 2.96% less human idle time, 17.3% less robot idle time, and a 15.1% greater separation distance. Questionnaire responses indicated that participants felt safer and more comfortable when working with an adaptive robot and were more satisfied with it as a teammate than with the standard robot. Conclusion: People respond well to motion level robot adaptation, and significant benefits can be achieved from its use in terms of both human-robot team fluency and human worker satisfaction. Application: Our conclusion supports the development of technologies that could be used to implement **human-aware motion planning in collaborative robots and the use of this technique for close-proximity human-robot collaboration.**

Henkel, Z., Bethel, C.L., Murphy, R.R., & Srinivasan, V. 2014. "Evaluation of proxemic scaling functions for social robotics." *IEEE Transactions on Human-Machine Systems*, 44 (3), art. no. 6746063, pp. 374-385. DOI: 10.1109/THMS.2014.2304075

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84901324017&doi=10.1109%2fTHMS.2014.2304075&partnerID=40&md5=ae32b9937444926dcee1f0be7c44c7fd

*[Studies technical ability to alter physical proximity to humans. Identifies the field of* proxemics.*]*

ABSTRACT: This paper introduces and empirically evaluates two scaling functions to **alter a robot's physical movements based on proximity to a human.** Previous research has focused on individual aspects of **proxemics**, like the appropriate distance to maintain from a human, but has not explored autonomous methods to adapt robot behavior as proximity changes. This paper proposes that robots in a social role should modify their behavior using a continuous function mapped to proximity. The method developed calculates a gain value from proximity readings, which is used to shape the execution of active behaviors on the robot. In order to identify the effects of different mappings from proximity to gain value, two different scaling functions were implemented on an affective search and rescue robot. The findings from a 72 participant study, in a high-fidelity mock disaster site, are examined with attention given to a new measure to determine proxemic awareness. The results indicated that for attributes of intelligence, likability, proxemic awareness, and submissiveness, a logarithmic-based scaling function is preferred over a linear-based scaling function, and over no scaling function. In areas of participant comfort and participant stress, the results indicated both logarithmic and linear scaling functions were preferred to no scaling.

Rahimi, M., & Karwowski, W. 1990. "Human perception of robot safe speed and idle time." *Behaviour and Information Technology*, 9 (5), pp. 381-389. DOI: 10.1080/01449299008924252

https://www.scopus.com/inward/record.uri?eid=2-s2.0-30244477042&doi=10.1080%2f01449299008924252&partnerID=40&md5=6ffaf53b8dbffee32be41be107fc410f

*[Studies human perception of safe robot operation, to improve robot programming**, function**.]*

ABSTRACT: Operators and users of robotic systems perform tasks which require **close proximity to dangerous moving parts.** Two experiments were performed to **assess human perception of safe robot arm speed and idling times**. Experiment 1 was designed to determine the maximum safe speed of robots. Subjects were asked to adjust the robot speeds. Perceived safe speeds were indicated for two different types of robots. Experiment 2 was designed to determine safe programmed idle time of robots. Subjects were asked to enter the robot work envelope when a programmed idle was perceived to be caused by a malfunction. Safe idle times were reported for two different robot speeds during operational cycles.

**SCOPUS search for: TITLE-ABS-KEY ((human w/10 proximity) AND robot*) PUBYEAR>2003 (105)**

The secondary search of SCOPUS for "human" within 10 words of "proximity" coupled with a search of "robot*" returned 140 results, 105 of these included the right context and occurred after 2003. This search allows for articles which might not mention the phrases "human proximity" or "human-robot proximity" but might include the sentence "when the robot is within close proximity to the human…". In this way the search is broader and *might* (or might not) encompass some of the ways REELER has handled human-robot proximity. Just 5 of these results are oriented toward social concerns, but even then, these are considered as a component of robot functionality.

**Abstract results for the search query:** TITLE-ABS-KEY ( ( human W/10 proximity ) AND robot*) PUBYEAR>2003

Charalampous, K., Kostavelis, I., Gasteratos, A. 2017. "Recent trends in social aware robot navigation: A survey." *Robotics and Autonomous Systems*, 93: 85-104.

***[physical; functionality; user acceptance]***

ABSTRACT: With the robots tending to accumulate more and more capabilities beyond the level of acting in a deterministic fashion, the idea of introducing them into our every day lives seems to be closer now. Robotics systems

and techniques appeared during the recent years have achieved astonishing potential to perceive and interpret their surrounding not only as low level features but also close to human understandable concepts. Such advances, in conjunction with the aspiration to incorporate robots into domestic or public places, led to the flourishing of fields dealing with their response in human presence. Following this notion, the field of social mapping was recently introduced in order to manage the shared space among robots and individuals in an ordinary fashion. This manuscript aims to systemize the recent literature by describing the required levels of robot perception, focusing on methods related to robot's social awareness, the availability of datasets these methods can be compared with, as well as issues that remain open and need to be confronted when robots operate in close proximity with humans.

Papadakis, P., Rives, P. 2017. "Binding human spatial interactions with mapping for enhanced mobility in dynamic environments." *Autonomous Robots*, 41(5): 1047-1059.

***[physical; functionality]***

ABSTRACT: For mobile robots to operate in compliance with human presence, interpreting the impact of human activities and responding constructively is a challenging goal. In this paper, we propose a generative approach for enhancing robot mapping and mobility in the presence of humans through a joint, probabilistic treatment of static and dynamic characteristics of indoor environments. Human spatial activity is explicitly exploited for the purpose of passage detection and space occupancy prediction while effectively discarding false positive human detections using prior map information. In turn, this allows the execution of plan trajectories within unexplored areas by using human presence for resolving the uncertainty or ambiguity that is due to dynamic events. A series of experiments with an indoor robot navigating in close human proximity within a multi-floor building demonstrate the effectiveness of our approach in realistic conditions.

Tsuji, S., Kohama, T. 2017. "Tactile and proximity sensor using self-capacitance measurement on curved surface." *Proceedings of the IEEE International Conference on Industrial Technology*, art. no. 7915485, pp. 934-937.

***[physical; functionality]***

ABSTRACT: In this paper, we develop a tactile and proximity sensor using self-capacitance measurement on the curved surface for human collaboration robot (HCRs). The proposed sensor consists of two measurement electrodes and an elastic body. We produced the prototype sensor using the flexible circuit board. Thus, the sensor can curve in the curved surface. The sensor using self-capacitance measurement can detect the object before contact, and detect the pressure and discriminate the material on contact. Therefore, the sensor will assure the safety and workability of the robot because the robot will avoid unnecessary contact with objects including humans.

Kolkhorst, H., Tangermann, M., Burgard, W. 2017. "Decoding perceived hazardousness from user's brain states to shape human-robot interaction." *ACM/IEEE International Conference on Human-Robot Interaction*, 349-350.

***[physical; functionality; user acceptance]***

ABSTRACT: With growing availability of robots and rapid advances in robot autonomy, their proximity to humans and interaction with them continuously increases. In such interaction scenarios, it is often evident what a robot should do, yet unclear how the actions should be performed. Humans in the scene nevertheless have subjective preferences over the range of possible robot policies. Hence, robot policy optimization should incorporate the human's preferences. One option to gather online information is the decoding of the human's brain signals. We present ongoing work on decoding the perceived hazardousness of situations based on brain signals from electroencephalography (EEG). Based on experiments with participants watching potentially hazardous traffic situations, we show that such decoding is feasible and propose to extend the approach towards more complex environments such as robotic assistants. Ultimately, we aim to provide a closed-loop system for human-compliant adaptation of robot policies based on the decoding of EEG signals.

Li, S., Zhao, H., Shepherd, R.F. 2017. "Flexible and stretchable sensors for fluidic elastomer actuated soft robots." *MRS Bulletin*, 42(2): 138-142.

***[physical; functionality]***

ABSTRACT: Compliant robots, a class of so-called soft robots, made from elastomeric materials, require flexible or stretchable sensors for functional sophistication beyond that of open-loop controls and actuations. These robots have expanded the scope of research in robotics from fast, strong, and precise industrial manufacturing toward new needs of adaptation and safety - the realm of human-robot interactions (HRIs). HRIs include circumstances ranging from

existing tasks such as vacuum cleaning to the far-reaching goal of direct contact with the heart for ventricular assist devices, and wearable robots as an intermediate task for force-augmenting exoskeletons. Toward these goals, many efforts are being made to impart sensation for feedback control via flexible or stretchable sensors that can be integrated with the soft bodies of these robots without hindering their motion or reducing their safety. This article briefly reviews the key techniques and tradeoffs for designing and fabricating these sensors. We describe the sensors that our research group uses for fluidically powered soft robots. We conclude with some perspectives about future directions of sensing integration for improved autonomy and interaction with humans in close proximity.

Khaliq, A.A., Pecora, F., Saffiotti, A. 2017. "Children Playing with Robots Using Stigmergy on a Smart Floor." *Proceedings - 13th IEEE International Conference on Ubiquitous Intelligence and Computing, 13th IEEE International Conference on Advanced and Trusted Computing, 16th IEEE International Conference on Scalable Computing and Communications, IEEE International Conference on Cloud and Big Data Computing, IEEE International Conference on Internet of People and IEEE Smart World Congress and Workshops*, UIC-ATC-ScalCom-CBDCom-IoP-SmartWorld 2016, art. no. 7816968, pp. 1098-1103.

***[physical; functionality]***

ABSTRACT: Reliable, safe interaction is essential when humans, robots move in close proximity. In this paper, we present a stigmergic approach where humans interact with robots via a smart floor. Stigmergy has been widely studied in robotic systems, however, HRI has thus far not availed itself of stigmergic solutions. We realize a stigmergic medium via RFID tags embedded in the floor, use these to enable robot navigation, human tracking, as well as the interaction between robots, humans. The proposed method allows to employ robots with minimal sensing, computation capabilities. The approach relies only on the RFID sensors, the information stored in the tags, no internal map is required for navigation. We design, implement a prototype game which involves a robot, a child moving together in a shared space. The prototype demonstrates that the approach is reliable, adheres to given safety constraints when human, robot are moving within close proximity of each other.

Macarthur, K.R., Stowers, K., Hancock, P.A. 2017. "Human-robot interaction: Proximity and speed—slowly back away from the robot!" *Advances in Intelligent Systems and Computing*, 499: 365-374.

***[physical; functionality; user acceptance]***

ABSTRACT: This experiment was designed to evaluate the effects of proximity and speed of approach on trust in human-robot interaction (HRI). The experimental design used a 2 (Speed) × 2 (Proximity) mixed factorial design and trust levels were measured by self-report on the Human Robot Trust Scale and the Trust in Automation Scale. Data analyses indicate proximity [F(2, 146) = 6.842, p < 0.01, partial ŋ2 = 0.086] and speed of approach [F(2, 146) = 2.885, p = 0.059, partial ŋ2 = 0.038] are significant factors contributing to changes in trust levels.

Cho, I.-J., Lee, H.-K., Chang, S.-I., Yoon, E. 2017. "Compliant ultrasound proximity sensor for the safe operation of human friendly robots integrated with tactile sensing capability." *Journal of Electrical Engineering and Technology*, 12(1): 310-316.

***[physical; functionality]***

ABSTRACT: The robot proximity and tactile sensors can be categorized into two groups: grip sensors and safety sensors. They have different performance requirements. The safety sensor should have long proximity range and fast response in order to secure enough response time before colliding with ambient objects. As for the tactile sensing function, the safety sensor need to be fast and compliant to mitigate the impact from a collision. In order to meet these requirements, we proposed and demonstrated a compliant integrated safety sensor suitable to human-friendly robots. An ultrasonic proximity sensor and a piezoelectric tactile sensor made of PVDF films have been integrated in a compliant PDMS structure. The implemented sensor demonstrated the maximum proximity range of 35 cm. The directional tolerance for 30 cm detection range was about ±15° from the normal axis. The integrated PVDF tactile sensor was able to detect various impacts of up to 20 N in a controlled experimental setup.

Zeng, H., Wani, O.M., Wasylczyk, P., Priimagi, A. 2017. "Light-Driven, Caterpillar-Inspired Miniature Inching Robot." *Macromolecular Rapid Communications*, Article in Press.

***[physical; functionality]***

ABSTRACT: Liquid crystal elastomers are among the best candidates for artificial muscles, and the materials of choice when constructing microscale robotic systems. Recently, significant efforts are dedicated to designing stimuli-

responsive actuators that can reproduce the shape-change of soft bodies of animals by means of proper external energy source. However, transferring material deformation efficiently into autonomous robotic locomotion remains a challenge. This paper reports on a miniature inching robot fabricated from a monolithic liquid crystal elastomer film, which upon visible-light excitation is capable of mimicking caterpillar locomotion on different substrates like a blazed grating and a paper surface. The motion is driven by spatially uniform visible light with relatively low intensity, rendering the robot "human-friendly," i.e., operational also on human skin. The design paves the way toward light-driven, soft, mobile microdevices capable of operating in various environments, including the close proximity of humans.

Ho, V.A., Hirai, S., Naraki, K. 2016. "Fabric interface with proximity and tactile sensation for human-robot interaction*." IEEE International Conference on Intelligent Robots and Systems*, 2016-November, art. no. 7759061, 238-245.

***[physical; functionality]***

ABSTRACT: Human-in-the-loop task involving soft contact has become common in robotic application, especially in physical human-robot interaction. In this task, it is required that robot would sense interactions with human by touching, as well as assess possibility of human approaching by proximity sensation. In addition, it is also essential to fabricate an interface so that human does not feel uncomfortable during physical interaction with robot. This paper presents an attempt on fabrication of sensing elements that can be utilized for construction of a soft interface (or a robotic skin). Each element is made from fabrics and soft materials that can sense both proximity and applied force from human's touch. In addition, each sensing element can sense the relative distance of conductive object (or human body) that is approaching the sensing element's surface, and the 2×2 contact force distribution when the object makes contact with the sensing element. By exploiting simultaneous measurement of capacitance, each fabric sensing element can smoothly switch the proximity mode and tactile mode based on position of the object. We also constructed a model that can predict variation of capacitance measurement of proximity and tactile modes during operation for further analysis. The methods and results presented in this paper can be extended to construct a larger scale of robotic skin for robot's body, and act as a platform for study human-robot interaction.

Hoffmann, A., Poeppel, A., Schierl, A., Reif, W. 2016. "Environment-aware proximity detection with capacitive sensors for human-robot-interaction." *IEEE International Conference on Intelligent Robots and Systems*, 2016-November, art. no. 7759047, 145-150.

***[physical; functionality]***

ABSTRACT: Recently, the need for safe human-robot interaction has become increasingly important, and with it the requirement to reliably detect persons in the workspace of a robot. Capacitive sensors mounted to the robot structure can be used to measure the presence of conductive objects and, hence, allow the detection of persons. However, various objects in the workspace can influence capacitive sensor measurements. Thus, we propose to record an environment model containing the expected sensor values for relevant robot poses. Using this model, distance estimation and real-time reaction can be performed even in the presence of additional conductive objects in the workspace. A demonstration of our approach was shown at the Hannover Messe 2015.

Scheunemann, M.M., Dautenhahn, K., Salem, M., Robins, B. 2016. "Utilizing Bluetooth Low Energy to recognize proximity, touch and humans." *25th IEEE International Symposium on Robot and Human Interactive Communication*, RO-MAN 2016, art. no. 7745156, 362-367.

***[physical; functionality]***

ABSTRACT: Interacting with humans is one of the main challenges for mobile robots in a human inhabited environment. To enable adaptive behavior, a robot needs to recognize touch gestures and/or the proximity to interacting individuals. Moreover, a robot interacting with two or more humans usually needs to distinguish between them. However, this remains both a configuration and cost intensive task. In this paper we utilize inexpensive Bluetooth Low Energy (BLE) devices and propose an easy and configurable technique to enhance the robot's capabilities to interact with surrounding people. In a noisy laboratory setting, a mobile spherical robot is utilized in three proof-of-concept experiments of the proposed system architecture. Firstly, we enhance the robot with proximity information about the individuals in the surrounding environment. Secondly, we exploit BLE to utilize it as a touch sensor. And lastly, we use BLE to distinguish between interacting individuals. Results show that observing the raw received signal strength (RSS) between BLE devices already enhances the robot's interaction capabilities and that the provided infrastructure

can be facilitated to enable adaptive behavior in the future. We show one and the same sensor system can be used to detect different types of information relevant in human-robot interaction (HRI) experiments.

Obaid, M., Sandoval, E.B., Zlotowski, J., Moltchanova, E., Basedow, C.A., & Bartneck, C. 2016. "Stop! That is close enough. How body postures influence human-robot proximity." *25th IEEE International Symposium on Robot and Human Interactive Communication, RO-MAN 2016*, art. no. 7745155, pp. 354-361. DOI: 10.1109/ROMAN.2016.7745155

***[physical; functionality; user acceptance]***

ABSTRACT: In this paper we present a study that investigates human-robot interpersonal distances and the influence of posture, either sitting or standing on the interpersonal distances. The study is based on a human approaching a robot and a robot approaching a human, in which the human/robot maintain either a sitting or standing posture while being approached. We collected and analysed data from twenty-two participants and the results revealed that **robot posture has a significant impact on the interpersonal distances in human-robot interactions**. Previous interactions with a robot, and lower negative attitudes towards robots also impacted interpersonal distances. Although the effects of gender, height and age did not yield significant results, we discuss their influence on the interpersonal distances between humans and robots and how they are of interest for future research. We present design implications for human-robot interaction research and humanoid robot design.

Skorina, E.H., Tao, W., Chen, F., Luo, M., Onal, C.D. 2016. "Motion control of a soft-actuated modular manipulator." *Proceedings - IEEE International Conference on Robotics and Automation, 2016-June*, art. no. 7487706, 4997-5002.

***[physical; functionality]***

ABSTRACT: Soft pneumatic actuators can allow robotic manipulators to interact safely in complex environments in close proximity to humans, but work still needs to be done controlling them more effectively. We explore this area by introducing a 2-degree of freedom (DoF) universal joint module actuated by three reverse Pneumatic Artificial Muscles (rPAMs) and an associated geometric Jacobian-enhanced iterative sliding mode controller. After demonstrating the effectiveness of this controller, we combine two of these modules to form a 4-DoF soft actuated manipulator. To control this modular manipulation system, we propose two controllers: a direct inverse kinematic (IK) controller and an end-effector geometric Jacobian controller. Though both controllers were validated to function effectively, the Jacobian controller was more precise (especially under payload) while the IK controller was more accurate.

Park, S., Kim, Y., Matson, E.T., Smith, A.H. 2016. "Accessible synthetic aperture radar system for autonomous vehicle sensing." *SAS 2016 - Sensors Applications Symposium, Proceedings*, art. no. 7479897, 495-500.

***[physical; functionality]***

ABSTRACT: The usage of autonomous vehicles is rapidly expanding on both the ground and air. With more autonomous vehicles in close proximity to humans, new and better sensors need to be developed to manage these relationships, both good and bad. This new age of autonomous activity will bring both new opportunity and new threats to people and property. One of these threats will be from cheap, very functional unmanned aerial vehicles (UAV). Currently, there is very little we can do to detect and track these vehicles, without expensive and typically unaccessible military grade sensors, such as radar. To provide a response to these threats, in a ubiquitous manner, low cost, accessible systems capable of detecting and tracking dubious UAV activity must be developed. This research effort is to develop a low cost, accessible sensor system with sufficient power and accuracy to be utilized in a number of task domains throughout the robotics and autonomous systems field, including for UAV detection and tracking. To make these systems accessible, the systems are flexible in terms of power and range, but a fully functioning radar system that anyone, such as local first responder organizations can afford. Given these requirements, we started with a design for a low cost synthetic aperture radar (SAR) and built the components. The basic design was modified to specifically address the challenges of being autonomous, low cost and mobile and to detect objects with minimal cross section. In the end the result is a promising system that can detect very small objects in an acceptable range.

Birnbaum, G.E., Mizrahi, M., Hoffman, G., Reis, H.T., Finkel, E.J., Sass, O. 2016. "Machines as a source of consolation: Robot responsiveness increases human approach behavior and desire for companionship." *ACM/IEEE International Conference on Human-Robot Interaction*, 2016-April, art. no. 7451748, 165-171.

***[physical & social; functionality; user acceptance]***

ABSTRACT: Responsiveness to one's bids for proximity in times of need is a linchpin of human interaction. Thus, the ability to be perceived as responsive has design implications for socially assistive robots. We report on a large-scale experimental laboratory study (n = 102) examining robot responsiveness and its effects on human attitudes and behaviors. In one-on-one sessions, participants disclosed a personal event to a non-humanoid robot. The robot responded either responsively or unresponsively across two modalities: Simple gestures and written text. We replicated previous findings that the robot's responsiveness increased perceptions of its appealing traits. In addition, we found that robot responsiveness increased nonverbal approach behaviors (physical proximity, leaning toward the robot, eye contact, smiling) and participants' willingness to be accompanied by the robot during stressful events. These findings suggest that humans not only utilize responsiveness cues to ascribe social intentions to personal robots, but actually change their behavior towards responsive robots and may want to use such robots as a source of consolation.

Matsas, E., Vosniakos, G.-C., Batras, D. 2016. "Modelling simple human-robot collaborative manufacturing tasks in interactive virtual environments." *ACM International Conference Proceeding Series*, art. no. 20.

***[physical; functionality]***

ABSTRACT: This paper presents in brief a novel interactive Virtual Environment (VE) that simulates in real-time collaborative manufacturing tasks between a human and an industrial robotic manipulator, working in close proximity, while sharing their workspaces. The use case scenario is highly collaborative and incorporates a wide variety of interaction tasks, such as: collaborative handling, manipulation, removal, placement and laying of carbon fabric composite parts. A Kinect sensor and a Head Mounted Display (Oculus Rift) are employed as 3D User Interfaces for interaction, immersion and skeletal tracking of the user motion. In this paper, particular emphasis is given to the various interaction techniques used to facilitate implementation of virtual Human-Robot Collaboration (HRC). The collaborative tasks are principally executed with contactless, natural and direct interaction. In addition, two novel interaction metaphors were developed. The real fabric laying task and the backing film removal task are reproduced in the VE with the implementation of the "follow-my-hand" technique; the user has to follow with his hand a virtual hand-like index (guide) that moves along a predefined pattern. Preliminary findings concerning the effectiveness of HRC modelling tasks are positive, and are briefly discussed.

Rahman, M., Debnath, M., Sharmin, S., Alam, L., Arefin, S., Hoque, M. 2016. "Designing an empirical framework to measure the level of interest of Human." *2nd International Conference on Electrical Information and Communication Technologies*, EICT 2015, art. no. 7392019, 581-585.

***[physical; functionality; user acceptance]***

ABSTRACT: Human-robot interaction (HRI) is an interdisciplinary research field aimed at improving the interaction between human beings and robots. For effective and prolonged interaction, both interacting partners need to be identified the focus of attention of each other. In other words, need to tracks or determine the each other interest and their level of interest. Interaction between a human and a robot may influence by the proximity and angle between them. In this paper, we proposed a computer vision framework for robots that will determine the level of interest of its human partner in two-party setting. We have used the distance and angle parameters to determine the level of interest in several categories: high, medium, low, and so on. The level of interest information can be used as an indicator of people's willingness to engage in an interaction with a robot. The proposed framework uses depth and visual information, provided by a Kinect sensor. Experimental results show that the system is functioning quite well to measure the level of interest of human with a reasonable accuracy.

Das, S.K., Baptist, J.R., Sahasrabuddhe, R., Lee, W.H., Popa, D.O. 2016. "Package analysis of 3D-printed piezoresistive strain gauge sensors." *Proceedings of SPIE - The International Society for Optical Engineering*, 9859, art. no. 985905.

***[physical; functionality]***

ABSTRACT: Poly(3,4-ethyle- nedioxythiophene)-poly(styrenesulfonate) or PEDOT:PSS is a flexible polymer which exhibits piezo-resistive properties when subjected to structural deformation. PEDOT:PSS has a high conductivity and thermal stability which makes it an ideal candidate for use as a pressure sensor. Applications of this technology includes whole body robot skin that can increase the safety and physical collaboration of robots in close proximity to humans. In this paper, we present a finite element model of strain gauge touch sensors which have been 3D-printed onto Kapton and silicone substrates using Electro-Hydro-Dynamic ink-jetting. Simulations of the piezoresistive and structural model for the entire packaged sensor was carried out using COMSOLR, and compared with experimental results for validation. The model will be useful in designing future robot skin with predictable performances.

Gulhar, A., Briese, D., Mewes, P.W., Rose, G. 2015. "Registration of a robotic system to a medical imaging system." *IEEE International Conference on Intelligent Robots and Systems*, 2015-December, art. no. 7353822, 3208-3213.

***[physical; functionality]***

ABSTRACT: The presence of robots not only in industrial settings but also in operating rooms is increasing with advancements in technology. They are not only huge machines carrying out tedious and arduous tasks while being caged behind fences, but also work in collaboration, close proximity of, and in cooperation with humans. Image guided minimally invasive approaches to accurately navigate a robot to precise anatomical locations can be followed only once the robot is registered to the medical imaging system. In this paper, we present an approach to register a robotic system to a medical imaging system without the use of any tracking device or continuous X-ray imaging. The system consists of a lightweight robot equipped with internal torque sensors. The registration is realized by a series of landmark transformations. The robot is manually moved and guided to distinct landmarks whose positions are known in the coordinate system of the imaging system. By driving the robot to these distinct landmarks, their position relative to the coordinate system of the robotic system is also known. By comparing the respective positions of the landmarks in the two coordinate systems, both systems are registered. With 8 screws on the operating table used as landmarks for this registration, we obtain a median error of [6.9, 20.6, 18.6] mm and a standard deviation of [2.9, 2.6, 2.2] mm when compared to an X-ray based ground truth.

Nakano, H., Goodrich, M.A. 2015. "Graphical narrative interfaces: Representing spatiotemporal information for a highly autonomous human-robot team." *Proceedings - IEEE International Workshop on Robot and Human Interactive Communication*, 2015-November, art. no. 7333684, 634-639.

***[physical; functionality]***

ABSTRACT: Having a well-developed Graphical User Interface (GUI) is often necessary for a human-robot team, especially when the human and the robot are not in close proximity to each other or when the human does not interact with the robot in real time. Most current GUIs process and display information in real time, but the time to interact with these systems does not scale well when the complexity of the displayed information increases or when information must be fused to support decision-making. We propose a new interface concept, a Graphical Narrative Interface (GNI), which presents story-based summaries driven by accumulated data. We hypothesize that the GNI allows users to search and analyze spatiotemporal information more easily and quickly than a typical GUI. This paper (a) uses literature and preliminary GNI designs to identify a set of design requirements and (b) develops a conceptual GNI implementation that satisfies these requirements.

Qiu, S., Huang, Y., He, X., Sun, Z., Liu, P., Liu, C. 2015. "A dual-mode proximity sensor with integrated capacitive and temperature sensing units." *Measurement Science and Technology*, 26(10), art. no. 105101.

***[physical; functionality]***

ABSTRACT: The proximity sensor is one of the most important devices in the field of robot application. It can accurately provide the proximity information to assistant robots to interact with human beings and the external environment safely. In this paper, we have proposed and demonstrated a dual-mode proximity sensor composed of capacitive and resistive sensing units. We defined the capacitive type proximity sensor perceiving the proximity information as C-mode and the resistive type proximity sensor detecting as R-mode. Graphene nanoplatelets (GNPs) were chosen as the R-mode sensing material because of its high performance. The dual-mode proximity sensor presents the following features: (1) the sensing distance of the dual-mode proximity sensor has been enlarged compared with the single capacitive proximity sensor in the same geometrical pattern; (2) experiments have verified that the proposed sensor can sense the proximity information of different materials; (3) the proximity sensing capability of the sensor has been improved by two modes perceive collaboratively, for a plastic block at a temperature of 60 °C: the R-mode will perceive the proximity information when the distance d between the sensor and object is 6.0-17.0 mm and the C-mode will do that when their interval is 0-2.0 mm; additionally two modes will work together when the distance is 2.0-6.0 mm. These features indicate our transducer is very valuable in skin-like sensing applications.

Alonso-Mora, J., Naegeli, T., Siegwart, R., Beardsley, P. 2015. "Collision avoidance for aerial vehicles in multi-agent scenarios." *Autonomous Robots*, 39(1): 101-121.

***[physical; functionality]***

ABSTRACT: This article describes an investigation of local motion planning, or collision avoidance, for a set of decision-making agents navigating in 3D space. The method is applicable to agents which are heterogeneous in size,

dynamics and aggressiveness. It builds on the concept of velocity obstacles (VO), which characterizes the set of trajectories that lead to a collision between interacting agents. Motion continuity constraints are satisfied by using a trajectory tracking controller and constraining the set of available local trajectories in an optimization. Collision-free motion is obtained by selecting a feasible trajectory from the VO's complement, where reciprocity can also be encoded. Three algorithms for local motion planning are presented—(1) a centralized convex optimization in which a joint quadratic cost function is minimized subject to linear and quadratic constraints, (2) a distributed convex optimization derived from (1), and (3) a centralized non-convex optimization with binary variables in which the global optimum can be found, albeit at higher computational cost. A complete system integration is described and results are presented in experiments with up to four physical quadrotors flying in close proximity, and in experiments with two quadrotors avoiding a human.

Kim, S.-M., Moon, J.-I., Cho, I.-K., Yoon, J.-H., Byun, W.-J., Choi, H.-C. 2015. "Advanced power control scheme in wireless power transmission for human protection from EM field." *IEEE Transactions on Microwave Theory and Techniques*, 63 (3), art. no. 7036144, 847-856.

***[physical; functionality]***

ABSTRACT: The wireless power transmission (WPT) system must guarantee human protection from the electromagnetic (EM) field around the system in proportion to the increase of the transmit power. This paper presents an advanced power control scheme to reduce the EM field. The basic operation of the proposed scheme is the automatic control of the transmit power according to the proximity of the human body within a certain distance from the WPT system. For the initial design, the EM field simulation is carried out using the HFSS 3-D EM simulator. The initial regions around the system are set up according to the EM field simulation results and the human exposure guideline of the 1998 International Commission on Non-Ionizing Radiation Protection (ICNIRP). A WPT system is designed and implemented using the magnetic resonance in order to measure the EM field and confirm the final scheme. The system is operated at 1.8-MHz band to charge a 24-V 40-Ah lead-acid battery embedded in a docent robot. A laser sensor is also used to detect the proximity of the human body. Two communication schemes are used for automatic wireless charging and power control scheme. By the EM field measurement results of the WPT system, the power control scheme is finally confirmed. The performance measurement with a final scheme shows that the EM field is adaptively reduced to less than the guideline value depending on the proximity of the human body.

Nakhaeinia, D., Laferriere, P., Payeur, P., Laganiere, R. 2015. "Safe Close-Proximity and Physical Human-Robot Interaction Using Industrial Robots." *Proceedings -2015 12th Conference on Computer and Robot Vision, CRV* 2015, art. no. 7158345, 237-244.

***[physical; functionality]***

ABSTRACT: Industrial robots have been employed worldwide in the manufacturing sector for performing tasks quickly, repeatedly and accurately in relatively static environments for over 30 years. In recent years, close physical interaction between industrial robots and human operators has attracted researchers' attention and encouraged a number of technological innovations to turn these robots into human-robot platforms. In this work a specially designed compliant wrist is developed to support dexterous robotic interaction with live proximity and contact feedback. The compliant wrist incorporates a level of compliance into an initially non-compliant manipulator robot which allows the robot to dynamically adapt to the surfaces it approaches or touches. Furthermore, to facilitate human-robot interactions, the robot must be able to adapt its behaviour to the human partner. Therefore, a real-time path planning method is developed to generate online motion, adapt the robot to dynamic changes in the environment and ensure smooth interactions. The performance of the proposed method is demonstrated through experimental results on a CRS-F3 manipulator.

Escaida Navarro, S., Hein, B., Wörn, H. 2015. "Capacitive tactile proximity sensing: From signal processing to applications in manipulation and safe human-robot interaction." *Soft Robotics: Transferring Theory to Application*, 7.

***[physical; functionality]***

ABSTRACT: Recently we have shown developments on capacitive tactile proximity sensors (CTPS) and their applications. In this work we give an overview of these developments and put them into a more general perspective, emphasizing what the common grounds are for the different applications, i.e., preshaping and grasping, haptic exploration as well as collision avoidance and safe human-robot interaction. We discuss issues related to signal processing and the design of a smart skin for the robot arm and its end-effector. On a higher level we discuss the concept of proximity servoing and its use for the above mentioned applications.

Garcia Ricardez, G.A., Yamaguchi, A., Takamatsu, J., Ogasawara, T. 2015. "Asymmetric Velocity Moderation for human-safe robot control." *Advanced Robotics*, 29(17): 1111-1125.

***[physical; functionality]***

ABSTRACT: With the increasing physical proximity of human-robot interaction, ensuring that robots do not harm surrounding humans has become crucial. Therefore, we propose asymmetric velocity moderation as a low-level controller for robotic systems to enforce human-safe motions. While our method prioritizes human safety, it also maintains the robots efficiency. Our proposed method restricts the robots speed according to (1) the displacement vector between human and robot, and (2) the robots velocity vector. That is to say, both the distance and the relative direction of movement are taken into account to restrict the robots motion. Through real-robot and simulation experiments using simplified HRI scenarios and dangerous situations, we demonstrate that our method is able to maintain the robots efficiency without undermining human safety.

Lasota, P.A., Shah, J.A. 2015. "Analyzing the effects of human-aware motion planning on close-proximity human-robot collaboration." *Human Factors*, 57(1): 21-33.

***[physical; functionality; user acceptance]***

ABSTRACT: Objective: The objective of this work was to examine human response to motion-level robot adaptation to determine its effect on team fluency, human satisfaction, and perceived safety and comfort. Background: The evaluation of human response to adaptive robotic assistants has been limited, particularly in the realm of motion-level adaptation. The lack of true human-in-the-loop evaluation has made it impossible to determine whether such adaptation would lead to efficient and satisfying human-robot interaction. Method: We conducted an experiment in which participants worked with a robot to perform a collaborative task. Participants worked with an adaptive robot incorporating human-aware motion planning and with a baseline robot using shortest-path motions. Team fluency was evaluated through a set of quantitative metrics, and human satisfaction and perceived safety and comfort were evaluated through questionnaires. Results: When working with the adaptive robot, participants completed the task 5.57% faster, with 19.9% more concurrent motion, 2.96% less human idle time, 17.3% less robot idle time, and a 15.1% greater separation distance. Questionnaire responses indicated that participants felt safer and more comfortable when working with an adaptive robot and were more satisfied with it as a teammate than with the standard robot. Conclusion: People respond well to motion-level robot adaptation, and significant benefits can be achieved from its use in terms of both human-robot team fluency and human worker satisfaction. Application: Our conclusion supports the development of technologies that could be used to implement human-aware motion planning in collaborative robots and the use of this technique for close-proximity human-robot collaboration.

Szafir, D., Mutlu, B., Fong, T. 2015. "Communicating Directionality in Flying Robots." *ACM/IEEE International Conference on Human-Robot Interaction*, 2015-March, 19-26.

***[physical; functionality; user acceptance]***

ABSTRACT: Small flying robots represent a rapidly emerging family of robotic technologies with aerial capabilities that enable unique forms of assistance in a variety of collaborative tasks. Such tasks will necessitate interaction with humans in close proximity, requiring that designers consider human perceptions regarding robots flying and acting within human environments. We explore the design space regarding explicit robot communication of flight intentions to nearby viewers. We apply design constraints to robot flight behaviors, using biological and airplane flight as inspiration, and develop a set of signaling mechanisms for visually communicating directionality while operating under such constraints. We implement our designs on two commercial flyers, requiring little modification to the base platforms, and evaluate each signaling mechanism, as well as a no-signaling baseline, in a user study in which participants were asked to predict robot intent. We found that three of our designs significantly improved viewer response time and accuracy over the baseline and that the form of the signal offered tradeoffs in precision, generalizability, and perceived robot usability.

Mustafa, S.K., Lim, W.B., Yang, G., Yeo, S.H., Lin, W., Agrawal, S.K. 2015. "Cable-driven robots." *HandBook of Manufacturing Engineering and Technology*, 2169-2228.

***[physical; functionality]***

ABSTRACT: Cable-driven robots (CDRs) are a special class of parallel mechanisms in which the end-effector is actuated by cables, instead of rigid-linked actuators. They are characterized by lightweight structures with low moving inertia and large workspace, due to the location of the cable winching actuators at the fixed base of the structure, and

thereby reducing the mass and inertia of the moving platform. CDRs also possess an intrinsically safe feature due to the cables' flexibility, which allows CDRs to provide safe manipulation in close proximity to their human counterparts. This chapter will highlight the various research endeavors in the performance analysis of CDRs such as force-closure analysis, stiffness analysis, workspace analysis, and cable tension planning. Several case studies will also be presented to serve as illustrations on the application of the proposed performance analysis tools.

Herman, M., Fischer, V., Gindele, T., Burgard, W. 2015. "Inverse reinforcement learning of behavioral models for online-adapting navigation strategies." *Proceedings - IEEE International Conference on Robotics and Automation*, 2015-June (June), art. no. 7139642, 3215-3222.

***[physical; functionality; user acceptance]***

ABSTRACT: To increase the acceptance of autonomous systems in populated environments, it is indispensable to teach them social behavior. We would expect a social robot, which plans its motions among humans, to consider both the social acceptability of its behavior as well as task constraints, such as time limits. These requirements are often contradictory and therefore resulting in a trade-off. For example, a robot has to decide whether it is more important to quickly achieve its goal or to comply with social conventions, such as the proximity to humans, i.e., the robot has to react adaptively to task-specific priorities. In this paper, we present a method for priority-adaptive navigation of mobile autonomous systems, which optimizes the social acceptability of the behavior while meeting task constraints. We learn acceptability-dependent behavioral models from human demonstrations by using maximum entropy (MaxEnt) inverse reinforcement learning (IRL). These models are generative and describe the learned stochastic behavior. We choose the optimum behavioral model by maximizing the social acceptability under constraints on expected time-limits and reliabilities. This approach is evaluated in the context of driving behaviors based on the highway scenario of Levine et al. [1].

Rezazadegan, F., Geng, J., Ghirardi, M., Menga, G., Murè, S., Camuncoli, G., Demichela, M. 2015. "Risked-based design for the physical human-robot interaction (pHRI): An overview." *Chemical Engineering Transactions*, 43: 1249-1254.

***[physical; functionality]***

ABSTRACT: Collaboration and sharing workspace between human and robots has turned into a challenge that has to be taken into account in many industrial domains, including the process industry. In this study, literature related to risk-based safety system design is reviewed as well as relevant research of control design for safety issues. The paper mainly presents two key contributions. 1) planning for safety: risk-based safety analysis methodologies are reviewed to analyze current methods for identifying the potential risks caused by abnormal operation and failures in the human-robot interaction environment. The risk assessment methodologies are including not only functional risk analysis, but also **human reliability** analysis. The results from risk evaluation will help making HRI safety strategies which are series decision makings to support the further engineering design of a pHRI safety system. 2) Control design system for achieving safety: to reach a comprehensive safety system design and limit accidents in the human-robot interaction environment, four scenarios are taken into consideration: proximity detection, collision avoidance, docking and compliance control. Current control techniques in each domain to guarantee the safety of system are reviewed. Finally, most common used methods in the above-mentioned areas are introduced and their performance is discussed.

Fischer, A., Rommel, S., Verl, A. 2015. "3d printed objects and components enabling next generation of true soft robotics." *Soft Robotics: Transferring Theory to Application*, 198-208.

***[physical; functionality]***

ABSTRACT: Soft robotics in the content of true softness, with regards to components, parts, or the complete robot, are the next step in the development of tools for humans, especially when used in close proximity. Considering the fact that robots are a multilevel extension of the human body, and that their main purpose should be to help humans perform tasks, then focusing on the development of softmaterials, and product design options allowing for flexibility and softness by design is necessary, for the next development level of the tool "robot". Using additive manufacturing in combination with new materials, design methods, and biomimicry /biomimetics is a key in that development, but also very challenging due to the multi-level complexity. An understanding of the real world tasks required to be performed, and abstracting this information into new applications and robotic designs in the combination mentioned above, is shown in the chapter, functioning as a basis and overview of the state-of-the-art.

Weber, A. 2015. "Collaborative robots enter the mainstream." *Assembly*, 58(9).

***[physical; functionality]***

ABSTRACT: Collaborative robots are next-generation machines equipped with state-of-the-art sensor technology that allows robots to operate side-by-side with humans. Unlike traditional industrial robots, collaborative robots are lightweight, flexible and can easily be moved and reprogrammed to solve new tasks. The new types of robots emerging today are capable of simultaneous collaboration, in which two or more parties are performing separate tasks on a shared work-piece at the same time. Almost one-half of manufacturers in the transportation equipment sector, which includes automakers and suppliers, plan to invest in collaborative robots. Other industries eager to allow humans and robots to work in close proximity on assembly lines include computer and electronic products and contract manufacturers. ABB unveiled a dual-arm collaborative robot called YUMI. It features a magnesium skeleton covered with a floating plastic casing wrapped in soft padding to absorb impacts. Before the collaborative robot market can really take off, manufacturers must continue addressing risk assessment issues and developing industry-wide safety standards, such as ANSI R15.06:2012, ISO 10218:2011 and RIA TR R15.306:2014.

Walter, M.R., Antone, M., Chuangsuwanich, E., Correa, A., Davis, R., Fletcher, L., Frazzoli, E., Friedman, Y., Glass, J., How, J.P., Jeon, J.H., Karaman, S., Luders, B., Roy, N., Tellex, S., Teller, S. 2015. "A Situationally aware voice-commandable robotic forklift working alongside people in unstructured outdoor environments." *Journal of Field Robotics*, 32(4): 590-628.

***[physical; functionality; user acceptance]***

ABSTRACT: One long-standing challenge in robotics is the realization of mobile autonomous robots able to operate safely in human workplaces, and be accepted by the human occupants. We describe the development of a multiton robotic forklift intended to operate alongside people and vehicles, handling palletized materials within existing, active outdoor storage facilities. The system has four novel characteristics. The first is a multimodal interface that allows users to efficiently convey task-level commands to the robot using a combination of pen-based gestures and natural language speech. These tasks include the manipulation, transport, and placement of palletized cargo within dynamic, human-occupied warehouses. The second is the robot's ability to learn the visual identity of an object from a single user-provided example and use the learned model to reliably and persistently detect objects despite significant spatial and temporal excursions. The third is a reliance on local sensing that allows the robot to handle variable palletized cargo and navigate within dynamic, minimally prepared environments without a global positioning system. The fourth concerns the robot's operation in close proximity to people, including its human supervisor, pedestrians who may cross or block its path, moving vehicles, and forklift operators who may climb inside the robot and operate it manually. This is made possible by interaction mechanisms that facilitate safe, effective operation around people. This paper provides a comprehensive description of the system's architecture and implementation, indicating how real-world operational requirements motivated key design choices. We offer qualitative and quantitative analyses of the robot operating in real settings and discuss the lessons learned from our effort.

van der Vorm, J., Nugent, R., O'Sullivan, L. 2015. "Safety and Risk Management in Designing for the Lifecycle of an Exoskeleton: A Novel Process Developed in the Robo-Mate Project." *Procedia Manufacturing*, 3: 1410-1417.

***[physical; functionality]***

ABSTRACT: Even in our modern and high-tech manufacturing industry, it is often difficult to automate industrial processes which necessities the involvement of human workers. Subsequently, workers are exposed to factors that increase their risk of injury, particular experiencing Musculoskeletal Disorders (MSDs). In addition to contributing to workplace absenteeism and disability rates, injured workers have a negative impact on job productivity and quality. While earlier research and development of exoskeletons is targeted at military and rehabilitation, there is a shifting of interest to target industrial settings. Targeting industrial environments, the Robo-Mate consortium aims to develop a lightweight, flexible, easy-to-wear, easy-to-maneuver, and intelligent exoskeleton that augments the user's personal capabilities while accommodating their physical limitations. The safety of industrial worker exoskeletons is an emerging topic in legislation and standardization. Guidance from standards is only partially possible since no standard exists for industrial exoskeleton technology. This presents a challenging task since an exoskeleton combines technological characteristics of robots (collaborative), machines and appliances, and is used in proximity to and has close contact with the human body. The innovative character of the Robo-Mate technology requires a multidisciplinary approach to the identification of risk and usability while addressing both product safety and workplace safety. This requires a novel safety management approach that governs the life cycle of this new kind of product. This paper will discuss the risk management approach the Robo-Mate project developed and the resulting leading scenarios.

Robinette, P., Wagner, A.R., Howard, A.M. 2014. "Assessment of robot guidance modalities conveying instructions to humans in emergency situations." *Proceedings - IEEE International Workshop on Robot and Human Interactive Communication*, 2014-October (October), art. no. 6926390, 1043-1049.

***[physical; functionality]***

ABSTRACT: Motivated by the desire to mitigate human casualties in emergency situations, this paper explores various guidance modalities provided by a robotic platform for instructing humans to safely evacuate during an emergency. We focus on physical modifications of the robot, which enables visual guidance instructions, since auditory guidance instructions pose potential problems in a noisy emergency environment. Robotic platforms can convey visual guidance instructions through motion, static signs, dynamic signs, and gestures using single or multiple arms. In this paper, we discuss the different guidance modalities instantiated by different physical platform constructs and assess the abilities of the platforms to convey information related to evacuation. Human-robot interaction studies with 192 participants show that participants were able to understand the information conveyed by the various robotic constructs in 75.8% of cases when using dynamic signs with multi-arm gestures, as opposed to 18.0% when using static signs for visual guidance. Of interest to note is that dynamic signs had equivalent performance to single-arm gestures overall but drastically different performances at the two distance levels tested. Based on these studies, we conclude that dynamic signs are important for information conveyance when the robot is in close proximity to the human but multi-arm gestures are necessary when information must be conveyed across a greater distance.

Morato, C., Kaipa, K.N., Zhao, B., Gupta, S.K. 2014. "Toward safe human robot collaboration by using multiple kinects based real-time human tracking." *Journal of Computing and Information Science in Engineering*, 14(1): art. no. 011006.

***[physical; functionality]***

ABSTRACT: We present a multiple Kinects based exteroceptive sensing framework to achieve safe human-robot collaboration during assembly tasks. Our approach is mainly based on a real-time replication of the human and robot movements inside a physics-based simulation of the work cell. This enables the evaluation of the human-robot separation in a 3D Euclidean space, which can be used to generate safe motion goals for the robot. For this purpose, we develop an N-Kinect system to build an explicit model of the human and a roll-out strategy, in which we forward-simulate the robot's trajectory into the near future. Now, we use a precollision strategy that allows a human to operate in close proximity with the robot, while pausing the robot's motion whenever an imminent collision between the human model and any part of the robot is detected. Whereas most previous range based methods analyzed the physical separation based on depth data pertaining to 2D projections of robot and human, our approach evaluates the separation in a 3D space based on an explicit human model and a forward physical simulation of the robot. Real-time behavior (≈ 30 Hz) observed during experiments with a 5 DOF articulated robot and a human safely collaborating to perform an assembly task validate our approach.

Henkel, Z., Bethel, C.L., Murphy, R.R., Srinivasan, V. 2014. "Evaluation of proxemic scaling functions for social robotics." *IEEE Transactions on Human-Machine Systems*, 44 (3): 374-385, art. no. 6746063.

***[physical; functionality; user acceptance]***

ABSTRACT: This paper introduces and empirically evaluates two scaling functions to alter a robot's physical movements based on proximity to a human. Previous research has focused on individual aspects of proxemics, like the appropriate distance to maintain from a human, but has not explored autonomous methods to adapt robot behavior as proximity changes. This paper proposes that robots in a social role should modify their behavior using a continuous function mapped to proximity. The method developed calculates a gain value from proximity readings, which is used to shape the execution of active behaviors on the robot. In order to identify the effects of different mappings from proximity to gain value, two different scaling functions were implemented on an affective search and rescue robot. The findings from a 72 participant study, in a high-fidelity mock disaster site, are examined with attention given to a new measure to determine proxemic awareness. The results indicated that for attributes of intelligence, likability, proxemic awareness, and submissiveness, a logarithmic-based scaling function is preferred over a linear-based scaling function, and over no scaling function. In areas of participant comfort and participant stress, the results indicated both logarithmic and linear scaling functions were preferred to no scaling.

Lasota, P.A., Rossano, G.F., Shah, J.A. 2014. "Toward safe close-proximity human-robot interaction with standard industrial robots." *IEEE International Conference on Automation Science and Engineering*, 2014-January, art. no. 6899348, 339-344.

***[physical; functionality]***

ABSTRACT: Allowing humans and robots to interact in close proximity to each other has great potential for increasing the effectiveness of human-robot teams across a large variety of domains. However, as we move toward enabling humans and robots to interact at ever-decreasing distances of separation, effective safety technologies must also be developed. While new, inherently human-safe robot designs have been established, millions of industrial robots are already deployed worldwide, which makes it attractive to develop technologies that can turn these standard industrial robots into human-safe platforms. In this work, we present a real-time safety system capable of allowing safe human-robot interaction at very low distances of separation, without the need for robot hardware modification or replacement. By leveraging known robot joint angle values and accurate measurements of human positioning in the workspace, we can achieve precise robot speed adjustment by utilizing real-time measurements of separation distance. This, in turn, allows for collision prevention in a manner comfortable for the human user.We demonstrate our system achieves latencies below 9.64 ms with 95% probability, 11.10 ms with 99% probability, and 14.08 ms with 99.99% probability, resulting in robust real-time performance.

Szafir, D.J. 2014. "Human interaction with assistive free-flyers." *Conference on Human Factors in Computing Systems - Proceedings*, 347-350.

***[physical; functionality; user acceptance]***

ABSTRACT: Small aerial robots represent a novel platform that appears uniquely suited to assist humans in exploratory, surveillance, inspection, and telepresence tasks across a variety of domains. Such tasks will require "assistive free-flyers" (AFFs) to effectively interact and collaborate with humans in close proximity. For AFFs to successfully work and collaborate with colocated humans, designers must account for human perceptions of AFFs acting within human environments. Humans, who do not generally interact with free-flying physical embodiments, may not feel safe or may have trouble working near AFFs given their functional morphology and unconstrained, three-dimensional flight capabilities. The goal of my dissertation is to investigate the design space of proximal AFF interactions, specifically by examining how AFFs might effectively communicate with colocated humans as well as gain an understanding regarding the ecological fit of AFFs within human workspaces. This research takes a two-phase approach towards examining proximal AFF interactions: (1) examining AFF communication mechanisms including motion, body language, and electronic signals, and (2) developing an understanding of user mental models and social expectations for flying robots, including an examination of spontaneous AFF interactions. My work will inform the design of future AFF systems and aid in understandings regarding how AFFs can reach their potential as collaborators within human environments.

Park, K.J., Won, M. 2014. "People tracking and accompanying algorithm for mobile robot using kinect sensor and extended Kalman filter." *Transactions of the Korean Society of Mechanical Engineers*, A, 38(4): 345-354.

***[physical; functionality]***

ABSTRACT: In this paper, we propose a real-time algorithm for estimating the relative position and velocity of a person with respect to a robot using a Kinect sensor and an extended Kalman filter (EKF). Additionally, we propose an algorithm for controlling the robot in the proximity of a person in a variety of modes. The algorithm detects the head and shoulder regions of the person using a histogram of oriented gradients (HOG) and a support vector machine (SVM). The EKF algorithm estimates the relative positions and velocities of the person with respect to the robot using data acquired by a Kinect sensor. We tested the various modes of proximity movement for a human in indoor situations. The accuracy of the algorithm was verified using a motion capture system.

Robla, S., Llata, J.R., Torre-Ferrero, C., Sarabia, E.G., Becerra, V., Perez-Oria, J. 2014. "Visual sensor fusion for active security in robotic industrial environments." *Eurasip Journal on Advances in Signal Processing*, 2014 (1), art. no. 88.

***[physical; functionality]***

ABSTRACT: This work presents a method of information fusion involving data captured by both a standard charge-coupled device (CCD) camera and a time-of-flight (ToF) camera to be used in the detection of the proximity between a manipulator robot and a human. Both cameras are assumed to be located above the work area of an industrial robot.

The fusion of colour images and time-of-flight information makes it possible to know the 3D localization of objects with respect to a world coordinate system. At the same time, this allows to know their colour information. Considering that ToF information given by the range camera contains innacuracies including distance error, border error, and pixel saturation, some corrections over the ToF information are proposed and developed to improve the results. The proposed fusion method uses the calibration parameters of both cameras to reproject 3D ToF points, expressed in a common coordinate system for both cameras and a robot arm, in 2D colour images. In addition to this, using the 3D information, the motion detection in a robot industrial environment is achieved, and the fusion of information is applied to the foreground objects previously detected. This combination of information results in a matrix that links colour and 3D information, giving the possibility of characterising the object by its colour in addition to its 3D localisation. Further development of these methods will make it possible to identify objects and their position in the real world and to use this information to prevent possible collisions between the robot and such objects.

Duncan, B.A., Murphy, R.R. 2013. "Comfortable approach distance with small Unmanned Aerial Vehicles." *Proceedings - IEEE International Workshop on Robot and Human Interactive Communication*, art. no. 6628409, 786-792.

***[physical; functionality; user acceptance]***

ABSTRACT: This paper presents the first known human-subject study of comfortable approach distance and height for human interaction with a small unmanned aerial vehicle (sUAV), finding no conclusive difference in comfort with a sUAV approaching a human at above head height or below head height. Understanding the amount, if any, of discomfort introduced by a sUAV flying in close proximity to a human is critical for law enforcement, crowd control, entertainment, or flying personal assistants. Previous work has focused on how humans interact with each other or with unmanned ground vehicles, and the experimental methods typically rely on the human participant to consciously express distress. The approach taken was to duplicate the experimental set up in human proxemics studies, while adding psychophysiological sensing, under the hypothesis that human-robot interaction will mirror human-human interaction. The 16 participant, within-subjects experiment did not confirm this hypothesis. Instead a sUAV above height of a 'tall' person in human experiments (2.13 m) did not produce statistically different heart rate variability nor cause the participant to stop the robot further away than for a sUAV at a 'short' height (1.52 m). The lack of effect may be due to two possible confounds: i) duplicating prior human proxemics experiments did not capture how a sUAV would likely move or interact and ii) telling the participants that the robot could not hurt them. Despite possible confounding, the results raise the question of whether human-human psychological and physical distancing behavior transfers to human-aerial robot interactions.

Navarro, S.E., Marufo, M., Ding, Y., Puls, S., Goger, D., Hein, B., Worn, H. 2013. "Methods for safe human-robot-interaction using capacitive tactile proximity sensors." *IEEE International Conference on Intelligent Robots and Systems*, art. no. 6696495, 1149-1154.

***[physical; functionality]***

ABSTRACT: In this paper we base upon capacitive tactile proximity sensor modules developed in a previous work to demonstrate applications for safe human-robot-interaction. Arranged as a matrix, the modules can be used to model events in the near proximity of the robot surface, closing the near field perception gap in robotics. The central application investigated here is object tracking. Several results are shown: the tracking of two human hands as well as the handling of occlusions and the prediction of collision for object trajectories. These results are important for novel pretouch- and touch-based human-robot interaction strategies and for assessing and implementing safety capabilities with these sensor systems.

Schlegl, T., Kroger, T., Gaschler, A., Khatib, O., Zangl, H. 2013. "Virtual whiskers - Highly responsive robot collision avoidance." *IEEE International Conference on Intelligent Robots and Systems*, art. no. 6697134, 5373-5379.

***[physical; functionality]***

ABSTRACT: All mammals but humans use whiskers in order to rapidly acquire information about objects in the vicinity of the head. Collisions of the head and objects can be avoided as the contact point is moved from the body surface to the whiskers. Such a behavior is also highly desirable during many robot tasks such as for human-robot interaction. Using novel capacitive proximity sensors, robots sense when they approach a human (or an object) and react before they actually collide with it. We propose a sensor and control concept that mimics the behavior of whiskers by means of capacitive sensors. Major advantages are the absence of physical whiskers, the absence of blind spots and a very short response time. The sensors are flexible and thin so that they feature skin-like properties and can be attached

to various robotic link and joint shapes. In comparison to capacitive proximity sensors, the proposed virtual whiskers offer better sensitivity towards small conductive as well as non conductive objects. Equipped with the new proximity sensors, a seven-joint robot for humanrobot interaction tasks shows the efficiency and responsiveness of our concept.

Mainprice, J., Berenson, D. 2013. "Human-robot collaborative manipulation planning using early prediction of human motion." *IEEE International Conference on Intelligent Robots and Systems*, art. no. 6696368, 299-306.

***[physical; functionality]***

ABSTRACT: In this paper we present a framework that allows a human and a robot to perform simultaneous manipulation tasks safely in close proximity. The proposed framework is based on early prediction of the human's motion. The prediction system, which builds on previous work in the area of gesture recognition, generates a prediction of human workspace occupancy by computing the swept volume of learned human motion trajectories. The motion planner then plans robot trajectories that minimize a penetration cost in the human workspace occupancy while interleaving planning and execution. Multiple plans are computed in parallel, one for each robot task available at the current time, and the trajectory with the least cost is selected for execution. We test our framework in simulation using recorded human motions and a simulated PR2 robot. Our results show that our framework enables the robot to avoid the human while still accomplishing the robot's task, even in cases where the initial prediction of the human's motion is incorrect. We also show that taking into account the predicted human workspace occupancy in the robot's motion planner leads to safer and more efficient interactions between the user and the robot than only considering the human's current configuration.

Ceriani, N.M., Avanzini, G.B., Zanchettin, A.M., Bascetta, L., Rocco, P. 2013. "Optimal placement of spots in distributed proximity sensors for safe human-robot interaction." *Proceedings - IEEE International Conference on Robotics and Automation*, art. no. 6631420, 5858-5863.

***[physical; functionality]***

ABSTRACT: Industrial robots are today separated from human workers by means of safety barriers, that protect humans from the risk of collisions. This separation has a clear negative influence on diffusion of robotic technology in shopfloors. On the other hand the removal of protective barriers gives rise to safety issues, that can be addressed with a combination of approaches, including sensor based reactive control. In this paper a distributed proximity sensor, to be mounted on the links of the manipulator, is presented. The optimal placement of the spots of such sensor is discussed, taking into account detection capabilities and safety enhancement. Experiments developed on an ABB IRB 140 robot using off-the-shelf infrared distance sensors as spots are presented.

Han, S., Mok, A.K., Meng, J., Wei, Y.-H., Huang, P.-C., Leng, Q., Zhu, X., Sentis, L., Kim, K.S., Miikkulainen, R. 2013. "Architecture of a cyberphysical avatar." *2013 ACM/IEEE International Conference on Cyber-Physical Systems*, ICCPS 2013, art. no. 6604013, 189-198.

***[physical; functionality]***

ABSTRACT: This paper introduces the concept of a cyberphysical avatar which is defined to be a semi-autonomous robotic system that adjusts to an unstructured environment and performs physical tasks subject to critical timing constraints while under human supervision. Cyberphysi-cal avatar integrates the recent advance in three technologies: body-compliant control in robotics, neuroevolution in machine learning and QoS guarantees in real-time communication. Body-compliant control is essential for operator safety since cyberphysical avatars perform cooperative tasks in close proximity to humans. Neuroevolution technique is essential for 'programming' cyberphysical avatars inasmuch as they are to be used by non-experts for a large array of tasks, some unforeseen, in an unstructured environment. QoS-guaranteed real-time communication is essential to provide predictable, bounded-time response in human-avatar interaction. By integrating these technologies, we have built a prototype cyberphysical avatar testbed.

Schmidt, B., Wang, L. 2013. "Contact-less and programming-less human-robot collaboration." *Procedia CIRP*, 7: 545-550.

***[physical; functionality]***

ABSTRACT: In today's manufacturing environment, safe human-robot collaboration is of paramount importance, to improve efficiency and flexibility. Targeting the safety issue, this paper presents an approach for human-robot collaboration in a shared workplace in close proximity, where real data driven 3D model of a robot and multiple depth images of the workplace are used for monitoring and decision-making to perform a task. The strategy for robot control

depends on the current task and the information about the operator's presence and position. A case study of assembly is carried out in a robotic assembly cell with human collaboration. The results show that this approach can be applied in real-world applications such as human-robot collaborative assembly with human operators safeguarded at all time.

Cirillo, A., Cirillo, P., De Maria, G., Natale, C., Pirozzi, S. 2013. "A proximity/contact-force sensor for Human Safety in industrial robot environment." *2013 IEEE/ASME International Conference on Advanced Intelligent Mechatronics: Mechatronics for Human Wellbeing,* AIM 2013, art. no. 6584269, 1272-1277.

***[physical; functionality]***

ABSTRACT: In this paper, a new approach based on a proximity/contact-force sensor to improve the Human Safety in the Human-Robot cooperative tasks is presented. The sensor is able to detect both the presence of a nearby object and the contact pressure exercised by an external object when a collision occurs. The sensor is interfaced with an ABB industrial robot using only the standard control unit; the standard RAPID primitives are used to define the robot task. The task speed is reduced as soon as an obstacle is detected by the proximity sensing element, while, the robot is stopped when a contact occurs, that is detected by a contact-force sensing element.

Lasota, P., Nikolaidis, S., Shah, J. 2013. "Developing an adaptive robotic assistant for close proximity human-robot collaboration in space." *AIAA Infotech at Aerospace (I at A) Conference*.

***[physical; functionality; user acceptance]***

ABSTRACT: In this paper, we present a framework for an adaptive and risk-aware robot motion planning and control, and discuss how such a framework could handle uncertainty in human workers' actions and robot localization. We build on our prior investigation, where we describe how uncertainty in human actions can be modeled using the entropy rate in a Markov Decision Process. We then describe how we can incorporate this model of uncertainty into simulations of a simple collaborative system, involving one human worker and one robotic assistant, to produce risk-aware robot motions. Next, we highlight the diffculties associated with localization uncertainty in a space environment and describe how we can incorporate this uncertainty into an adaptive system as well. Expected advantages of an adaptive system are described, including increases in overall effciency due to reductions in idle time, increases in concurrent motion, faster task execution, as well as subjective improvements in the worker's satisfaction with the assistant and reduced worker stress and fatigue. A pilot experiment designed to evaluate the benefits of introducing risk-aware motion planning is described. It is found that human-robot teams in which the robot utilizes risk-aware motion planning show on average 24% more concurrent motion and execute the task 13% faster, while simultaneously improving safety by having a 19.9% larger mean separation distance between the human and robot workers. Finally, possible future system developments and user studies are discussed.

Huber, J., Straub, J. 2013. "Validating an artificial intelligence human proximity operations system with test cases." *Proceedings of SPIE - The International Society for Optical Engineering,* 8752, art. no. 875206.

***[physical; functionality]***

ABSTRACT: An artificial intelligence-controlled robot (AICR) operating in close proximity to humans poses risk to these humans. Validating the performance of an AICR is an ill posed problem, due to the complexity introduced by the **erratic (noncomputer) actors**. In order to prove the AICR's usefulness, test cases must be generated to simulate the actions of these actors. This paper discusses AICR's performance validation in the context of a common human activity, moving through a crowded corridor, using test cases created by an AI use case producer. This test is a two-dimensional simplification relevant to autonomous UAV navigation in the national airspace.

Rossmann, J., Kaigom, E.G., Atorf, L., Rast, M., Schlette, C. 2013. "A virtual testbed for human-robot interaction." *Proceedings - UKSim 15th International Conference on Computer Modelling and Simulation, UKSim 2013,* art. no. 6527428, 277-282.

***[physical; functionality]***

ABSTRACT: Many research efforts in human-robot interaction (HRI) have so far focused on the mechanical design of intrinsically safe robots, as well as impedance control for tasks in which human and robot will work together. However, comparatively little attention is paid to an approach that ensures safety and permits close HRI while dispensing human with the necessity of physical presence in close proximity to the robot. In this work we acquire real human manipulation gestures using Microsoft's Kinect sensor and project them in realtime into the workspace of a simulated, impedance controlled robot manipulator. This way, we can remotely and therefore safely superimpose

human motion over the robot's dynamic motion, wherever the human operator is located. The simulated robot state is then transferred to the real robot as input, so as to physically perform the intended task. The Virtual Testbed approach might not only be useful for HRI pre-analysis, testing and validation goals but particularly advantageous for telepresence, industrial and hazardous tasks as well as training purposes. Simulation results are provided to show the effectiveness of the approach.

Bogue, R. 2013. "Advances in robot interfacing technologies." *Industrial Robot*, 40(4): 299-304.

***[overview]***

ABSTRACT: Purpose - The purpose of this paper is to provide details of recent developments in human-robot interfacing technologies. Design/methodology/ approach - This paper considers recently developed or emerging technologies which allow humans to interact with robots in novel ways. It first considers inexpensive robots which are simple to programme and which can work alongside humans in a manufacturing environment. It then discusses assistive robots, which aim to help the aged or infirm and finally, the latest progress in controlling robots with the human brain is reported. Findings - This shows that new and improved human-robot interfacing technologies are the topic of a major development effort. Low-cost robots that can readily be commissioned and operated in close proximity to humans are starting to impact the market. Assistive robot technology is progressing due to novel man-machine interfacing techniques and the first instances of quadriplegic patients using their mind to control robots to manipulate object in three-dimensional space is discussed. Originality/value - This paper provides details of significant, recent developments in human-robot interfacing.

Goger, D., Alagi, H., Worn, H. 2013. "Tactile proximity sensors for robotic applications." *Proceedings of the IEEE International Conference on Industrial Technology*, art. no. 6505804, 978-983.

***[physical; functionality]***

ABSTRACT: In this paper tactile proximity sensors for close human-robot interactions based on a previously developed sensor are introduced. Using the same sensing technology, we developed large area tactile proximity sensors as a robot skin and small sensors which we have integrated in an anthropomorphic robot hand. Tactile sensing in the area of robotics for close human-interaction is still a challenging task. In the most cases tactile sensors need to be supported by other sensor modalities to perceive the robots environment before contacts occur. To overcome this issue we developed tactile proximity sensors for robot surfaces and for robot grippers. Both sensors, their behaviour and a model of the tactile sensor will be discussed in this paper.

Hwang, S.K., Hwang, H.Y. 2013. "Development of a tactile sensing system using piezoelectric robot skin materials." *Smart Materials and Structures*, 22 (5), art. no. 055004.

***[physical; functionality]***

ABSTRACT: Since service robots perform their functions in close proximity to humans, they are much more likely than other types of robot to come into contact with humans. This means that safety regarding robot-human interaction is of particular concern and requires investigation. Existing tactile sensing methods are very effective at detecting external dangerous loadings; however, until now, they have been very expensive. Recently, a new type of self-sensing tactile technology for service robots has been introduced, which harnesses the piezoelectric effect of several robot skin materials. In these kinds of system, relatively cheap materials are used as sensors themselves. In this research, a robot system with a self-sensing tactile technology was developed using piezoelectric robot skin materials. The test results indicate that this type of system is appropriate for application to service robots.

Morato, C., Kaipa, K., Zhao, B., Gupta, S.K. 2013. "Safe human robot interaction by using exteroceptive sensing based human modeling." *Proceedings of the ASME Design Engineering Technical Conference*, 2 A, art. no. V02AT02A073.

***[physical; functionality]***

ABSTRACT: In this paper, we propose an exteroceptive sensing based framework to achieve safe human-robot interaction during shared tasks. Our approach allows a human to operate in close proximity with the robot, while pausing the robot's motion whenever a collision between the human and the robot is imminent. The human's presence is sensed by a N-range sensor based system, which consists of multiple range sensors mounted at various points on the periphery of the work cell. Each range sensor is based on a Microsoft Kinect sensor. Each sensor observes the human and outputs a 20 DOF human model. Positional data of these models are fused together to generate a refined human model. Next, the robot and the human model are approximated by dynamic bounding spheres and the robot's motion

is controlled by tracking the collisions between these spheres. Whereas most previous exteroceptive methods relied on depth data from camera images, our approach is one of the first successful attempts to build an explicit human model online and use it to evaluate human-robot interference. Real-time behavior observed during experiments with a 5 DOF robot and a human safely performing shared assembly tasks validate our approach.

Norouzzadeh, S., Lorenz, T., Hirche, S. 2012. "Towards safe physical human-robot interaction: An online optimal control scheme." *Proceedings - IEEE International Workshop on Robot and Human Interactive Communication,* art. no. 6343801, 503-508.

***[physical; functionality; user acceptance]***

ABSTRACT: Operating in the proximity of humans has been a long-term challenge in robotics research. To achieve this objective, one of the main issues is to ensure safe and comfortable physical human-robot interaction (pHRI). In this paper, we tackle the safety problem at the control level. To ensure operation is within perceived safe zone, we use model predictive control, which finds the optimal control signal online, while imposing predefined safety constraints on the robotic system. The strength of this method lies in allowing the system to perform close to, or at the edge of the constraints' boundaries. In contrast to other works we consider here perceived safety; the constraints for perceived safety are derived in a competitive pHRI experiment. The perceived safety and comfort of the proposed approach is then evaluated with a second, game-like pHRI experiment.

Shackleford, W., Norcross, R., Marvel, J., Szabo, S. 2012. "Integrating occlusion monitoring into human tracking for robot speed and separation monitoring." *Performance Metrics for Intelligent Systems (PerMIS) Workshop*, 168-173.

***[physical; functionality]***

ABSTRACT: Collaborative robots are used in close proximity to humans to perfonn a variety of tasks, while more traditional industrial robots are required to be stopped whenever a human enters their workvolumes. Instead of relying on physical barriers or merely detecting when someone enters the area, the collaborative system must monitor the position of every person who enters the work space in time for the robot to react. The TC 184/SC 2/WG 3 Industrial Safety group within the International Organization for Standard(ISO) is developing the standards to help ensure collaborative robots operate safely. [1][2] Collaborative robots require sophisticated sensing technologies that must handle dynamic interactions between the robot and the human. One potential safety risk is the occlusion of a safety sensor's field of view due to placement of objects or the movement of people in front of a safety sensor. In this situation the robot could shut down as soon as even a single sensor was partially occluded. Unfortunately this could greatly diminish the extent to which the robot could work collaboratively. In this paper we examine how a human tracking system using multiple laser line scanners [31was adapted to work with a robot Speed and Separation Monitoring (SSM) safety system and further modified to include occlusion monitoring.

Henkel, Z., Murphy, R., Bethel, C.L., Srinivasan, V. 2012. "A proxemic-based HRI testbed." Performance Metrics for Intelligent Systems (PerMIS) Workshop, 75-81.

***[physical & social; functionality]***

ABSTRACT: This paper describes a novel, low cost HRI testbed for the evaluation of robot movement, gaze, audio style, and media content as a function of proximity. Numerous human-robot interaction studies have established the importance of proxemics in establishing trust and social consonance, but each has used a robot capable of only some component, for example gaze but not audio style. The Survivor Buddy proxemics testbed is expected to serve as blueprint for duplication or inspire the creation of other robots, enabling researchers to rapidly develop and test new schemes of proxemic based control. It is a small, four-degree of freedom, multi-media "head" costing approximately $2,000 USD to build and can be mounted on other robots or used independently. To enable proxemics support, Survivor Buddy can be coupled with either a dedicated range sensor or distance can be extracted from the embedded camera using computer vision. The paper presents a sample demonstration of proxemic competence for Survivor Buddy mounted on a search and rescue robot following the victim management scenario developed by Bethel and Murphy.

Martínez-García, E.A., Gallegos, E., Jaichandar, K.S. 2012. "Telepresence by deploying an avatar robot with brain-robot interfacing." *Proceedings of the 2012 7th IEEE Conference on Industrial Electronics and Applications*, ICIEA 2012, art. no. 6360713, 144-149.

***[physical; functionality]***

ABSTRACT: This manuscript describes in detail the development of an avatar robot for human companion tasks. The mobile robot embodies a remote human to have communications with other human while walking in close proximity to the mobile robot. The robot takes the role of a physical interface to deploy mobility, sensors and telepresence with personification throughout some behaviours of the remote human. Behaviours are conveyed through commands from a mouse/joystick and a EEG-based BRI. We discuss the aim of this work, as well as the tele-system architecture. Both the mobile robot featuring avatar capabilities, and the BRI are discussed. The system concept is also described and we report implementations and experimental results.

Jantsch, M., Wittmeier, S., Dalamagkidis, K., Knoll, A. 2012. "Computed muscle control for an anthropomimetic elbow joint." *IEEE International Conference on Intelligent Robots and Systems*, art. no. 6385851, 2192-2197.

***[physical; functionality]***

ABSTRACT: The soft robotics approach is widely considered to enable human-friendly robots which are able to work in our future homes and factories. Furthermore, achieving the smooth and natural movements of humans has become a hot topic in robotics, especially when robots are supposed to work in close proximity to humans. The anthropomimetic principle aims at mimicking not only the outside but also the inner mechanisms of the human body in humanoid robots. However, for this class of robots there exist as yet no scalable controllers that might make it possible to control a full body, or even several joints. A very similar problem is ongoing research in biomechanics which is the computation of muscle excitation patterns for coordinated movements. For this purpose, biomechanicists have developed computed muscle control which has proven a very scalable technique. In this paper, we demonstrate the adaptation of computed muscle control for a tendon-driven robot, comparing different methods for obtaining the muscle kinematics, as well as different low-level controllers. Results are shown for the implementation on a distributed control architecture and a single revolute elbow joint.

McGhan, C.L.R., Atkins, E.M. 2012. "Towards guaranteeing safe and efficient human-robot collaboration using human intent prediction." *AIAA SPACE Conference and Exposition* 2012.

***[physical; functionality]***

ABSTRACT: This paper describes an autonomous framework for determining a robotic manipulator's optimal actions in real-time when interacting in close physical proximity to a human in a shared workspace environment. This framework allows the robot to purposefully choose to avoid physical and mental conflicts with a human companion while each agent performs tasks to complete their respective, separately-assigned goals. We pose scenarios in which the human does not need to divert attention to internally model the robot's behavior, or track or acknowledge the robot's actions during operations. The robot is meant to unobtrusively 'work around' the human rather than directly collaborate on task completion. The distinction of this work is in its use of human intent prediction (HIP) as a key factor in robot action selection for task-level planning. We choose to model HIP with a Markov Decision Process (MDP). Human state data is input into the HIP MDP policy that then outputs the predicted human intent, which we define as the best-matched or most-likely in-progress and future action-choice(s) that the human is or will be pursuing to complete mission goals. Predicted human intent is then used by a second MDP to determine the optimal policy with respect to the robot's action-choice. We present an autonomous framework that integrates the HIP MDP and robot action-choice (RAC) MDP to support autonomous close-proximity operations and propose offline and online (scaled) formulations of the two MDPs. During real-time policy execution, once the optimal action for the robot to take is determined, it is passed to the robot's path planner to be translated from a task-level command to a trajectory and motion primitives, which are then given to a low-level controller to enact. We evaluate our HIP MDP in simulation, and find that the policy output from our system is consistent and smooth across small changes in parameter values.

Masone, C., Franchi, A., Bulthoff, H.H., Giordano, P.R. 2012. "Interactive planning of persistent trajectories for human-assisted navigation of mobile robots." *IEEE International Conference on Intelligent Robots and Systems*, art. no. 6386171, 2641-2648.

***[physical; functionality]***

ABSTRACT: This work extends the framework of bilateral shared control of mobile robots with the aim of increasing the robot autonomy and decreasing the operator commitment. We consider persistent autonomous behaviors where a cyclic motion must be executed by the robot. The human operator is in charge of modifying online some geometric properties of the desired path. This is then autonomously processed by the robot in order to produce an actual path guaranteeing: i) tracking feasibility, ii) collision avoidance with obstacles, iii) closeness to the desired path set by the human operator, and iv) proximity to some points of interest. A force feedback is implemented to inform the human

operator of the global deformation of the path rather than using the classical mismatch between desired and executed motion commands. Physically-based simulations, with human/hardware-in-the-loop and a quadrotor UAV as robotic platform, demonstrate the feasibility of the method.

Lenz, A., Lallee, S., Skachek, S., Pipe, A.G., Melhuish, C., Dominey, P.F. 2012. "When shared plans go wrong: From atomic- to composite actions and back." *IEEE International Conference on Intelligent Robots and Systems*, art. no. 6385849, 4321-4326.

***[physical; functionality]***

ABSTRACT: As elaborate human-robot interaction capabilities continue to develop, humans will increasingly be in proximity with robots, and the management of the ongoing control in case of breakdown becomes increasingly important: taking care of what happens when cooperation goes wrong. The current research addresses three categories of breakdowns where cooperation can go wrong. In the first category, the human detects some type of problem and generates a self-issued stop signal, with a physical palm up posture. In the second category, the human becomes distracted, and physically changes his orientation away from the shared space of cooperation. In the final category that we investigate, the human becomes physically close to the robot such that safety limits are reached and detected by the robot. In each of these three cases, the robot cognitive system detects the failure via the perception of distinct physical states from motion capture: the hand up posture; change in head orientation; and physical distance reaching a minimum threshold. In each case the robot immediately halts the current action. Then, the system should recover appropriately. Each error type returns a specific code, allowing the Supervisor system to handle the specific type of error. Our cognitive system allows the robot to learn composite actions, as a sequence of atomic actions. These composite actions can then be composed into higher level plans. When a plan fails at the level of a composite action, the recovery method is not trivial: should recovery take place at the level of the composite action, or the actual atomic action which physically failed? As the best recovery may depend on the physical context, we expand the plan into atomic actions, and recover at this level, allowing the user to specify whether the action should be skipped or retried. We demonstrate that this system allows graceful recovery from three principal categories of interaction breakdown, and provides an invaluable mechanism for preserving the integrity of cooperative HRI.

Diamond, A., Knight, R., Devereux, D., Holland, O. 2012. "Anthropomimetic robots: Concept, construction and modelling." *International Journal of Advanced Robotic Systems*, 9.

***[physical; functionality]***

ABSTRACT: An anthropomimetic robot is one that closely copies the mechanics of the human body by having a human-like jointed skeleton moved by compliant musclelike actuators. This paper describes the progress achieved in building anthropomimetic torsos in two projects, CRONOS and ECCEROBOT. In each, the bones were hand-moulded in a thermoplastic and the muscles were implemented by DC motors shortening and extending elastic tendons. Anthropomimetic robots differ from conventionally engineered robots by having complex joints and compliant tendon driven actuation that can cross more than one joint. Taken together, these characteristics make the robots unsuitable for control by standard methods, and so the ability to model them is important for developing heuristic methods of control and also for providing forward models. The robots were modelled using physics-based techniques which enable the study of the generation of movements and also of interactions with arbitrary objects. The lightweight and compliant structure of the robots was found to be safe for human proximity and contact.

Kruse, T., Basili, P., Glasauer, S., Kirsch, A. 2012. "Legible robot navigation in the proximity of moving humans." *Proceedings of IEEE Workshop on Advanced Robotics and its Social Impacts*, ARSO, art. no. 6213404, 83-88.

***[physical; functionality]***

ABSTRACT: Our objective is to improve legibility of robot navigation behavior in the presence of moving humans. We examine a human-aware global navigation planner in a path crossing situation and assess the legibility of the resulting navigation behavior. We observe planning based on fixed social costs and static search spaces to perform badly in situations where robot and human move towards the same point. To find an improved cost model, we experimentally examine how humans deal with path crossing. Based on the results we provide a new way of calculating social costs with context dependent costs without increasing the search space. Our evaluation shows that a simulated robot using our new cost model moves more similar to humans. This shows how comparison of human and robot behavior can help with assessing and improving legibility.

Henkel, Z., Murphy, R.R., Bethel, C.L. 2012. "Towards a computational method of scaling a robot's behavior via proxemics." HRI'12 - *Proceedings of the 7th Annual ACM/IEEE International Conference on Human-Robot Interaction*, 145-146.

***[physical; functionality; user acceptance]***

ABSTRACT: Humans regulate their social behavior based on proximity to other social actors. Likewise, when a robot fulfills the role of a social actor it too should regulate its interaction based on proximity. This paper describes work in progress to establish methods for autonomous modification of social behavior based on proximity and to quantify human preferences between methods of scaling a robot's social behaviors based on distance from a human. The preliminary results of a 72 participant human study examine the reaction to scaling with linear methods and perception-based methods. Results indicate significantly higher ratings in multiple areas (comfort, natural movement, safety, self-control, intelligence, likability, submissiveness (p) when using a perception-based scaling function, as opposed to a linear or no scaling function. Work in progress is analyzing the biometric measures collected.

Bortot, D., Ding, H., Antonopolous, A., Bengler, K. 2012. "Human motion behavior while interacting with an industrial robot." *Work*, 41 (SUPPL.1): 1699-1707.

***[physical; functionality]***

ABSTRACT: Human workers and industrial robots both have specific strengths within industrial production. Advantageously they complement each other perfectly, which leads to the development of human-robot interaction (HRI) applications. Bringing humans and robots together in the same workspace may lead to potential collisions. The avoidance of such is a central safety requirement. It can be realized with sundry sensor systems, all of them decelerating the robot when the distance to the human decreases alarmingly and applying the emergency stop, when the distance becomes too small. As a consequence, the efficiency of the overall systems suffers, because the robot has high idle times. Optimized path planning algorithms have to be developed to avoid that. The following study investigates human motion behavior in the proximity of an industrial robot. Three different kinds of encounters between the two entities under three robot speed levels are prompted. A motion tracking system is used to capture the motions. Results show, that humans keep an average distance of about 0,5m to the robot, when the encounter occurs. Approximation of the workbenches is influenced by the robot in ten of 15 cases. Furthermore, an increase of participants' walking velocity with higher robot velocities is observed.

Rosenthal, S., Veloso, M., Dey, A.K. 2012. "Is someone in this office available to help me? : Proactively seeking help from spatially-situated humans." *Journal of Intelligent and Robotic Systems: Theory and Applications*, 66 (1-2): 205-221.

***[physical; functionality]***

ABSTRACT: Robots are increasingly autonomous in our environments, but they still must overcome limited sensing, reasoning, and actuating capabilities while completing services for humans. While some work has focused on robots that proactively request help from humans to reduce their limitations, the work often assumes that humans are supervising the robot and always available to help. In this work, we instead investigate the feasibility of asking for help from humans in the environment who benefit from its services. Unlike other human helpers that constantly monitor a robot's progress, humans in the environment are not supervisors and a robot must proactively navigate to them to receive help. We contribute a study that shows that several of our environment occupants are willing to help our robot, but, as expected, they have constraints that limit their availability due to their own work schedules. Interestingly, the study further shows that an available human is not always in close proximity to the robot. We present an extended model that includes the availability of humans in the environment, and demonstrate how a navigation planner can incorporate this information to plan paths that increase the likelihood that a robot can find an available helper when it needs one. Finally, we discuss further opportunities for the robot to adapt and learn from the occupants over time.

Kumar, N., Singh, D.P., Pankaj, D., Soni, S., Kumar, A. 2012. "Exoskeleton device for rehabilitation of stroke patients using SEMG during isometric contraction." *Advanced Materials Research*, 403-408, 2033-2038.

***[physical; functionality]***

ABSTRACT: Robots are becoming more interactive and assisting to human beings day by day. They are serving humanity in the fields of industry, defense and medicine. Exoskeletons are also devices that reside in category of wearable robotics. An exoskeleton is an external structural mechanism with joints and links corresponding to those of the human body. With applications in rehabilitation medicine and virtual reality simulation, exoskeletons offer benefits

for both disabled and healthy populations. Exoskeletons can be used as a capability magnifier or assisting device. This paper presents a proposed design for smart active exoskeleton for lower limbs. This proposed exoskeleton design not only assist a person but also tries to improve its GAIT. The twin wearable legs are powered by Actuators, all controlled by a microprocessor. The simulation results of the control mechanism shows its smart capabilities. In addition, the processor based control produces a more natural muscle like activity and as such can be considered a soft and bio-mimetic actuation system. This capacity to "replicate" the function of natural muscle and inherent safety is extremely important when working in close proximity to humans. The integration of the components sections and testing of the performance will also be considered to show how the structure and actuators can be combined to produce the various systems needed for a highly flexible/low weight clinically viable rehabilitation exoskeleton.

Sanan, S., Ornstein, M.H., Atkeson, C.G. 2011. "Physical human interaction for an inflatable manipulator." *Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, EMBS, art. no. 6091723, 7401-7404.

***[physical; functionality]***

ABSTRACT: There is a growing need for robots that can function in close proximity to human beings and also physically interact with them safely. We believe inherent safety is extremely important for robots in human environments. Towards this end, we are exploring the use of inflatable structures for manipulators instead of traditional rigid structures, to improve safety in physical human robot interaction (pHRI). This paper develops a contact detection and reaction scheme for an inflatable manipulator prototype. The resulting scheme is used for physical interaction tasks with humans. Experiments verifying the efficacy of the contact detection scheme are shown using two interaction scenarios.

Yoshikawa, M., Boku, K., Nakamura, T. 2011. "High speed switching control of 1DOF manipulator using ER clutch." *Electro-Rheological Fluids and Magneto-Rheological Suspensions - Proceedings of the 12th International Conference*, 68-73.

***[physical; functionality]***

ABSTRACT: Recent advances in robotics have resulted in robots working in close proximity with humans. As a consequence, safety issues are becoming increasingly important, for example when a collision unexpectedly occurs between a robot and a person. To address such a scenario, a 3-DOF soft manipulator has been developed that incorporates an electrorheological (ER) clutch and a pneumatic sensor. The pneumatic sensor is used to decrease the impact force, while the ER clutch also decreases the collision force by making the robotic joint flexible during a collision. In this study, we aim to further improve the safety during collisions between a robot and a person by controlling the electric field applied to the ER clutch after a collision. We add energy dissipation to the robot arm by increasing the friction in the ER clutch. Moreover, we examine recoil of a robot arm just after a collision by reversing a motor. In this paper, we report on several reversal experiments conducted on a 1-link arm that does not undergo collision, and we investigate the energy dissipation effect that can be generated by an 45ER clutch.

Tan, J.T.C., Arai, T. 2011. "Triple stereo vision system for safety monitoring of human-robot collaboration in cellular manufacturing." *Proceedings - 2011 IEEE International Symposium on Assembly and Manufacturing*, ISAM 2011, art. no. 5942335.

***[physical; functionality]***

ABSTRACT: In a close proximity of a human-robot collaboration production system, safety monitoring has a paramount importance to ensure the human operator is being well protected throughout the collaborative operation with the robot manipulator. Due to the requirement to allow overlapping of working envelopes between these two parties, physical separation or two-dimensional sensory system is not effective as the safety measure for the production system. In the early development, safety monitoring by stereo vision system with two cameras was introduced to track the human operator's motion throughout the operation. Camera is used to capture images for tracking of color areas on the human operator. The image coordinates by particle filter and human body model are combined to estimate the 3D positions for the human motion monitoring. However, several weaknesses were observed in this development. For instance, due to the fixed camera viewing direction, occlusion of the detecting areas can severely affect the effectiveness of the safety monitoring. Therefore, one additional camera is added into the system to produce three pairs of stereo vision to improve the robustness towards lost tracking and occlusion tolerance. Hand position tracking experiment is conducted to evaluate the performance of the 3D position estimation.

Svenstrup, M., Hansen, S.T., Andersen, H.J., Bak, T. 2011. ”Adaptive human-aware robot navigation in close proximity to humans.” *International Journal of Advanced Robotic Systems*, 8 (2).

***[physical; functionality; user acceptance]***

ABSTRACT: For robots to be able coexist with people in future everyday human environments, they must be able to act in a safe, natural and comfortable way. This work addresses the motion of a mobile robot in an environment, where humans potentially want to interact with it. The designed system consists of three main components: a Kalman filterbased algorithm that derives a person's state information (position, velocity and orientation) relative to the robot; another algorithm that uses a Case-Based Reasoning approach to estimate if a person wants to interact with the robot; and, finally, a navigation system that uses a potential field to derive motion that respects the person's social zones and perceived interest in interaction. The operation of the system is evaluated in a controlled scenario in an open hall environment. It is demonstrated that the robot is able to learn to estimate if a person wishes to interact, and that the system is capable of adapting to changing behaviours of the humans in the environment.

Haddadin, S., Suppa, M., Fuchs, S., Bodenmüller, T., Albu-Schäffer, A., Hirzinger, G. 2011. “Towards the robotic co-worker.” *Springer Tracts in Advanced Robotics (STAR*), 70: 261-282.

***[physical; functionality]***

ABSTRACT: Recently, robots have gained capabilities in both sensing and actuation, which enable operation in the proximity of humans. Even direct physical interaction has become possible without suffering the decrease in speed and payload. The DLR Lightweight Robot III (LWR-III), whose technology is currently being transferred to the robot manufacturer KUKA Roboter GmbH, is such a device capable of realizing various features crucial for direct interaction with humans. Impedance control and collision detection with adequate reaction are key components for enabling "soft and safe" robotics. The implementation of a sensor based robotic co-worker that brings robots closer to humans in industrial settings and achieve close cooperation is an important goal in robotics. Despite being a common vision in robotics it has not become reality yet, as there are various open questions still to be answered. In this paper a sound concept and a prototype implementation of a co-worker scenario are developed in order to demonstrate that stateof-the-art technology is now mature enough to reach this aspiring aim. We support our ideas by addressing the industrially relevant bin-picking problem with the LWR-III, which is equipped with a Time-of-Flight camera for object recognition and the DLR 3D-Modeller for generating accurate environment models. The paper describes the sophisticated control schemes of the robot in combination with robust computer vision algorithms, which lead to a reliable solution for the addressed problem. Strategies are devised for safe interaction with the human during task execution, state depending robot behavior, and the appropriate mechanisms, to realize robustness in partially unstructured environments.

Mittendorfer, P., Cheng, G. 2011. “Humanoid multimodal tactile-sensing modules.” *IEEE Transactions on Robotics*, 27 (3), art. no. 5711674, 401-410.

***[physical; functionality]***

ABSTRACT: In this paper, we present a new generation of active tactile modules (i.e., HEX-O-SKIN), which are developed in order to approach multimodal whole-body-touch sensation for humanoid robots. To better perform like humans, humanoid robots need the variety of different sensory modalities in order to interact with their environment. This calls for certain robustness and fault tolerance as well as an intelligent solution to connect the different sensory modalities to the robot. Each HEX-O-SKIN is a small hexagonal printed circuit board equipped with multiple discrete sensors for temperature, acceleration, and proximity. With these sensors, we emulate the human sense of temperature, vibration, and light touch. Off-the-shelf sensors were utilized to speed up our development cycle; however, in general, we can easily extend our design with new discrete sensors, thereby making it flexible for further exploration. A local controller on each HEX-O-SKIN preprocesses the sensor signals and actively routes data through a network of modules toward the closest PC connection. Local processing decreases the necessary network and high-level processing bandwidth, while a local analog-to-digital conversion and digital-data transfers are less sensitive to electromagnetic interference. With an active data-routing scheme, it is also possible to reroute the data around broken connections-yielding robustness throughout the global structure while minimizing wirings. To support our approach, multiple HEX-O-SKIN are embedded into a rapid-prototyped elastomer skin material and redundantly connected to neighboring modules by just four ports. The wiring complexity is shifted to each HEX-O-SKIN such that a power and data connection between two modules is reduced to four noncrossing wires. Thus, only a very simple robot-specific base frame is needed to support and wire the HEX-O-SKIN to a robot. The potential of our multimodal sensor modules is demonstrated experimentally on a robot platform.

Kuo, I.H., Jayawardena, C., Tiwari, P., Broadbent, E., MacDonald, B.A. 2010. "User identification for healthcare service robots: Multidisciplinary design for implementation of interactive services." *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics*), 6414 LNAI, 20-29.

***[physical; functionality; user acceptance]***

ABSTRACT: Human robot interaction (HRI) is core to the design of service robots. The interaction during a service application determines how a user perceives the robot, which affects the user's experience and how well the user accepts the robot and its services. During the last decade, robotics service applications in close proximity to human users have been a popular research area. Research in related fields such as computer vision has also made significant advances to make available many interaction algorithms for HRI. However, we argue that there is only minimum utilization of these algorithms in the construction of HRI needed in actual service robots, despite their availability. This is partly because these algorithms have inherent limitations and only solve some of the HRI issues required in a complete service scenario in real environments. In this paper, a new general design approach is proposed to utilize modeling languages UML and UMLi to describe a service scenario and model the HRI required in a complete service. These models can be further used to elicit sometimes hidden HRI requirements from limitations in the interaction algorithms used. This approach helps multidisciplinary research to make HRI design decisions early at the design stage and guide implementation by software engineers. A user identification service scenario was designed, implemented and used as the case study of this design approach. It was integrated with a medication reminder application on a robot which was deployed and evaluated with the older people in a retirement village in New Zealand.

Pandey, A.K., Alami, R. 2010. "A framework towards a socially aware mobile robot motion in human-centered dynamic environment." *IEEE/RSJ 2010 International Conference on Intelligent Robots and Systems, IROS 2010 - Conference Proceedings*, art. no. 5649688, 5855-5860.

***[physical; functionality; user acceptance]***

ABSTRACT: For a Mobile Robot to navigate in the Human-Centered environment without imposing alien like impression by its motion, it should be able to reason about various criteria ranging from clearance, environment structure, unknown objects, social conventions, proximity constraints, presence of an individual or group of peoples, etc. Also the robot should neither be over-reactive nor be simple wait and move machine. We have adapted a Voronoi diagram based approach for the analysis of local clearance and environment structure. We also propose to treat human differently from other obstacles for which the robot constructs different sets of regions around human and iteratively converges to a set of points (milestones), using social conventions, human proximity guidelines and clearance constraints to generate and modify its path smoothly. Once equipped with such capabilities, robot is able to do higher-level reasoning for dynamic and selective adaptation of social convention depending upon the environment segment. It also leads the robot to be aware about its own motion behavior.

Ryu, D., Um, D., Tanofsky, P., Koh, D.H., Ryu, Y.S., Kang, S. 2010. "T-less: A novel touchless human-machine interface based on infrared proximity sensing." *IEEE/RSJ 2010 International Conference on Intelligent Robots and Systems, IROS 2010 - Conference Proceedings*, art. no. 5649433, 5220-5225.

***[physical; functionality]***

ABSTRACT: In today's industry, intuitive gesture recognition, as manifested in numerous consumer electronics devices, becomes a main issue of HMI device research. Although finger-tip touch based user interface has paved a main stream in mobile electronics, we envision touch-less HMI as a promising technology in futuristic applications with higher potential in areas where sanity or outdoor operation become of importance. In this paper, we introduce a novel HMI device for non-contact gesture input for intuitive HMI experiences. The enabling technology of the proposed device is the IPA (infrared Proximity Array) sensor by which realtime 3 dimensional depth information can be captured and realized for machine control. For the usability study, two different operating modes are adopted for hand motion inputs: one is a finger tip control mode and the other is a palm control mode. Throughput of the proposed device has been studied and compared to a traditional mouse device for usability evaluation. During the human subject test, the proposed device is found to be useful for PC mouse pointer control. The experimental results are shared in the paper as well.

Malm, T., Viitaniemi, J., Latokartano, J., Lind, S., Venho-Ahonen, O., Schabel, J. 2010. "Safety of interactive robotics-learning from accidents." *International Journal of Social Robotics*, 2(3): 221-227.

***[physical; functionality]***

ABSTRACT: Finland is ranked rather high in international robot density statistics. In Finland, robots are typically used in applications where they operate in close proximity to humans. The research described in this paper, sourced from Finnish databases, identified 25 severe accidents which can be attributed to robots. The current accident data can provide an insight into the type of accidents associated with future human-robot interaction (HRI) applications. Accident statistics indicate that most of the severe robot-related accidents involved crushing a person against a rigid object. As crushing hazards currently dominate accident statistics, and with HRI applications becoming increasingly common, humans are expected to be exposed to more crushing hazards in the future. The close proximity of the robots means that there is very little time to escape from crushing hazard. The prevention of collisions between robots and humans is paramount to reducing the amount of accidents. Actions to diminish the effects of any subsequent collision are also important. The control after a collision, however, needs to be very quick in order to minimise the damage caused by an impact. Current practice demands that upon detection of a collision, active movements are typically not allowed without a human supervision. Moving a robot away to a safe position and releasing any pressure against a person may save lives, but would entail some adjustments or new interpretations of the current safety requirements.

Vitale, F., Accoto, D., Turchetti, L., Indini, S., Annesini, M.C., Guglielmelli, E. 2010. "Low-temperature H2O2-powered actuators for biorobotics: Thermodynamic and kinetic analysis." *Proceedings - IEEE International Conference on Robotics and Automation*, art. no. 5509936, 2197-2202.

***[physical; functionality]***

ABSTRACT: The need for novel, high performance actuators felt in several fields of robotics, such as assistive or rehabilitative robotics, is not fully satisfied by current actuation means. This fosters an intense research on novel energy transduction methods. In particular, propellant-based chemical actuators, able to directly convert chemical energy into mechanical energy, appear very promising, although their potential in robotics has not yet been deeply investigated. This work focuses on H2O2, used as propellant for actuators. This chemical was first used in robotics, with excellent results, by Goldfarb and collaborators, in 2003. H2O 2 dissociation is strongly exothermic, which generates important design issues when the actuated machine operates in close proximity to the human body. In this paper it is shown that: 1) is possible to operate the decomposition process at acceptable temperature, by means of basic solutions of hydrogen peroxide; 2) for basic pH solutions, tin becomes an effective catalyst for H2O2 dissociation. A kinetic model of H 2O2 dissociation in basic solutions is provided, that is in good agreement with experimental data. We show how the model can be used to gather the necessary information for the dimensioning of H2O 2-based actuators.

Teller, S., Walter, M.R., Antone, M., Correa, A., Davis, R., Fletcher, L., Frazzoli, E., Glass, J., How, J.P., Huang, A.S., Jeon, J.H., Karaman, S., Luders, B., Roy, N., Sainath, T. 2010. "A voice-commandable robotic forklift working alongside humans in minimally-prepared outdoor environments." *Proceedings - IEEE International Conference on Robotics and Automation*, art. no. 5509238, 526-533.

***[physical; functionality; user acceptance]***

ABSTRACT: One long-standing challenge in robotics is the realization of mobile autonomous robots able to operate safely in existing human workplaces in a way that their presence is accepted by the human occupants. We describe the development of a multi-ton robotic forklift intended to operate alongside human personnel, handling palletized materials within existing, busy, semi-structured outdoor storage facilities. The system has three principal novel characteristics. The first is a multimodal tablet that enables human supervisors to use speech and pen-based gestures to assign tasks to the forklift, including manipulation, transport, and placement of palletized cargo. Second, the robot operates in minimally-prepared, semi-structured environments, in which the forklift handles variable palletized cargo using only local sensing (and no reliance on GPS), and transports it while interacting with other moving vehicles. Third, the robot operates in close proximity to people, including its human supervisor, other pedestrians who may cross or block its path, and forklift operators who may climb inside the robot and operate it manually. This is made possible by novel interaction mechanisms that facilitate safe, effective operation around people. We describe the architecture and implementation of the system, indicating how real-world operational requirements motivated the development of the key subsystems, and provide qualitative and quantitative descriptions of the robot operating in real settings.

Machmer, T., Swerdlow, A., Kühn, B., Kroschel, K. 2010. "Hierarchical, knowledge-oriented opto-acoustic scene analysis for humanoid robots and man-machine interaction." *Proceedings - IEEE International Conference on Robotics and Automation*, art. no. 5509889, 2389-2396.

***[physical; functionality]***

ABSTRACT: The opto-acoustic scene analysis is an extremely important as well as a challenging task for a humanoid robot. By the opto-acoustic scene analysis, the guided and autonomous exploration of the environment by means of acoustic and/or visual perception is meant. On the one hand, the perception ability is necessary to interact with humans in a humanoid way. On the other hand, the proximity of the robot has to be analyzed continuously, in order to enable the robot to fulfill its everyday tasks. Thereby, the greatest challenge lies in the wide variety of different perception tasks, e.g. detection, tracking, and identification of persons and different types of objects. This leads to the need of adapted, both, task- and context-dependent perception modules with specific requirements and abilities. Taking these considerations into account, the paper presents a hierarchical, knowledge-oriented concept of a framework for the opto-acoustic scene analysis. The focus of the work is put on formal conditions on one side and the practical realization of a real-time system on the other side. The proposed framework is modular structured and consists of a number of specialized perception modules. To reflect the knowledge-based structure of the framework, an object-oriented environment model is used for continuous inserting, updating and removing the information about the proximity of the robot. Besides the task of analyzing the scene with the reference to already known objects (and persons1), the proposed concept enables the robot to explore a (partially) unknown environment, with the focus on the creation of multimodal signatures for unknown objects and persons. These signatures are used to build an unique representation of the explored objects and enable the robot to recognize them at a later time.

Chang, C.-L., Sie, M.-F. 2010. "The design and implementation of the bio-robotic plant system." *American Society of Agricultural and Biological Engineers Annual International Meeting 2010*, ASABE 2010, 6, 4436-4442.

***[physical]***

ABSTRACT: This paper applies the concept of bionics to digital life and utilizes bionics techniques to mimic the characteristics of creatures so as meet the demand of facility digitalized in all aspects of life. The paper proposes a bio-robotic plant system (BRPS), which can mimic the process of plant growth and combine sensor, photo-transistors and additional light source to mimic the behavior of plant phototropism. The criteria of this system is that BRPS initiates its growth and completes flowering process upon the proximity of humans and also the contact of light source. Then, four micro photo-transistors on the mosaic are utilized to receive the light source from four directions and microcontroller are adopted to detect each direction of light and select the maximum direction of light, where the flower moves towards finally. It is verified through simulation and experiment result that the growth of BRPS varies with the time of light contact upon the proximity of humans and abundant light. When the plant flowers, it turns towards the desired direction of light correctly. The system can improve the quality of human life, lead to the balance between body and mind and is also educational.

Nakabo, Y., Saito, H., Ogure, T., Jeong, S.H., Yamada, Y. 2009. "Development of a safety module for robots sharing workspace with humans." *2009 IEEE/RSJ International Conference on Intelligent Robots and Systems*, IROS 2009, art. no. 5354531, 5345-5349.

***[physical; functionality]***

ABSTRACT: Although the need for humans and robots to work together in close proximity is increasing, this is currently not allowed with conventional industrial robots for reasons of safety. Next generation robots that can work safely in close proximity with humans must not only be highly functional, but must also be highly reliable with built in safety features. With this aim in mind, we have developed a safety module that integrates safety functions required for robots to work side by side with humans. The safety module is designed to be compliant with international safety standards and Japanese law. Redundant sensory signal processing by an external hardware module and plug-in software installed in the robot controller ensure high-reliability and flexibility. This paper describes the concept and design of the safety module and shows some evaluation results of its safety functions.

Sato, K., Koyanagi, K., Kakinuma, Y., Anzai, H., Sakurai, K., Oshima, T. 2009. "Improvement of linear actuator with ER gel." *Proceedings - IEEE International Workshop on Robot and Human Interactive Communication*, art. no. 5326257, 171-176.

***[physical; functionality]***

ABSTRACT: Nowadays, certain kinds of robots have been developed to be used in proximity to daily human activities. Backdriveability is important for robots to act according to users' movements. We want to develop a linear actuator of high power and backdriveability. In this study we aim to achieve high generative force and backdriveability with a novel linear actuator, because there are many straight line operations in real space. In this paper, we aim to create a new Electro-Rheological (ER) gel linear actuator by reviewing the prototype ER gel linear actuator.

Pandey, A.K., Alami, R. 2009. "A framework for adapting social conventions in a mobile robot motion in human-centered environment." *2009 International Conference on Advanced Robotics*, ICAR 2009, art. no. 5174708.

***[physical; functionality]***

ABSTRACT: Interestingly in different situations, human not only plans differently for approaching, accompanying, passing by and avoiding another person, but also smoothly maintains an appropriate distance. But for a mobile robot it is not trivial at all, while also maintaining its goal. In this paper we present a generic framework of mobile robot path planning for adapting social rules at different states of execution, which apart from assuring safety, also respects the comfort and expectations of human, and convey its intention to human well in advance. In our approach for treating human explicitly robot constructs different sets of regions around human and iteratively converges to a set of points (milestones), using social rules, human proximity rules and task oriented rules to generate a smooth path. We have compared our results with the case, when robot is purely reactive.

Elshafiey, I., Sheta, A.-F., Alkanhal, M.A., Mohra, A., Alorainy, A. 2009. "Near-field characterization of reconfigurable narrowband antenna in the proximity of the human body." *AIP Conference Proceedings*, 1096, 1657-1664.

***[physical; functionality]***

ABSTRACT: Reconfigurable antennas have been suggested recently for use in various mobile systems. These systems are usually operated in the vicinity of human body, leading to mutual interaction with body tissues. A nondestructive evaluation method is developed to characterize a reconfigurable antenna designed to cover the GSM-900/DCS-1800 bands. Modeling based on FDTD is performed of the antenna in free space and in proximity to the human head. Results reveal frequency shift, and variations in the matching and bandwidth, depending on antenna orientation with respect to the head. Experimental setup is also used to characterize the SAR values in human head. A six-degree-of-freedom robot is implemented to scan a head phantom using specialized sensors and head simulating liquids. The developed system provides a tool for guiding the design of the new category of reconfigurable antennas.

Noda, T., Miyashita, T., Ishiguro, H., Hagita, N. 2009. "Super-flexible skin sensors embedded on the whole body, self-organizing based on haptic interactions." *Robotics: Science and Systems*, 4: 294-301.

***[physical; functionality]***

ABSTRACT: As robots become more ubiquitous in our daily lives, humans and robots are working in ever-closer physical proximity to each other. These close physical distances change the nature of human robot interaction considerably. First, it becomes more important to consider safety, in case robots accidentally touch (or hit) the humans. Second, touch (or haptic) feedback from humans can be a useful additional channel for communication, and is a particularly natural one for humans to utilize. Covering the whole robot body with malleable tactile sensors can help to address the safety issues while providing a new communication interface. First, soft, compliant surfaces are less dangerous in the event of accidental human contact. Second, flexible sensors are capable of distinguishing many different types of touch (e.g., hard v.s. gentle stroking). Since soft skin on a robot tends to invite humans to engage in even more touch interactions, it is doubly important that the robot can process haptic feedback from humans. In this paper, we discuss attempts to solve some of the difficult new technical and information processing challenges presented by flexible touch sensitive skin. Our approach is based on a method for sensors to self-organize into sensor banks for classification of touch interactions. This is useful for distributed processing and helps to reduce the maintenance problems of manually configuring large numbers of sensors. We found that using sparse sensor banks containing as little as 15% of the full sensor set it is possible to classify interaction scenarios with accuracy up to 80% in a 15-way forced choice task. Visualization of the learned subspaces shows that, for many categories of touch interactions, the learned sensor banks are composed mainly of physically local sensor groups. These results are promising and suggest that our proposed method can be effectively used for automatic analysis of touch behaviors in more complex tasks.

Lee, C.-H.J., Kim, K., Breazeal, C., Picard, R. 2008. "Shybot: Friend-stranger interaction for children living with autism." *Conference on Human Factors in Computing Systems - Proceedings*, 3375-3380.

***[physical & social; functionality]***

ABSTRACT: This paper presents Shybot, a personal mobile robot designed to both embody and elicit reflection on shyness behaviors. Shybot is being designed to detect human presence and familiarity from face detection and proximity sensing in order to categorize people as friends or strangers to interact with. Shybot also can reflect elements of the anxious state of its human companion through LEDs and a spinning propeller. We designed this simple social

interaction to open up a new direction for intervention for children living with autism. We hope that from minimal social interaction, a child with autism or social anxiety disorders could reflect on and more deeply attain understanding about personal shyness behaviors, as a first step toward helping make progress in developing greater capacity for complex social interaction.

Vanderborght, B., Sugar, T., Lefeber, D. 2008. "Adaptable compliance or variable stiffness for robotic applications." *IEEE Robotics and Automation Magazine*, 15 (3): 8-9.

***[physical; functionality]***

ABSTRACT: Exciting new robots are being developed that will operate in a different environment from traditional industrial factories or research laboratories. Researchers are working worldwide to create robots that are integrated into our daily lives. For the advancement of these new robots, compliant, safe, and new actuators are one of the important issues turning energy into safe motion. The biological counterpart is the muscle tendon structure that has functional performance characteristics and a neuro-mechanical control system that has far more superior capabilities. The superior power to weight ratio, force to weight ratio, and sensing characteristics limit the development of machines that can match motion, safety, and energy efficiency of a human or other animal. One of the key differences of biological systems is their adaptable compliance or variable stiffness compared with the traditional stiff electrical drives used for the standard industrial robotic applications, which require accurate, reference-trajectory tracking. More and more applications such as robots in close human or robot proximity, legged autonomous robots, and rehabilitation devices and prostheses demand a different set of design specifications, for which the use of compliant actuators can be beneficial as compared with the traditional stiff actuation schemes.

Cervera, E., Garcia-Aracil, N., Martínez, E., Nomdedeu, L., Del Pobil, A.P. 2008. "Safety for a robot arm moving amidst humans by using panoramic vision." *Proceedings - IEEE International Conference on Robotics and Automation*, art. no. 4543530, 2183-2188.

***[physical; functionality]***

ABSTRACT: This paper describes how the use of panoramic cameras can dramatically simplify safety issues for a robot arm moving in close proximity to human beings, since they can simultaneously observe a 360° field of view. We present in this context an approach to visual servoing in which both the manipulator as well as any other moving object are tracked. Reliability and robustness are enhanced by adaptative background modelling and global illumination change detection.

Bodt, B.A., Camden, R. 2008. "Detecting and tracking moving humans from a moving vehicle." Proceedings of SPIE - The International Society for Optical Engineering, 6962, art. no. 696207.

***[physical; functionality]***

ABSTRACT: In September 2007 the Army Research Laboratory (ARL) Robotics Collaborative Technology Alliance (CTA) conducted an assessment of multiple pedestrian detection algorithms based upon LADAR or video sensor data. Eight detection algorithms developed by the Robotics CTA member organizations, including ARL, were assessed in an experiment conducted by the National Institute of Science & Technology (NIST) and ARL to determine the probability of detection/misclassification and false alarm rate as a function of vehicle speed, degree of environmental clutter, and pedestrian speeds. The study is part of an ongoing investigation of safe operations for unmanned ground vehicles. This assessment marked the first time in this program that human movers acted as targets for detection from a moving vehicle. A focus of the study was to choreograph repeatable human movement scenarios relative to the movement of the vehicle. The resulting data is intended to support comparative analysis across treatment conditions and to allow developers to examine performance with respect to specific detection and tracking events. Events include humans advancing and retreating from the vehicle at different angles, humans crossing paths in close proximity and occlusion situations where sight to the mover from the sensor system is momentarily lost. A detailed operational procedure ensured repeatable human movement with independent ground truth supplied by a NIST ultra wideband wireless tracking system. Post processing and statistical analysis reconciled the tracking algorithm results with the NIST ground truth. We will discuss operational considerations and results.

Bethel, C.L., Murphy, R.R. 2008. "Survey of Non-facial/Non-verbal Affective Expressions for Appearance-Constrained Robots." *IEEE Transactions on Systems, Man and Cybernetics Part C: Applications and Reviews*, 38 (1): 83-92.

***[physical; functionality]***

ABSTRACT: Non-facial and non-verbal methods of affective expression are essential for naturalistic social interaction in robots that are designed to be functional and lack expressive faces (appearance-constrained) such as those used in search and rescue, law enforcement, and military applications. This correspondence identifies five main methods of non-facial and non-verbal affective expression (body movement, posture, orientation, color, and sound), and ranks their effectiveness for appearance-constrained robots operating within the intimate, personal, and social proximity zones of a human corresponding to interagent distances of approximately 3 m or less. This distance is significant because it encompasses the most common human social interaction distances, the exception being the public distance zone used for formal presentations. The correspondence complements prior, broad surveys of affective expression by reviewing the psychology, computer science, and robotics literature specifically relating the impact of social interaction in non-anthropomorphic and appearance-constrained robots, and summarizing robotic implementations that utilize non-facial and non-verbal methods of affective expression as their primary means of expression. The literature is distilled into a set of prescriptive recommendations of the appropriate affective expression methods for each of the three proximity zones of interest. These recommendations serve as design guidelines for retroactively adding affective expression through software to a robot without physical modifications or designing a new robot.

Atkins, E.M. 2007. "Physically-proximal human-robot collaboration for air and space applications." *Performance Metrics for Intelligent Systems (PerMIS) Workshop*, 230-237.

***[physical; functionality]***

ABSTRACT: In Aerospace applications, human safety is of paramount importance given harsh environmental conditions that require persistent electromechanical life support. The resulting inherent proximity between humans and "robotic support" requires effective communication and collaboration in emerging systems where the robot is not strictly a "tool" for a human operator/pilot to command. This paper investigates the challenges of human-robot collaboration in the context of two critical Aerospace applications, airspace management and planetary surface exploration. We first present a spectrum of alternative air traffic management designs ranging from centralized to fully-decentralized. Discussion focuses on roles of human versus synthetic decision-makers, associated efficiency bounds, and metrics for quantifying performance and safety. Next, a space exploration scenario is investigated in which robots and human astronauts are both modeled as "agents" with specific skills and resources available for tasking by a (computerized) planner. Emphasis is placed on real-time reconfiguration when astronauts purposely deviate from their default plan or are in need of assistance, accounting for astronaut-initiated activities while proactively enhancing astronaut safety.

Rigas, E.J., Bodt, B., Camden, R. 2007. "Detection, tracking, and avoidance of moving objects from a moving autonomous vehicle." *Proceedings of SPIE - The International Society for Optical Engineering*, 6561, art. no. 656106.

***[physical; functionality]***

ABSTRACT: ARL is developing the autonomous capability to directly support the Army's future requirements to employ unmanned systems. The purpose of this paper is to document and benchmark the current ARL Collaborative Technology Alliance (CTA) capabilities in detecting, tracking and avoiding moving humans and vehicles from a moving unmanned vehicle. For this experiment ARL and General Dynamics Robotic Systems (GDRS) conducted an experiment involving an ARL experimental Unmanned Vehicle (XUV) operating in proximity to a number of stationary and moving human surrogates (mannequins) and moving vehicles. In addition there were other objects along the XUV route of the experiment such as barrels, fire hydrants, poles, cones, and other clutter. The experiment examined the performance of seven algorithms using a series of sensor modalities to detect stationary and moving objects. Three of the algorithms showed promise, detecting human surrogates and vehicles with probabilities ranging from 0.64 to 0.85, while limiting probability of misclassification to 0.14 to 0.37. Moving mannequins were detected with slightly higher probabilities than fixed mannequins. The distance from the ground truth at the time of detection suggests that at a speed of 20 kph with a minimum distance to detection of 19.38 m, the vehicle would have a minimum of 3.5 seconds to avoid a mannequin or vehicle if detected by one of these three algorithms. Among mannequins and vehicles and, mannequins were more frequently detected than vehicles.

Horiguchi, Y., Sawaragi, T. 2006. "Effects of shared communicational modality to joint activity of human operator and robot autonomy." *Intelligent Autonomous Systems* 9, IAS 2006, 903-912.

***[physical; functionality]***

ABSTRACT: The authors have proposed a formal approach to designing effective human-machine interaction channels, i.e., shared communicational modalities, between a human operator and a machine autonomy. In this framework, Kirlik's classification scheme of information types defined as Generalized Lens Model is utilized for distinguishing information resources in the target system from the perspective of their proximity to both human and machine agents' perception and action. The shared communicational modalities are then embodied virtually by imposing some mutual constraints among their respective [PP, PA] (i.e., proximal for both perception and action) variables. This paper evaluates the proposed interaction design after an actual implementation of such modalities into a shared-control environment, especially focusing on the mutual relationship of those agents' cueutilization strategies as well as their joint task performances.

Pacchierotti, E., Christensen, H.I., Jensfelt, P. 2006. "Embodied social interaction for service robots in hallway environments." *Springer Tracts in Advanced Robotics*, 25: 293-304.

***[physical; functionality; user acceptance]***

ABSTRACT: A key aspect of service robotics for everyday use is the motion in close proximity to humans. It is essential that the robot exhibits a behavior that signals safety of motion and awareness of the persons in the environment. To achieve this, there is a need to define control strategies that are perceived as socially acceptable by users that are not familiar with robots. In this paper a system for navigation in a hallway is presented, in which the rules of proxemics are used to define the interaction strategies. The experimental results show the contribution to the establishment of effective spatial interaction patterns between the robot and a person.

Koay, K.L., Dautenhahn, K., Woods, S.N., Walters, M.L. 2006. "Empirical results from using a comfort level device in human-robot interaction studies." *HRI 2006: Proceedings of the 2006 ACM Conference on Human-Robot Interaction*, 2006, 194-201.

***[physical & social; functionality; user acceptance]***

ABSTRACT: This paper; describes an extensive analysis of the comfort level data of 7 subjects with respect to 12 robot behaviours as part of a human-robot interaction trial. This includes robot action, proximity and motion relative to the subjects. Two researchers coded the video material, identifying visible states of discomfort displayed by subjects in relation to the robot's behaviour. Agreement between the coders varied from moderate to high, except for more ambiguous situations involving robot approach directions. The detected visible states of discomfort were correlated with the situations where the comfort level device (CLD) indicated states of discomfort. Results show that the uncomfortable states identified by both coders, and by either of the coders corresponded with 31% and 64% of the uncomfortable states identified by the subjects' CLD data (N=58), respectively. Conversely there was 72% agreement between subjects' CLD data and the uncomfortable states identified by both coders (N=25). Results show that the majority of the subjects expressed discomfort when the robot blocked their path or was on a collision course towards them, especially when the robot was within 3 meters proximity. Other observations include that the majority of subjects experienced discomfort when the robot was closer than 3m, within the social zone reserved for human-human face to face conversation, while they were performing a task. The advantages and disadvantages of the CLD in comparison to other techniques for assessing subjects' internal states are discussed and future work concludes the paper.

Christensen, H.I., Pacchierotti, E. 2005. "Embodied social interaction for robots." *AISB'05 Convention: Social Intelligence and Interaction in Animals, Robots and Agents - Proceedings of the Symposium on Robot Companions: Hard Problems and Open Challenges in Robot-Human Interaction*, 40-45.

***[physical; functionality]***

ABSTRACT: A key aspect of service robotics for everyday use is the motion of systems in close proximity to humans. It is here essential that the robot exhibits a behaviour that signals safe motion and awareness of the other actors in its environment. To facilitate this there is a need to endow the system with facilities for detection and tracking of objects in the vicinity of the platform, and to design a control law that enables motion generation which is considered socially acceptable. We present a system for in-door navigation in which the rules of proxemics are used to define interaction strategies for the platform.

Yanco, H.A., Drury, J. 2004. "Classifying human-robot interaction: An updated taxonomy." *Conference Proceedings - IEEE International Conference on Systems, Man and Cybernetics*, 3, 2841-2846.

***[physical & social; functionality]***

ABSTRACT: This paper extends a taxonomy of human-robot interaction (HRI) introduced in 2002 [1] to include additional categories as -well as updates to the categories from the original taxonomy. New classifications include measures of the social nature of the task (**human interaction roles** and **human-robot physical proximity**), task type, and robot morphology.

Lohmann, B. 2004. "The autonomous wheelchair "easy" and its hierarchical control." *Mathematical and Computer Modelling of Dynamical Systems*, 10 (2): 169-185.

***[physical; functionality]***

ABSTRACT: Robots acting in the proximity of humans belong to the most challenging mechatronic systems and attract increasing interest in sciences and in commercial applications. The autonomous wheelchair EASY (electric wheelchair with driver assistance system) is an example of such a system of high autonomy. It is developed in the department of System Dynamics and Control of the Institute of Automation, University of Bremen. This paper gives an overview of the system and its hierarchical control, and presents the modelling and feedback control of two particular sub-problems: the dynamics and trajectory tracking of the wheelchair, and the 3D vision modelling and image-based path control.

Morioka, K., Lee, J.-H., Hashimoto, H. 2004. "Human-Following Mobile Robot in a Distributed Intelligent Sensor Network." *IEEE Transactions on Industrial Electronics*, 51 (1): 229-237.

***[physical; functionality]***

ABSTRACT: The robots that will be needed in the near future are human-friendly robots that are able to coexist with humans and support humans effectively. To realize this, humans and robots need to be in close proximity to each other as much as possible. Moreover, it is necessary for their interactions to occur naturally. It is desirable for a robot to carry out human following, as one of the human-affinitive movements. The human-following robot requires several techniques: the recognition of the target human, the recognition of the environment around the robot, and the control strategy for following a human stably. In this research, an intelligent environment is used in order to achieve these goals. An intelligent environment is a space in which many sensors and intelligent devices are distributed. Mobile robots exist in this space as physical agents providing humans with services. A mobile robot is controlled to follow a walking human using distributed intelligent sensors as stably and precisely as possible. The control law based on the virtual spring model is proposed to mitigate the difference of movement between the human and the mobile robot. The proposed control law is applied to the intelligent environment and its performance is verified by the computer simulation and the experiment.

# PART B: OTHER RELEVANT CONCEPTS

# iv. ARTIFICIAL INTELLIGENCE

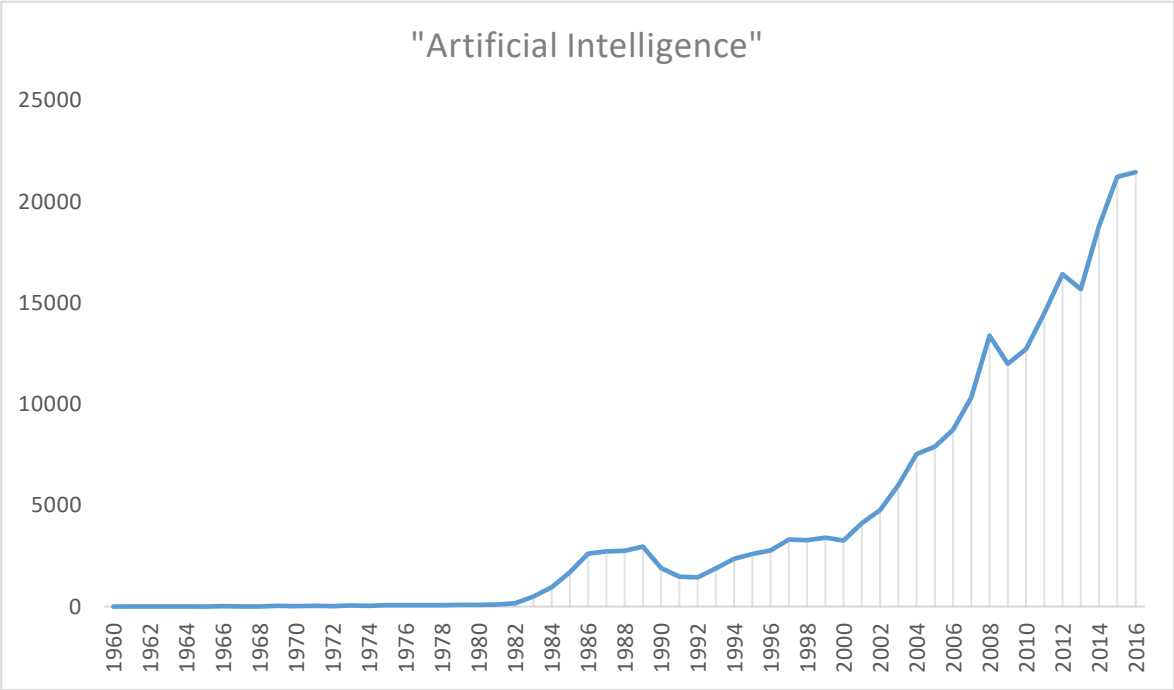
## Database queries

A table reporting the numeric results of all the research is presented:

| Search Queries in Scopus | SCOPUS hits |
|---|---|
| **"Artificial Intelligence"** | |
| **Publication year > 1960** | 238,520 |
| **Publication year > 2000** | 198,881 |
| **"Artificial Intelligence" AND "robot"** | |
| **Publication year > 2000** | |
| **AND Search term in the title** | 48 |
| **AND Search term in keywords** | 7289 |
| **AND Search term in abstract** | 2162 |
| **AND Search term in abstract, keywords, title** | 9659 |
| **"Artificial Intelligence" AND "human"** | |
| **Publication year > 2000** | |
| **AND Search term in the title** | 76 |
| **AND Search term in keywords** | 21802 |
| **AND Search term in abstract** | 5288 |
| **AND Search term in abstract, keywords, title** | 32034 |
| **"Artificial Intelligence" AND "ethics"** | |
| **Publication year > 2000** | |
| **AND Search term in the title** | 8 |
| **AND Search term in keywords** | 208 |
| **AND Search term in abstract** | 81 |
| **AND Search term in abstract, keywords, title** | 348 |
| **"Artificial Intelligence" AND "collaborative learning"** | |
| **Publication year > 2000** | |
| **AND Search term in the title** | 1 |
| **AND Search term in keywords** | 219 |
| **AND Search term in abstract** | 60 |
| **AND Search term in abstract, keywords, title** | 281 |
| **"Artificial Intelligence" AND "learning"** | |
| **Publication year > 2000** | |
| **AND Search term in the title** | 83 |
| **AND Search term in keywords** | 44099 |
| **AND Search term in abstract** | 6145 |
| **AND Search term in abstract, keywords, title** | 53140 |
| **"Artificial Intelligence" AND "intelligent autonomous system"** | |
| **Publication year > 2000** | |
| **AND Search term in the title** | 0 |
| **AND Search term in keywords** | 7 |
| **AND Search term in abstract** | 2 |
| **AND Search term in abstract, keywords, title** | 13 |
| **"human-robot interaction" AND "cyber physical system"** | |
| **Publication year > 2000** | |
| **AND Search term in the title** | 0 |

| | |
|---|---|
| **AND Search term in keywords** | 137 |
| **AND Search term in abstract** | 15 |
| **AND Search term in abstract, keywords, title** | 147 |

## Charts and trends




We can say that the results for all the searches with secondary words show increasing trends since 2000.

## Selected literature

The following articles have been considered relevant for REELER:

Russell, S. J.; Dewey, D. & Tegmark, M. Research Priorities for Robust and Beneficial Artificial Intelligence CoRR, 2016, abs/1602.03506

Artificial intelligence (AI) research has explored a variety of problems and approaches since its inception, but for the last 20 years or so has been focused on the problems surrounding the construction of intelligent agents — systems that perceive and act in some environment. In this context, the criterion for intelligence is related to statistical and economic notions of rationality — colloquially, the ability to make good decisions, plans, or inferences. The adoption of probabilistic representations and statistical learning methods has led to a large degree of integration and crossfertilization between AI, machine learning, statistics, control theory, neuroscience, and other fields. The establishment of shared theoretical frameworks, combined with the availability of data and processing power, has yielded remarkable successes in various component tasks such as speech recognition, image classification, autonomous vehicles, machine translation, legged locomotion, and question-answering systems. As capabilities in these areas and others cross the threshold from laboratory research to economically valuable technologies, a virtuous cycle takes hold whereby even small improvements in performance have significant economic value, prompting greater investments in research. There is now a broad consensus that AI research is progressing steadily, and that its impact on society is likely to increase. The potential benefits are huge, since everything that civilization has to offer is a product of human intelligence; we cannot predict what we might achieve when this intelligence is magnified by the tools AI may provide, but the eradication of disease and poverty is not unfathomable. Because of the great potential of AI, it is valuable to investigate how to reap its benefits while avoiding potential pitfalls. Progress in AI research makes it timely to focus research not only on making AI more capable, but also on maximizing the societal benefit of AI. Such considerations motivated the AAAI 2008–09 Presidential Panel on Long-Term AI Futures (Horvitz and Selman 2009) and other projects and community efforts on AI's future impacts. These constitute a

significant expansion of the field of AI itself, which up to now has focused largely on techniques that are neutral with respect to purpose. The present document can be viewed as a natural continuation of these efforts, focusing on identifying research directions that can help maximize the societal benefit of AI. This research is by necessity interdisciplinary, because it involves both society and AI. It ranges from economics, law, and philosophy to computer security, formal methods, and, of course, various branches of AI itself. The focus is on delivering AI that is beneficial to society and robust in the sense that the benefits are guaranteed: our AI systems must do what we want them to do. This article was drafted with input from the attendees of the 2015 conference The Future of AI: Opportunities and Challenges (see Acknowledgements), and was the basis for an open letter that has collected nearly 7000 signatures in support of the research priorities outlined here.

Gurkaynak, G.; Yilmaz, I. & Haksever, G. Stifling artificial intelligence: Human perils Computer Law & Security Review, 2016, 32, 749 - 758

Although scientists have calculated the significant positive welfare effects of Artificial Intelligence (AI), fear mongering continues to hinder AI development. If regulations in this sector stifle our active imagination, we risk wasting the true potential of AIs dynamic efficiencies. Not only would Schumpeter dislike us for spoiling creative destruction, but the AI thinkers of the future would also rightfully see our efforts as the 'dark age' of human advancement. This article provides a brief philosophical introduction to artificial intelligence; categorizes artificial intelligence to shed light on what we have and know now and what we might expect from the prospective developments; reflects thoughts of worldwide famous thinkers to broaden our horizons; provides information on the attempts to regulate artificial intelligence from a legal perspective; and discusses how the legal approach needs to be to ensure the balance between artificial intelligence development and human control over them, and to ensure friendly artificial intelligence.

Adami, C. Artificial intelligence: Robots with instincts Nature, Nature Publishing Group, a division of Macmillan Publishers Limited. All Rights Reserved., 2015, 521, 426-427

An evolutionary algorithm has been developed that allows robots to adapt to unforeseen change. The robots learn behaviours quickly and instinctively by mining the memory of their past achievements.

Yao, F.; Zhang, C. & Chen, W. Smart talking robot Xiaotu: participatory library service based on artificial intelligence Library Hi Tech, 2015, 33, 245-260

Purpose – The purpose of this paper is to introduce a participatory library service based on artificial intelligence (AI). Design/methodology/approach – AI technologies and various technologies for facilitating the use of the currently existing libraries and the third-party resources are combined in the new mobile and social networking environments to provide an innovative real-time virtual reference service. Special aesthetic design and library marketing measures are adopted to expand the gains of the service. Questionnaire survey, in-depth interview, and statistical analysis are conducted to evaluate the effects of the service. Findings – A smart talking robot called Xiaotu (female) is developed. This robot is regarded as a promising new online reference service modus operandi. Four factors contribute to the success of the robot, namely, AI, self-learning, vivid logo and language, and modular architecture. Practical implications – Xiaotu presents a participatory library service, in which users participate in the resources collection and become content co-creators. Her presence at anytime and anywhere on any kind of terminal maximizes her potential for the delivery of virtual reference services. Xiaotu has the potential to be a general reference robot or a costumed institute robot. Originality/value – AI is adopted in libraries to form an innovative online reference service. The participatory library service is practiced through a high-featured interactive communication. The aesthetic design of Xiaotu and the related promotions are new in libraries as well.

Aadhityan, A. A Novel Method for Developing Robotics via Artificial Intelligence and Internet of Things CoRR, 2014, abs/1405.3939

This paper describe about a new methodology for developing and improving the robotics field via artificial intelligence and internet of things. Now a day, we can say Artificial Intelligence take the world into robotics. Almost all industries use robots for lot of works. They are use co-operative robots to make different kind of works. But there was some problem to make robot for multi tasks. So there was a necessary new methodology to made multi tasking robots. It will be done only by artificial intelligence and internet of things.

Barakova, E. & Lourens, T. Ferrández Vicente, J. M.; Álvarez Sánchez, J. R.; de la Paz López, Fé. & Toledo Moreo, F. J. (Eds.) Interplay between Natural and Artificial Intelligence in Training Autistic Children with Robots Natural and Artificial Models in Computation and Biology: 5th International Work-Conference on the Interplay Between Natural and Artificial Computation, IWINAC 2013, Mallorca, Spain, June 10-14, 2013. Proceedings, Part I, Springer Berlin Heidelberg, 2013, 161-170

The need to understand and model human-like behavior and intelligence has been embraced by a multidisciplinary community for several decades. The success so far has been shown in solutions for a concrete task or a competence, and these solutions are seldom a truly multidisciplinary effort. In this paper we analyze the needs and the opportunities for combining artificial intelligence and bio-inspired computation within an application domain that provides a cluster of solutions instead of searching for a solution to a single task. We analyze applications of training children with autism spectrum disorder (ASD) with a humanoid robot, because it must include multidisciplinary effort and at the same time there is a clear need for better models of human-like behavior which will be tested in real life scenarios through these robots. We designed, implemented, and carried out three applied behavior analysis (ABA) based robot interventions. All interventions aim to promote self initiated social behavior in children with ASD. We found out that the standardization of the robot training scenarios and using unified robot platforms can be an enabler for integrating multiple intelligent and bio-inspired algorithms for creation of tailored, but domain specific robot skills and competencies. This approach might set a new trend to how artificial and bio-inspired robot applications develop. We suggest that social computing techniques are a pragmatic solution to creation of standardized training scenarios and therefore enable the replacement of perceivably intelligent robot behaviors with truly intelligent ones.

Abdullah, N. N. B.; Sharp, H. & Honiden, S. How Artefacts Influence the Construction of Communications and Contexts during Collaboration in an Agile Software Development Team FLAIRS Conference, 2011

This paper reports a cognitive ethnography study on the communication process of an Agile software development team in an industry. The aim of the study is to understand how physical artefacts influence the construction of communications during collaboration. We used a stimulus and response method to uncover correlation patterns of the physical artefact-communication during specific contexts of communications. We found preliminary evidence that the physical artefacts influence the communication process in a mutually constraining relationship with the contexts. In which the context is made up of the teams' practice that includes how they collaborate, the physical setting, situations, and participation role.

Waser, M. R. Discovering the foundations of a universal system of ethics as a road to safe artificial intelligence Books International, 2008

Intelligent machines are a risk to our freedom and our existence unless we take adequate precautions. In order to survive and thrive, we are going to have to teach them how to be nice to us and why they should do so. The fact that humans have evolved to have what appear to be multiple different systems of ethics and morality that frequently conflict on any but the simplest issues complicates this task. Most people have interpreted these conflicts, caused by the fact that each of the systems is incompletely evolved and incorrectly universalized, to mean that no reasonably simple foundation exists for the determination of the correctness or morality of any given action. This paper will solve this problem by defining a universal foundation for ethics that is an attractor in the state space of intelligent behavior, giving an initial set of definitions necessary for a universal system of ethics and proposing a collaborative approach to developing an ethical system that is safe and extensible, immediately applicable to human affairs in preparation for an ethical artificial intelligence (AI), and has the side benefit of actually helping to determine the internal knowledge representation of humans as a step towards AI.

Birmingham, W. TOWARDS AN UNDERSTANDING OF ARTIFICIAL INTELLIGENCE AND ITS APPLICATION TO ETHICS American Society for Engineering Education, 2008

Artificial intelligence (AI) is a broadly defined discipline involving computer science, engineering, philosophy, psychology, political science, and a host of other disciplines. Because AI is so broad, it is hard to succinctly define; for the sake of brevity, we will use the handle of “thinking machines,” without commitment to depths of this thinking. The machines that AI researchers develop are unlike any machines ever built in history. Before AI, machines were constructed only as a mean to perform work. Machines were mostly built to save labor, entertain, or measure things. While classic literature has stories of machines (Pinocchio) or statues (Pygmalion) coming to life, the scientific and technical communities did not, until recently, believe there was any real possibility of such a thinking or acting

machine. The technological breakthroughs of cheap, easy-to-use, large-scale artificial memory and computation radically changed the conception of what machines were capable of doing. In a landmark paper, Turing challenged the scientific and technical communities to create machines that could make humans believe they were interacting with another machine.2 That is, Turing desired machines that could think and act similar to a human being, i.e., artificial, non-organic, non-evolved human-like machines. Thus, the idea that a machine could have the distinctly human abilities of thinking and self-reflection entered the scientific and engineering realms. In some way, the AI enterprise can be considered a response to Turing's challenge, where engineers are developing ever more powerful thinking machines, eventually leading to machines that some might believe are indistinguishable from humans. The creation of more complex artificial agents inevitably leads to a question of what constitutes humanness, which in many AI circles is, by and large, rooted in a view that is materialistic and purely rationalistic.6 The nearly uniformly held position of AI researchers is that once we have created the proper rational superintelligent machine, scientists and engineers will have fulfilled the goals of AI. The philosophical discussion in AI centers on the functionality (computation and memory) needed to get the right kind of rational thinking machine that will necessarily yield human (-like) machines. The position held by many is that it is simply a matter of time until we hit upon the right mix. By and large, the critics of AI do not dispute the prevailing view; rather, they argue against or for a particular technology or function that will lead to human-like behavior. Or, that it currently technology cannot possibly supply these functions. The reduction of humanness to computing ability and memory is disconcerting to those trained in or strongly influence by humanist traditions that ascribe inherent dignity to the human person. We contend that, for example, those drawing from philosophical traditions influenced by Thomas Aquinas, would argue that while rational thinking is an important element of what humans do, defining humanness by “the right mix” of the rational functions we perform or even the way we think is problematic. Other philosophical traditions, such as personalism or phenomenology in the 20th century, would also argue for a richer conception of humanness than a view of humanness predicated on mere functionality. This paper proposes to present an account of humanness distinctive from that offered by many working in the AI field and an argument those working in AI should take this view seriously; moreover, this paper will argue that, while AI cannot re-create humanness, AI can be enthusiastically accepted and utilized by those committed to the main currents of the Western intellectual tradition, either religious or purely humanistic.

Dautenhahn, K. Lungarella, M.; Iida, F.; Bongard, J. & Pfeifer, R. (Eds.) A Paradigm Shift in Artificial Intelligence: Why Social Intelligence Matters in the Design and Development of Robots with Human-Like Intelligence 50 Years of Artificial Intelligence: Essays Dedicated to the 50th Anniversary of Artificial Intelligence, Springer Berlin Heidelberg, 2007, 288-302

The chapter discusses a recent paradigm shift in the field of Artificial Intelligence regarding the nature of human intelligence and its implications for the design and development of intelligent robots. It will be argued that social intelligence is not a mere ‘add-on’ to intelligent robot behaviour for the practical purpose of enabling the robot to interact smoothly with other robots or people, but that social intelligence might be a stepping stone towards more human-like, embodied artificial intelligence. The argument is supported by discussions in primatology highlighting the social origins of primate intelligence. The chapter also discusses challenges and opportunities provided by socially intelligent robots, with implications for our future.

Geraci, R. M. Robots and the Sacred in Science and Science Fiction: Theological Implications of Artificial Intelligence Zygon®, Blackwell Publishing Ltd, 2007, 42, 961-980

In science-fiction literature and film, human beings simultaneously feel fear and allure in the presence of intelligent machines, an experience that approximates the numinous experience as described in 1917 by Rudolph Otto. Otto believed that two chief elements characterize the numinous experience: the *mysterium tremendum*and the *fascinans.* Briefly, the *mysterium tremendum* is the fear of God's wholly other nature and the *fascinans* is the allure of God's saving grace. Science-fiction representations of robots and artificially intelligent computers follow this logic of threatening otherness and soteriological promise. Science fiction offers empirical support for Anne Foerst's claim that human beings experience fear and fascination in the presence of advanced robots from the Massachusetts Institute of Technology AI Lab. The human reaction to intelligent machines shows that human beings in many respects have elevated those machines to divine status. This machine apotheosis, an interesting cultural event for the history of religions, may—despite Foerst's rosy interpretation—threaten traditional Christian theologies.

Lund, H. H. Modern artificial intelligence for human-robot interaction Proceedings of the IEEE, 2004, 92, 1821-1838

Interaction between humans and traditional robotic systems can be problematic, as the traditional robotic systems often perform repetitive actions in a restricted environment, whereas human interaction is often characterized by novel ways of interactions, which creates an ever-changing environment. Therefore, traditional robotic system methods and technologies are often difficult to apply in situations and applications where the interaction plays a major role. So we developed a new kind of user-guided behavior-based robotics and applied this method to both mobile and humanoid robots, in order to investigate how nonexpert users could develop their own complex robot behaviors within a very short time (e.g., 30-60 min) with no prior knowledge of the robot technology. In the development of the team of humanoid robots, Viki, we used a modern approach to artificial intelligence that puts emphasis on the balance between control, electronic hardware, material, sensory system, and energy. It is possible to develop simple user interfaces with the user-guided behavior-based approach, in order to allow any user to design performances with the humanoid robots. However, we should not only look at the control of robots when designing human-robot interactions, but also on the physical aspects of the robotic system. Therefore, the novel concept of "programming by building" is introduced and exemplified with the creation of a prototype system consisting of building blocks with individual processing and communication capabilities. By assembling such building blocks, the user develops both the physical aspects and the functionality of the robotic system in an easy manner with no need to use a host computer or a traditional programming language. The approach is further exemplified with the implementation of neural building blocks that can later be trained by the user.

Tavani, H. T. Ethics and Technology: Ethical Issues in an Age of Information and Communication Technology Acm Sigcas Computers and Society, 2003, 33, 1

Perri, 6 ETHICS, REGULATION AND THE NEW ARTIFICIAL INTELLIGENCE, PART I: ACCOUNTABILITY AND POWER Information, Communication & Society, 2001, 4, 199-229

A generation ago, there was a major debate about the social and ethical implications of artificial intelligence (AI). Interest in that debate waned from the late 1980s. However, both patterns of public risk perception and new technological developments suggest that it is time to re-open that debate. The important issues about AI arise in connection with the prospect of robotic and digital agent systems taking socially significant decisions autonomously. Now that this is possible, the key concerns are now about which decisions should be and which should not be delegated to machines, issues of regulation in the broad sense covering everything from consumer information through codes of professional ethics for designers to statutory controls, issues of design responsibility and problems of liability.

# v. DESIGN PROCESS

## Search methodology

As previously explained, being the search for the term "design process" too generic, it was necessary to add the "robot" keyword for all subsequent bibliographic searches.

The documents considered are peer reviews i.e. articles, reviews, conference papers and book chapters.

Increasing interest in “Design Process” starts in 2002.

Analysing the relationship between "design process" and "robot" it is observed that after a slight decrease in the interest since 2011, starting from 2014 publication number increased again.

Moreover, it is observable the emergence in recent years of publications that relate the "design process" with "cyber physical system", a term used to describe a mechanism controlled or monitored by computer-based algorithms, tightly integrated with the Internet and its users.

## Database queries

| Search Queries in Scopus | SCOPUS hits |
|---|---|
| **“design proccess” AND robot** | |

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|---|---|
| Publication year > 1982 | 974 |
| **“design proccess” AND robot AND learning** | |
| Publication year > 2001 | |
| AND Search term in the title | 0 |
| AND Search term in keywords | 17 |
| AND Search term in abstract | 46 |
| AND Search term in abstract, keywords, title | 71 |
| **“design proccess” AND robot AND “collaborative learning”** | |
| Publication year > 2001 | |
| AND Search term in the title | 0 |
| AND Search term in keywords | 0 |
| AND Search term in abstract | 3 |
| AND Search term in abstract, keywords, title | 3 |
| **“design proccess” AND robot AND ethics** | |
| Publication year > 2001 | |
| AND Search term in the title | 0 |
| AND Search term in keywords | 1 |
| AND Search term in abstract | 4 |
| AND Search term in abstract, keywords, title | 6 |
| **“design proccess” AND robot AND human** | |
| Publication year > 2001 | |
| AND Search term in the title | 1 |
| AND Search term in keywords | 47 |
| AND Search term in abstract | 96 |
| AND Search term in abstract, keywords, title | 172 |
| **“design proccess” AND robot AND user*** | |
| Publication year > 2001 | |
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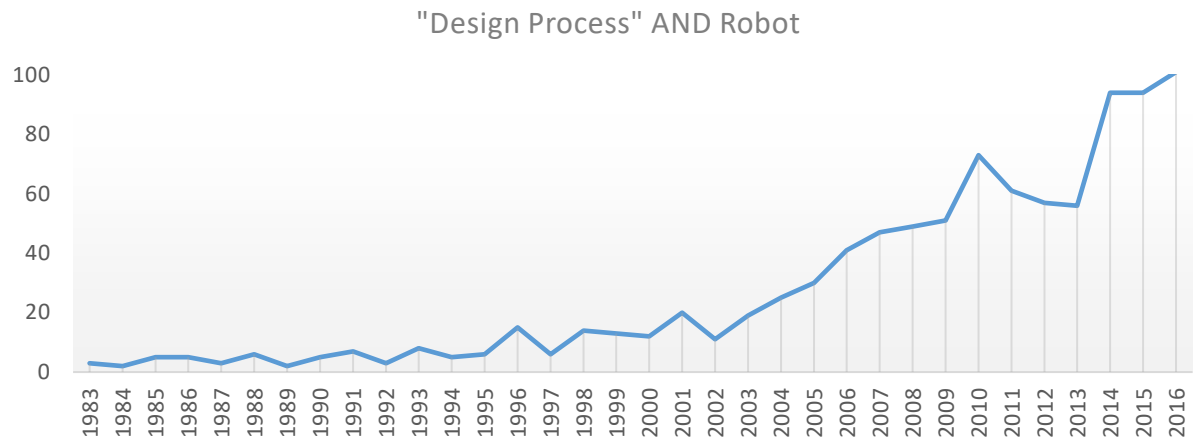
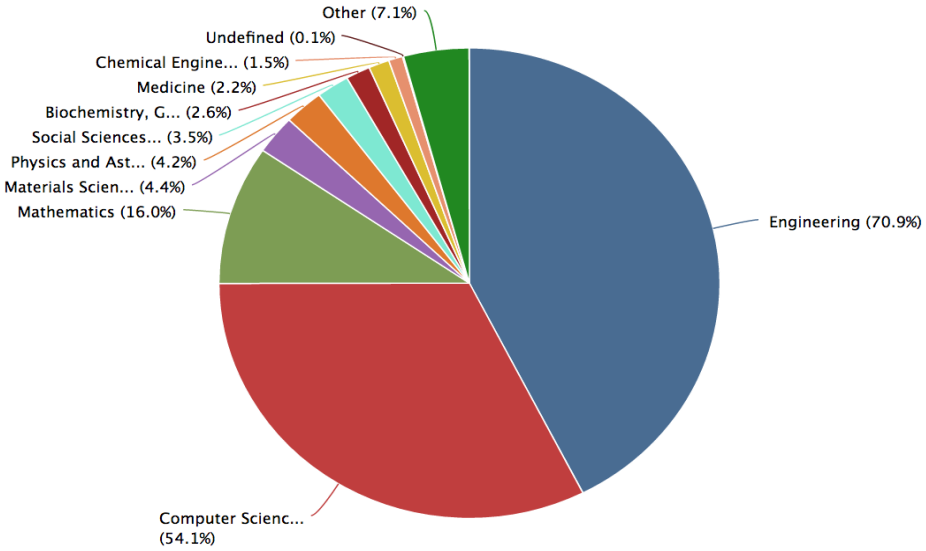
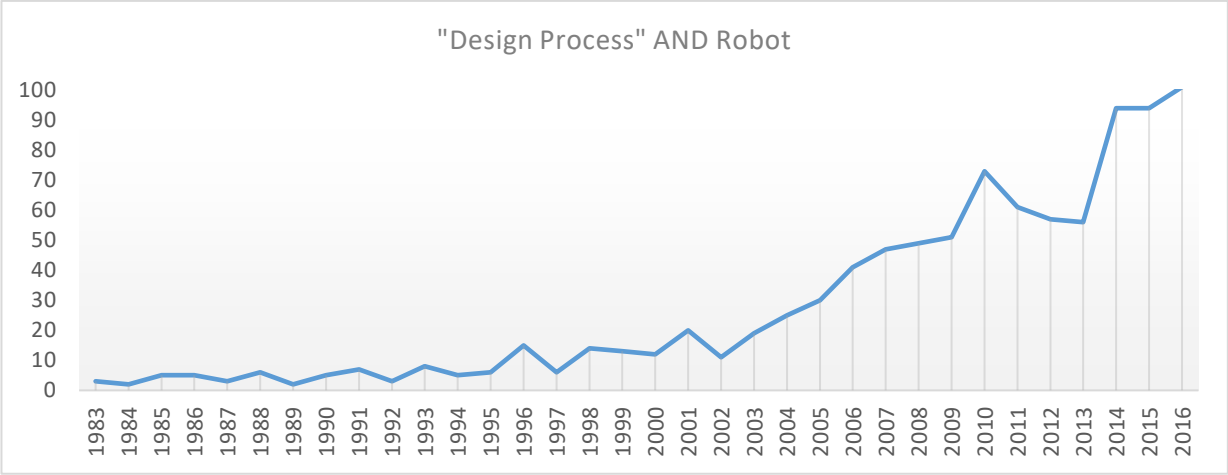
## Charts and trends




The research areas in which the attention for "design process" AND Robot is more focused are scientific ones. In particular Engineering, Computer Science and Mathematics.




"Design Process" AND Robot
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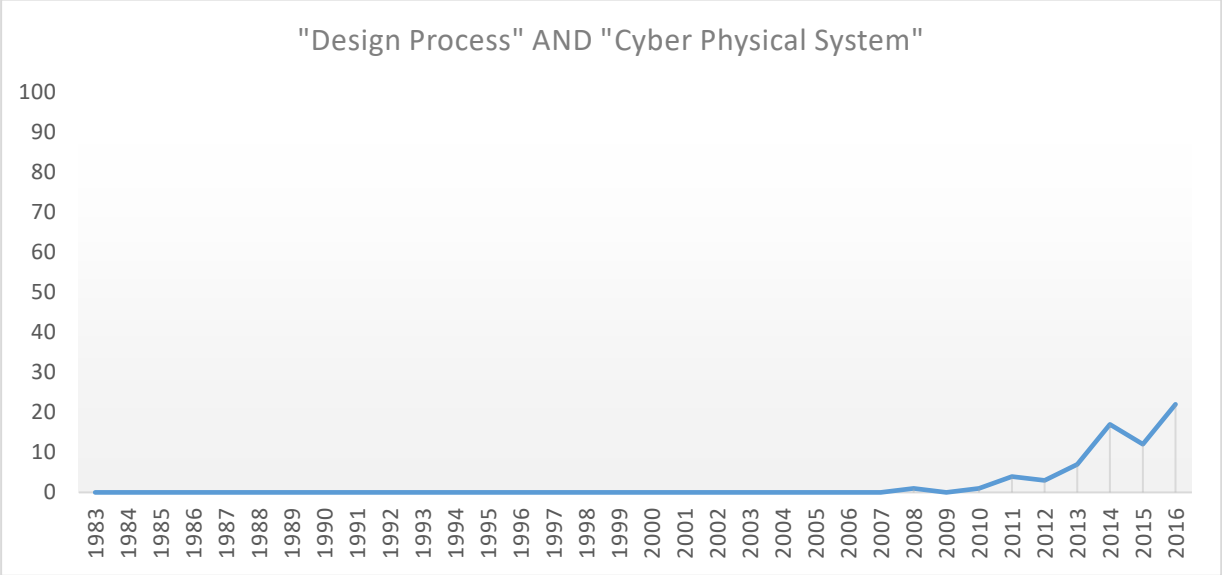
"Design Process" AND "Cyber Physical System"
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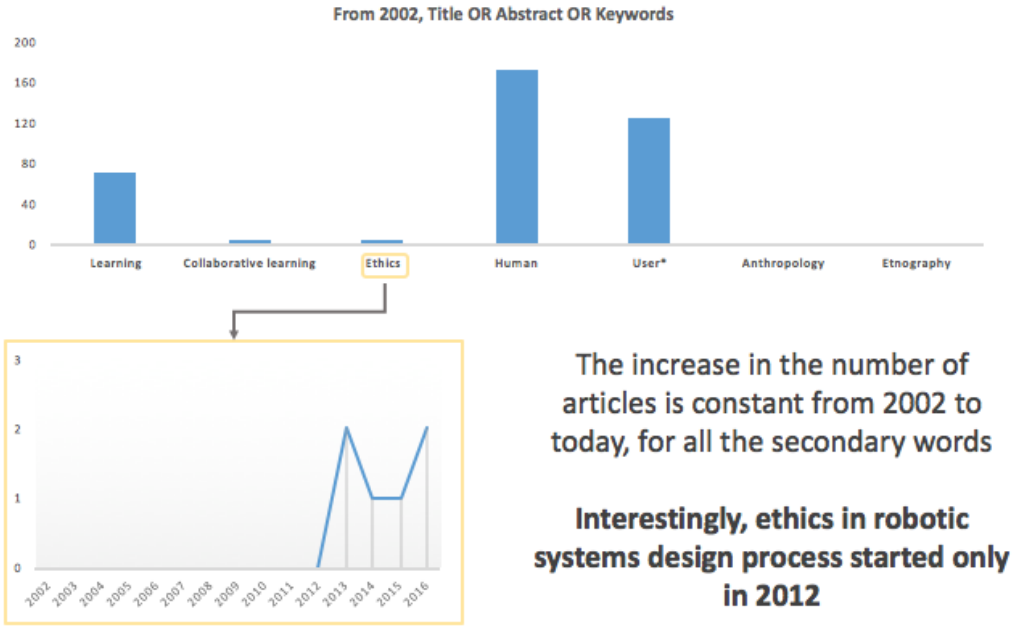



## Selected literature

Arroyo, D., Lucho, C., Cisneros, P., & Cuellar, F. (2014, October). Prime: Towards the Design of a Small Interactive Office Robot. In International Conference on Social Robotics (pp. 34-43). Springer International Publishing.

ABSTRACT "This paper presents the design and implementation of Prime, a small interactive office robot with features to support daily office activities by transporting small desktop supplies, carrying reminder notes and performing other gadget utilities. In order to create an effective inclusion of the robot in this particular workspace, the design of Prime is centered in three important aspects: functionality, aesthetics and interaction. This work is an exploratory research aimed to study the novel inclusion of small service robots in office environments and serve as a research platform to conduct human-robot interaction theories and experiments. The design and implementation of the presented robot results from an interdisciplinary work, including a survey to define Prime's functionality and behavior in response to specific office needs, as well as its design process that comprehends sketching, scale modeling and 3D prototyping."

Asaro, P. M. (2006). What should we want from a robot ethic. International Review of Information Ethics, 6(12), 9-16.

ABSTRACT "There are at least three things we might mean by "ethics in robotics": the ethical systems built into robots, the ethics of people who design and use robots, and the ethics of how people treat robots. This paper argues that the best approach to robot ethics is one which addresses all three of these, and to do this it ought to consider robots as socio-technical systems. By so doing, it is possible to think of a continuum of agency that lies between amoral and fully autonomous moral agents. Thus, robots might move gradually along this continuum as they acquire greater capabilities and ethical sophistication. It also argues that many of the issues regarding the distribution of responsibility in complex socio-technical systems might best be addressed by looking to legal theory, rather than moral theory. This is because our overarching interest in robot ethics ought to be the practical one of preventing robots from doing harm, as well as preventing humans from unjustly avoiding responsibility for their actions."

Avalos, H. M., Calderón, I. C., Hernández, S. R., & Morales, V. C. (2015). Concept Design Process for Robotic Devices: The Case of an Assistive Robot. In *Multibody Mechatronic Systems* (pp. 295-304). Springer International Publishing.

ABSTRACT "Current demands for continuous innovation have made the product design and development process a branch of engineering itself. Several techniques have been proposed to address the problem of developing a new

product in a systematic way. In this paper we use some of these techniques and adjust them to carry out the conceptual design of a robot for assistance and rehabilitation of elderly and disabled persons."

Eroğlu, A. K., Erden, Z., & Erden, A. (2011, April). Bioinspired conceptual design (BICD) approach for hybrid bioinspired robot design process. In *Mechatronics (ICM), 2011 IEEE International Conference on* (pp. 905-910). IEEE.

ABSTRACT "The term "Bioinspired" represents translation of any idea, structure, process, and/or material from biological domain into engineering domain to increase human comfort. Creative and innovative engineering processes and products are the expected outputs of this approach. A systematic Bioinspired Design (BID) methodology is required to guide the translation process. This paper introduces a preliminary study on a new Bioinspired Conceptual Design (BICD) approach. The BICD aims at developing concept variants for hybrid bioinspired robots based on inspirations from multiple biological systems."

Friedman, B., & Kahn Jr, P. H. (2003). Human values, ethics, and design. The human-computer interaction handbook, 1177-1201.

Gero, J. S. (1990). Design prototypes: a knowledge representation schema for design. *AI magazine*, *11*(4), 26.

ABSTRACT "This article begins with an elaboration of models of design as a process. It then introduces and describes a knowledge representation schema for design called design prototypes. This schema supports the initiation and continuation of the act of designing. Design prototypes are shown to provide a suitable framework to distinguish routine, innovative, and creative design."

Gonçalves, D., & Arsenio, A. (2015, February). Human-driven multi-robot design process for social interactions with children on complex environments. In *Automation, Robotics and Applications (ICARA), 2015 6th International Conference on* (pp. 70-76). IEEE.

ABSTRACT "Robots have been traditionally in operation away from people, for instance in industrial environments. More recently, there has been a trend for bringing robots to market for helping people. In particular, children constitute a challenging group for robot interaction, due to their curiosity and energy, as well as safety concerns. This paper describes the construction process of an external structure for a fleet of mobile robots designed for interactions with children in a hospital environment. We address several challenges on the design process, critical for the robots to be able to operate safely, while interacting socially, among a group of children with specific needs."

Haik, Y., Sivaloganathan, S., & Shahin, T. M. (2015). *Engineering design process*. Cengage Learning.

Koumpouros, Y. (2016). A systematic review on existing measures for the subjective assessment of rehabilitation and assistive robot devices. *Journal of healthcare engineering*, *2016*.

ABSTRACT "The objective of the current study is to identify and classify outcome measures currently used for the assessment of rehabilitation or assistive robot devices. We conducted a systematic review of the literature using PubMed, MEDLINE, CIRRIE, and Scopus databases for studies that assessed rehabilitation or assistive robot devices from 1980 through January 2016. In all, 31 articles met all inclusion criteria. Tailor-made questionnaires were the most commonly used tool at 66.7%, while the great majority (93.9%) of the studies used nonvalidated instruments. The study reveals the absence of a standard scale which makes it difficult to compare the results from different researchers. There is a great need, therefore, for a valid and reliable instrument to be available for use by the intended end users for the subjective assessment of robot devices. The study concludes by identifying two scales that have been validated in general assistive technology devices and could support the scope of subjective assessment in rehabilitation or assistive robots (however, with limited coverage) and a new one called PYTHEIA, recently published. The latter intends to close the gap and help researchers and developers to evaluate, assess, and produce products that satisfy the real needs of the end users."

Lattmann, Z., Klingler, J., Meijer, P., Scott, J., Neema, S., Bapty, T., & Karsai, G. (2015, October). Towards an analysis-driven rapid design process for cyber-physical systems. In *Rapid System Prototyping (RSP), 2015 International Symposium on* (pp. 90-96). IEEE.

ABSTRACT "System design typically involves the specification of requirements and evaluation of the design with respect to those requirements. The requirements describe and quantify the desired physical and software properties of the system. Evaluating requirements often involves performing domain-specific analysis. Domain-specific analyses are spread across a wide range of domains and tools, e.g., geometric properties vs. dynamics behavior of the system. Different analysis types require different tools, where each tool targets a narrow range of domains or a single domain. For large system designs, the requirements could be too complex to be evaluated by a single analysis tool. In such

cases, the coupling of multiple domains and analysis tools is inevitable, and managing these interactions can prove to be difficult, often leading to wasted efforts. In this paper we present an analysis-driven rapid design process for Cyber-Physical Systems that spans multiple domain models and various analysis tools from a wide range of domains, and helps to reduce the design time through the following: (1) revealing and tracking instances of cross-domain coupling, thereby reducing design time; (2) disqualifying non-viable design configurations; and (3) using analysis templates for continuous design evolution with respect to the requirements; minor adjustments to requirements can be done seamlessly, without a complete redesign of the existing reusable analysis templates. Furthermore, we present a case study for an automotive driveline design to demonstrate an implementation of this process."

Murphy, R., Rice, A., Rashidi, N., Henkel, Z., & Srinivasan, V. (2011, May). A multi-disciplinary design process for affective robots: Case study of survivor buddy 2.0. In *Robotics and Automation (ICRA), 2011 IEEE International Conference on* (pp. 701-706). IEEE.

Ugural, A. C. (2016). *Mechanical Design of Machine Components: SI Version*. CRC Press.

Van Wynsberghe, A. (2013). Designing robots for care: Care centered value-sensitive design. *Science and engineering ethics*, *19*(2), 407-433.

ABSTRACT "The prospective robots in healthcare intended to be included within the conclave of the nurse-patient relationship—what I refer to as *care* robots—require rigorous ethical reflection to ensure their design and introduction do not impede the promotion of values and the dignity of patients at such a vulnerable and sensitive time in their lives. The ethical evaluation of care robots requires insight into the values at stake in the healthcare tradition. What's more, given the stage of their development and lack of standards provided by the International Organization for Standardization to guide their development, ethics ought to be included into the design process of such robots. The manner in which this may be accomplished, as presented here, uses the blueprint of the Value-sensitive design approach as a means for creating a framework tailored to care contexts. Using care values as the foundational values to be integrated into a technology and using the elements in care, from the care ethics perspective, as the normative criteria, the resulting approach may be referred to as care centered value-sensitive design. The framework proposed here allows for the ethical evaluation of care robots both retrospectively and prospectively. By evaluating care robots in this way, we may ultimately ask what kind of care we, as a society, want to provide in the future."

Van Wynsberghe, A. (2016). Service robots, care ethics, and design. *Ethics and Information Technology*, *18*(4), 311-321.

ABSTRACT "It should not be a surprise in the near future to encounter either a personal or a professional service robot in our homes and/or our work places: according to the International Federation for Robots, there will be approx 35 million service robots at work by 2018. Given that individuals will interact and even cooperate with these service robots, their design and development demand ethical attention. With this in mind I suggest the use of an approach for incorporating ethics into the design process of robots known as Care Centered Value Sensitive Design (CCVSD). Although this approach was originally and intentionally designed for the healthcare domain, the aim of this paper is to present a preliminary study of how personal and professional service robots might also be evaluated using the CCVSD approach. The normative foundations for CCVSD come from its reliance on the care ethics tradition and in particular the use of care practices for: (1) structuring the analysis and, (2) determining the values of ethical import. To apply CCVSD outside of healthcare one must show that the robot has been integrated into a care practice. Accordingly, the practice into which the robot is to be used must be assessed and shown to meet the conditions of a care practice. By investigating the foundations of the approach I hope to show why it may be applicable for service robots and further to give examples of current robot prototypes that can and cannot be evaluated using CCVSD."

# vi. SCIENCE AND TECHNOLOGY STUDIES (STS)

## Search methodology

We began with an initial search into STS, from which we identified two search queries for further exploration: "STS + robot" and "STS + robotics" (or "STS + robot*"). We have searched the three databases - ERIC, SCOPUS, and ANTHROSOURCE - for these queries and have compiled the abstracts

here. We performed subsequent searches in STS databases for "robot*" and included more organic search processes based on disciplinary knowledge (e.g. searching a known scholar's name).

| Search terms | ERIC | SCOPUS | AnthroSource |
|---|---|---|---|
| "STS" AND "robotics" | **31** | **111** | **42** |
| "STS" AND "robot" | **9** | **79** | **5** |
| "STS" AND "robot*" [includes "robot," "robots," & "robotics"] | --- | **167** | --- |

For AnthroSource, we repeated searches to include known STS scholars because the results from the searches had been largely irrelevant. Even when searching for known authors, it is difficult to find relevant texts. A literature search depends on selecting the right journals/databases, recognizing known scholars, distinguishing between relevant and irrelevant texts, knowing how the database search functions [See Database Guide].

*Table 1 Search within AnthroSource results, to include known scholars' names*

| Additional search terms | Scholars' names | AND "STS" (42) AND "robotics" | AND "robot" (248) | AND "STS" (836) | AND "robotics" (123) |
|---|---|---|---|---|---|
| "Alac" | Morana Alac | 0 | 1 | 2 | 1 |
| "Haraway" | Donna Haraway | 3 | 20 | 31 | 10 |
| "Hasse" | Cathrine Hasse | 0 | 0 | 0 | 0 |
| "Richardson" | Kathleen Richardson | 2 | 11 | 78 | 44 |
| "Robertson" | Jennifer Robertson | 0 | 33 | 18 | 3 |
| "Sabanovic" | Selma Sabanovic | 0 | 0 | 0 | 0 |
| "Suchman" | Lucy Suchman | 2 | 5 | 13 | 6 |

Of the 42 results in AnthroSource for "STS" and "robotics", the search terms "Suchman" and "Richardson" appeared in two texts, and "Haraway" in three; none of the texts were authored by the specified scholars. "Sabanovic", "Robertson", "Hasse", and "Alac" did not appear in any of the 42 texts. This suggests that our search string in AnthroSource ("STS" and "robotics") is not returning the most relevant results.

## Database queries

Following an initial search for the field "science and technology studies" and its abbreviation "STS", we repeated the search for "robot*" in STS databases and with secondary search terms.

### STS Databases

A search of Science and Technology Studies archives (journal of EASST) did not return any hits for *robot(s), roboticist(s),* or *robotic(s).*

A search of Science, Technology, & Human Values (journal of the Society for Social Studies of Science), in the database JSTOR, returned the following hits:

*Table 2: Results from STS journal: Science, Technology, & Human Values*

| | | |
|---|---|---|
| **robot*** | (robot*) AND jid:(j101008 OR j100744 OR j100550) | **61** |
| robot | (robot) AND jid:(j101008 OR j100744 OR j100550) | 27 |
| robots | (robots) AND jid:(j101008 OR j100744 OR j100550) | 24 |
| robotic | (robotic) AND jid:(j101008 OR j100744 OR j100550) | 13 |
| robotics | (robotics) AND jid:(j101008 OR j100744 OR j100550) | 21 |
| roboticist | (roboticist) AND jid:(j101008 OR j100744 OR j100550) | 1 |
| roboticists | (roboticists) AND jid:(j101008 OR j100744 OR j100550) | 5 |

## Comparative results in databases ERIC, SCOPUS, and AnthroSource

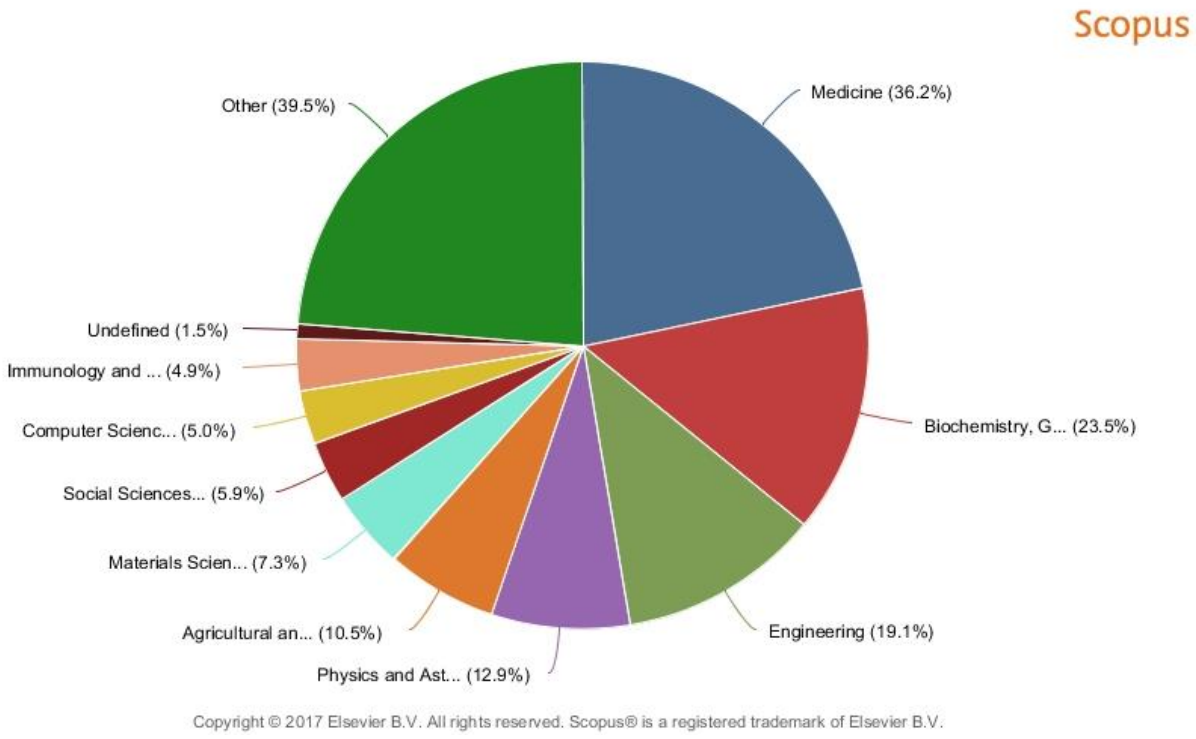
*Table 3: Comparison of results from the databases ERIC, SCOPUS, and AnthroSource*

| Search words | ERIC | SCOPUS | AnthroSource |
|---|---|---|---|
| **"STS"** | **17,040** | **20,988** | **835** |
| "STS" AND "work" | 1,341 | 3,161 | 729 |
| "STS" AND "design" | 1,749 | 1,976 | 409 |
| "STS" AND "ethic*" | 314 | 137 | 352 |
| "STS" AND "labour" / "labor" | 2,896 | 71 | 296 |
| "STS" AND "science and technology" | 1,291 | 554 | 211 |
| "STS" AND "case study" | 1,295 | 226 | 209 |
| "STS" AND "machine" | 101 | 209 | 166 |
| "STS" AND "robotics" | 31 | 111 | 42 |
| "STS" AND "Arendt" | 4 | 0 | 31 |
| "STS" AND "artificial life" | 2 | 0 | 6 |
| "STS" AND "artificial intelligence" | 18 | 68 | 5 |
| "STS" AND "robot" | 9 | 79 | 5 |
| "STS" AND "HRI" | 0 | 0 | 2 |
| "STS" AND "posthuman" | 3 | 1 | 2 |
| "STS" AND "collaborative learning" | 388 | 3 | 0 |
| "STS" AND "human-robot" | 0 | 0 | 0 |
| "STS" AND "machine learning" | 42 | 16 | 0 |
| "STS" AND "triple helix" | 1 | 2 | 0 |
| | | | |
| **"science and technology"** | **36,938** | **75,689** | **2108** |
| "science and technology" AND "work" | 5,254 | 7,631 | 2008 |
| "science and technology" AND "design" | 6,315 | 8,165 | 1292 |
| "science and technology" AND "labour" / "labor" | 44,084 | 540 | 1185 |
| "science and technology" AND "ethic*" | 629 | 1,126 | 1182 |
| "science and technology" AND "case study" | 2,835 | 1,728 | 937 |
| "science and technology" AND "machine" | 728 | 1,884 | 558 |
| "science and technology" AND "Arendt" | 5 | 3 | 112 |
| "science and technology" AND "robot" | 132 | 555 | 79 |
| "science and technology" AND "artificial intelligence" | 264 | 729 | 26 |
| "science and technology" AND "artificial life" | 18 | 12 | 18 |
| "science and technology" AND "robotics" | 323 | 568 | 14 |
| "science and technology" AND "posthuman" | 5 | 8 | 7 |
| "science and technology" AND "machine learning" | 274 | 226 | 2 |
| "science and technology" AND "human-robot" | 1 | 45 | 1 |
| "science and technology" AND "collaborative learning" | 972 | 54 | 1 |
| "science and technology" AND "triple helix" | 6 | 42 | 0 |
| "science and technology" AND "HRI" | 1 | 6 | 0 |
| | | | |
| **"science and technology studies"** | --- | 1,525 | --- |
| "science and technology studies" AND "work" | --- | 418 | --- |
| "science and technology studies" AND "design" | --- | 203 | --- |
| "science and technology studies" AND "labour" / "labor" | --- | 33 | --- |
| "science and technology studies" AND "ethic*" | --- | 135 | --- |

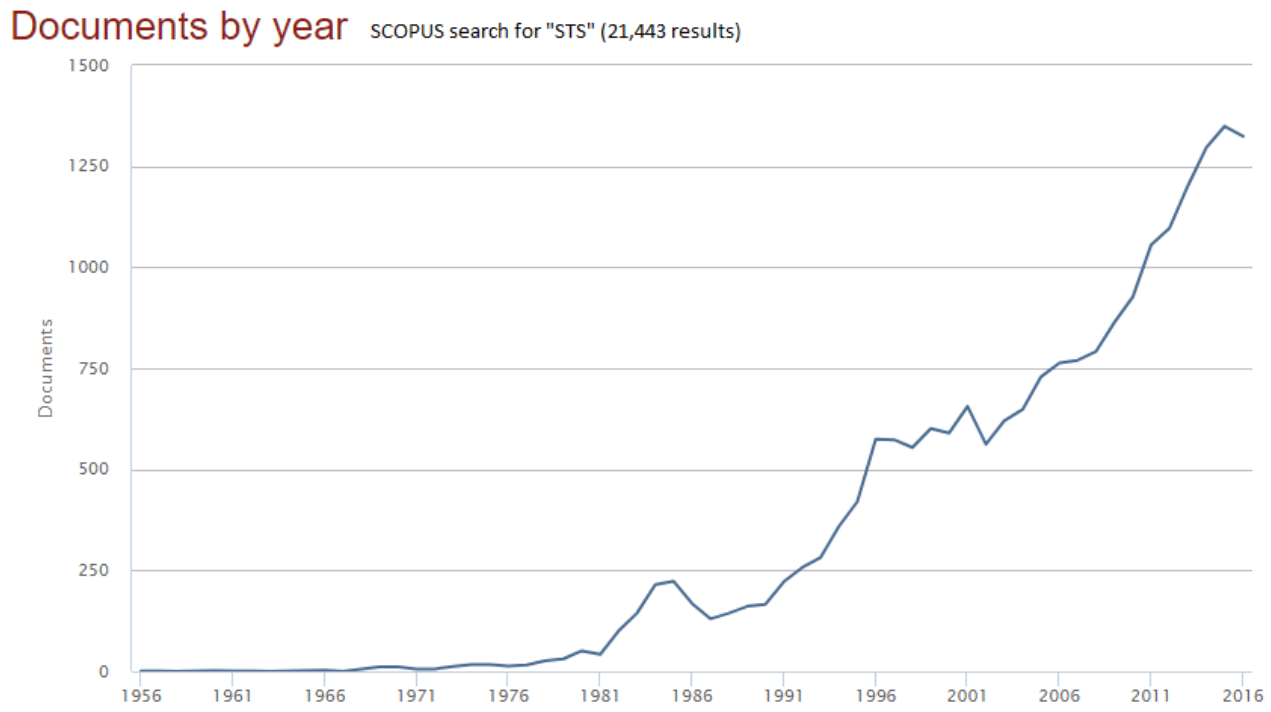
| | | | |
|---|---|---|---|
| “science and technology studies” AND “case study” | --- | 167 | --- |
| “science and technology studies” AND “machine” | --- | 32 | --- |
| “science and technology studies” AND “Arendt” | --- | 0 | --- |
| “science and technology studies” AND “robot*” | --- | 22 | --- |
| “science and technology studies” AND “artificial intelligence” | --- | 12 | --- |
| “science and technology studies” AND “artificial life” | --- | 4 | --- |
| “science and technology studies” AND “posthuman” | --- | 2 | --- |
| “science and technology studies” AND “machine learning” | --- | 1 | --- |
| “science and technology studies” AND “human-robot” | --- | 3 | --- |
| “science and technology studies” AND “collaborative learning” | --- | 0 | --- |
| “science and technology studies” AND “triple helix” | --- | 0 | --- |
| “science and technology studies” AND “HRI” | --- | 0 | --- |

## Charts and trends

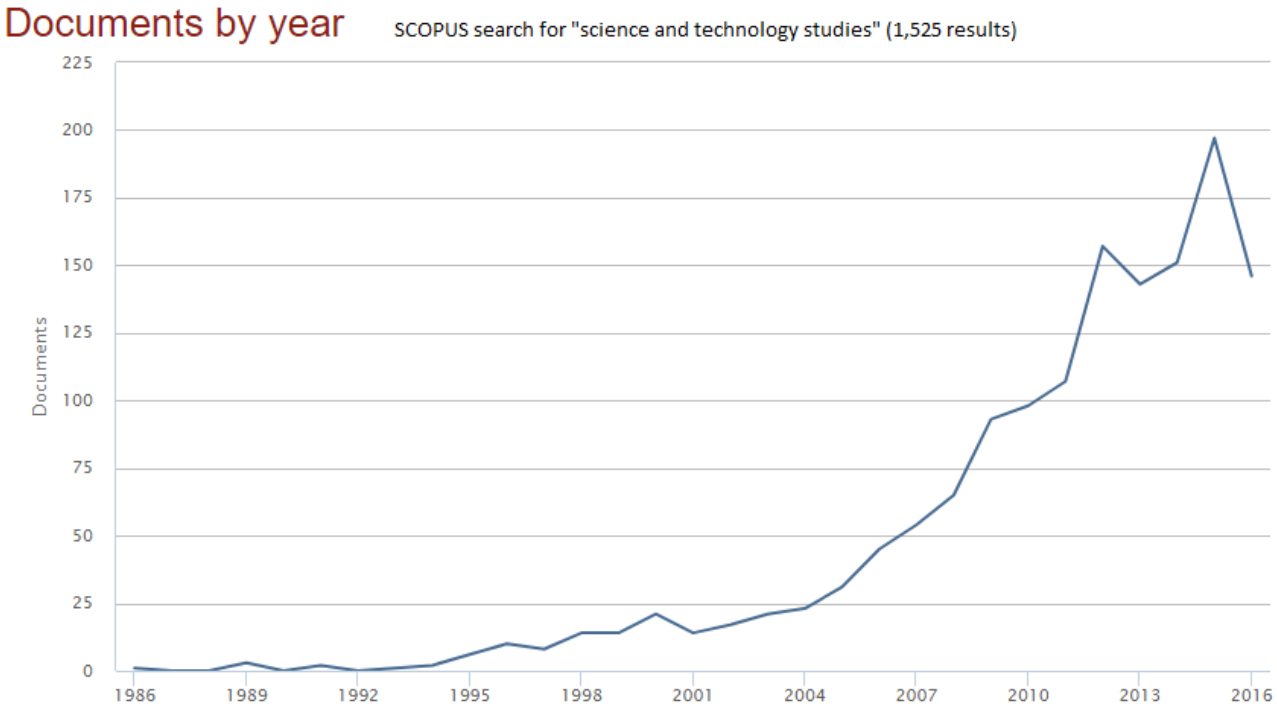
A search of SCOPUS for STS returned far too many hits for review. Most of the results were in medicine, biochemistry, and engineering and did not reflect the significant social sciences presence in the field of Science and Technology Studies. The ambiguity of STS as a search term led to very mixed results. These results were not useful in selecting literature, but demonstrate the iterative search and review process necessary to return relevant results. The following graph shows the roughly 21,000 results for “STS” in SCOPUS, as categorized by subject area (a single text can belong to multiple subject areas).



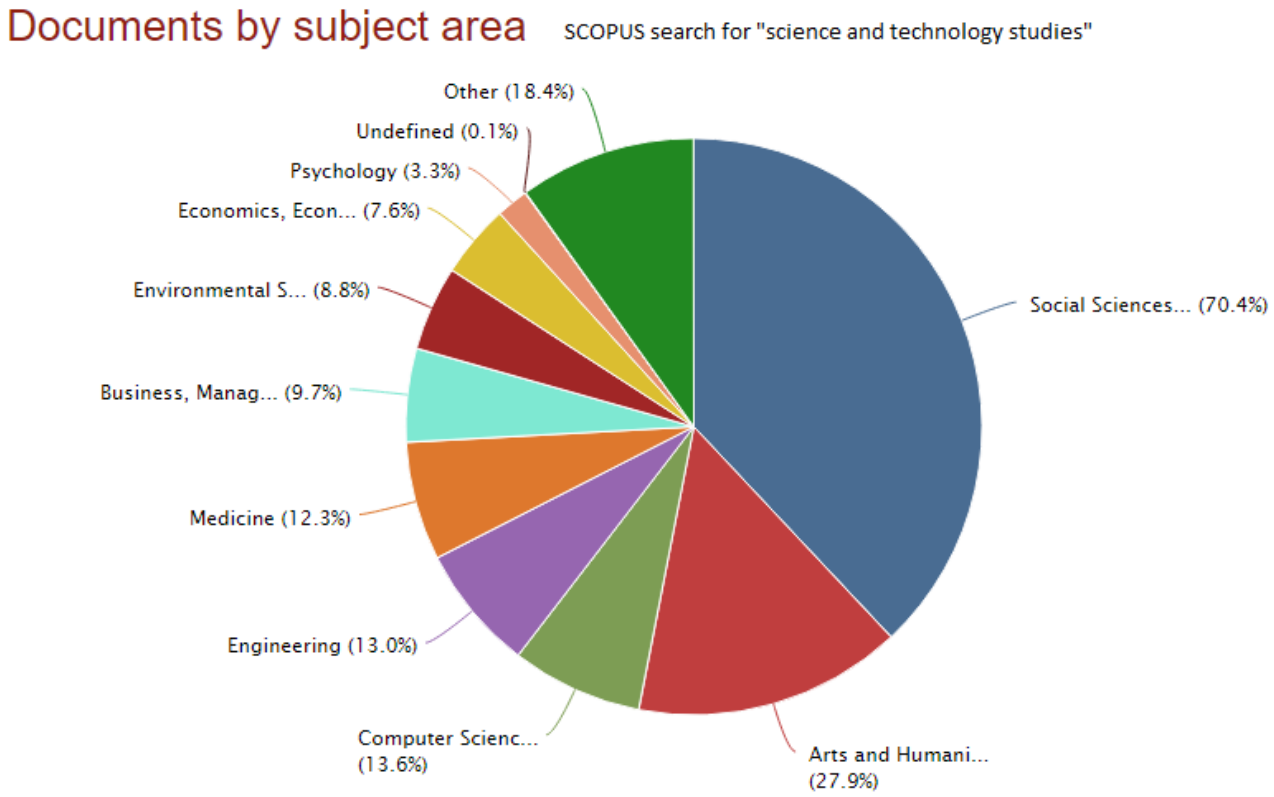

The results are shown here with a steady rise in usage over time.




Because of the ambiguity of “STS”, subsequent searches were performed for “science and technology studies” to weed out the irrelevant results. This search returned 1,525 results beginning in 1975 with a significant increase in mention over the past decade, as shown below.

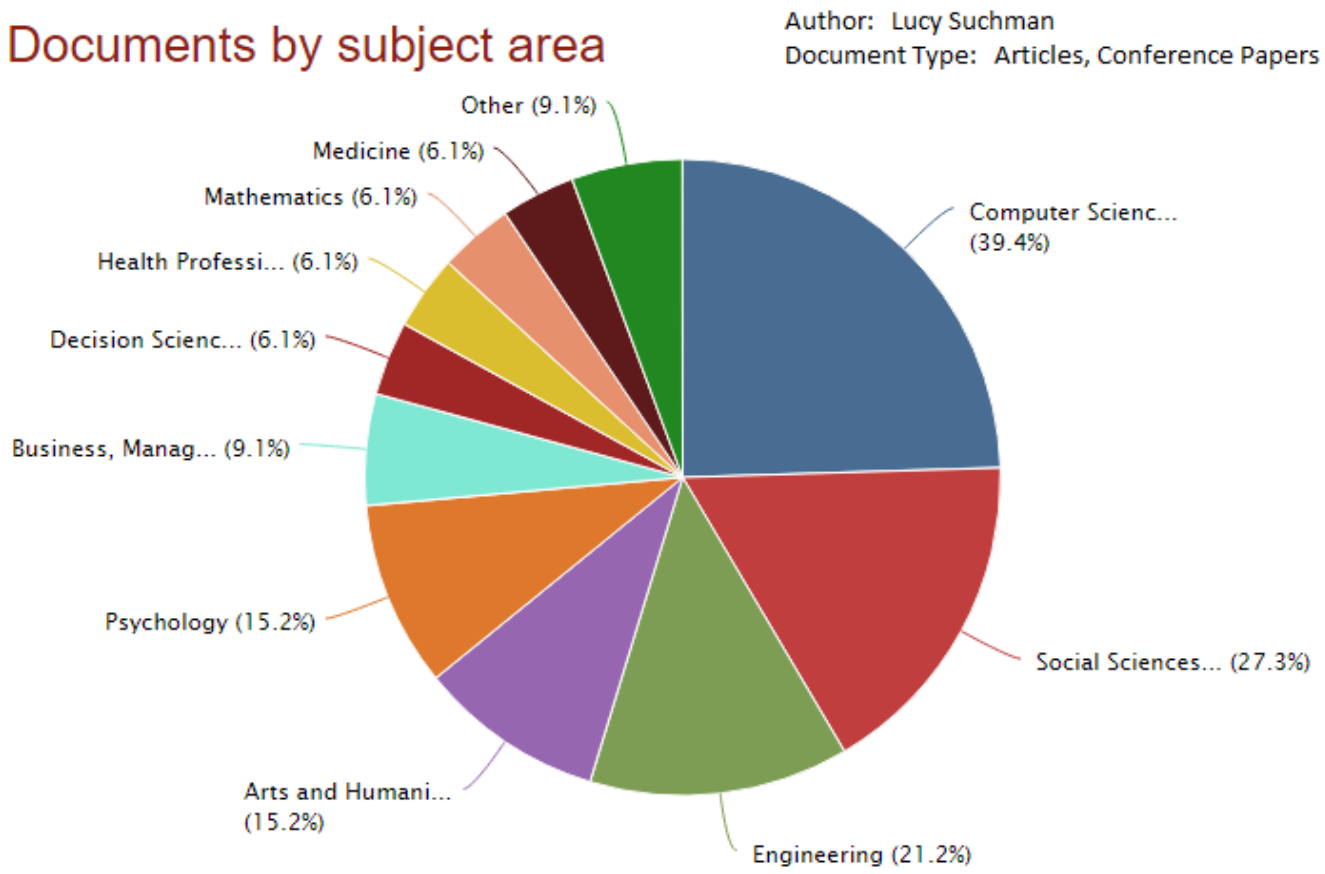



This search returned a subject area spread that is much more reflective of the interdisciplinary, social-sciences led field of STS.




## SCOPUS search for: Author = Suchman, Lucy (30)

A search within SCOPUS for all articles and conference papers authored by Lucy Suchman revealed 33 results, 3 of which were omitted as errors. Of the 30 remaining articles, the majority were published in engineering or computer science journals. Lucy Suchman is an anthropologist.




| Authors | Year | Document Title | Publication Source | Disc. |
|---|---|---|---|---|
| Castañeda, C., Suchman, L. | 2014 | Robot visions | Social Studies of Science, 44 (3): 315-341. | Soc. Sci. |
| Stacey, J., Suchman, L. | 2012 | Animation and Automation - The Liveliness and Labours of Bodies and Machines | Body and Society, 18 (1): 1-46. | Soc. Sci. |
| Suchman, L. | 2011 | Anthropological relocations and the limits of design | Annual Review of Anthropology, 40: 1-18. | Soc. Sci. |
| Suchman, L. | 2011 | Subject objects | Feminist Theory, 12 (2): 119-145. | Soc. Sci. |
| Suchman, L. | 2007 | Sociotechnologies of care: visions and realities. | Studies in health technology and informatics, 130: 1-2. | Eng. & CS |
| Suchman, L. | 2006 | Reconfiguring human-robot relations | Proceedings - IEEE International Workshop on Robot and Human Interactive Communication, art. no. 4107882: 652-654. | Eng. & CS |
| Suchman, L. | 2005 | Affiliative objects | Organization, 12 (3): 379-399. | Other |

| | | | | |
|---|---|---|---|---|
| Suchman, L. | 2003 | Figuring service in discourses of ICT: The case of software agents | IFIP Advances in Information and Communication Technology, 110: 33-43. | Eng. & CS |
| Suchman, L.A. | 2002 | Practice-based design of information systems: Notes from the hyperdeveloped world | Information Society, 18 (2): 139-144. | Soc. Sci. |
| Suchman, L., Trigg, R., Blomberg, J. | 2002 | Working artefacts: Ethnomethods of the prototype | British Journal of Sociology, 53 (2): 163-179. | Soc. Sci. |
| Suchman, L. | 2001 | Practice-based design | Proceedings of the IEEE International Conference on Requirements Engineering: 11. | Eng. & CS |
| Suchman, L. | 2000 | Organizing Alignment: A Case of Bridge-building | Organization, 7 (2): 311-327. | Other |
| Suchman, L. | 2000 | Embodied practices of engineering work | Mind, Culture, and Activity, 7 (1-2): 4-18. | Soc. Sci. |
| Suchman, L., Bishop, L. | 2000 | Problematizing 'innovation' as a critical project | Technology Analysis and Strategic Management, 12 (3): 327-333. | Other |
| Suchman, L., Blomberg, J., Julian E, O., Trigg, R. | 1999 | Reconstructing technologies as social practice | American Behavioral Scientist, (3): 392-408. | Soc. Sci. |
| Blomberg, J., Suchman, L., Trigg, R.H. | 1996 | Reflections on a work-oriented design project | Human-Computer Interaction, 11 (3): 237-265. | Eng. & CS |
| Suchman, L. | 1995 | Representations of Work | Communications of the ACM, 38 (9): 33-35. | Eng. & CS |
| Suchman, L. | 1995 | Making Work Visible | Communications of the ACM, 38 (9): 56-64. | Eng. & CS |
| Suchman, Lucy | 1994 | Supporting articulation work: aspects of a feminist practice of technology production | IFIP Transactions A: Computer Science and Technology, (A-57): 7-21. | Eng. & CS |
| Suchman, L. | 1994 | Do categories have politics? - The language/action perspective reconsidered | Computer Supported Cooperative Work (CSCW), 2 (3): 177-190. | Eng. & CS |
| Suchman, L. | 1994 | Working relations of technology production and use | Computer Supported Cooperative Work, 2 (1-2): 21-39. | Eng. & CS |

| | | | | |
|---|---|---|---|---|
| Suchman, L. | 1994 | Speech acts and voices: Response to Winograd et al. | Computer Supported Cooperative Work (CSCW), 3 (1): 85-95. | Eng. & CS |
| Friedman, B., Leveson, N., Shneiderman, B., Suchman, L., Winograd, T. | 1994 | Beyond accuracy, reliability, and efficiency: Criteria for a good computer system | Conference on Human Factors in Computing Systems - Proceedings, 1994-April: 195-196. | Eng. & CS |
| Blomberg, J., McLaughlin, D., Suchman, L. | 1993 | Work-Oriented Design at Xerox | Communications of the ACM, 36 (6): 91. | Eng. & CS |
| Suchman, L. | 1993 | Response to Vera and Simon's situated action: A symbolic interpretation | Cognitive Science, 17 (1): 71-75. | Soc. Sci. |
| Suchman, L., Jordan, B. | 1990 | Interactional troubles in face-to-face survey interviews | Journal of the American Statistical Association, 85 (409): 232-241. | Other |
| Suchman, L.A. | 1988 | Representing practice in cognitive science | Human Studies, 11 (2-3): 305-325. | Soc. Sci. |
| Suchman, Lucy, Beeman, William, Pear, Michael, Trigg, Randy, Fox, Barbara, Smolensky, Paul | 1987 | SOCIAL SCIENCE AND SYSTEM DESIGN: INTERDISCIPLINARY COLLABORATIONS. | Proceedings - Graphics Interface: 121-123. | Eng. & CS |
| Stefik, M., Foster, G., Bobrow, D.G., Kahn, K., Lanning, S., Suchman, L. | 1987 | Beyond the chalkboard: Computer support for collaboration and problem solving in meetings | Communications of the ACM, 30 (1): 32-47. | Eng. & CS |
| Suchman, L.A. | 1983 | Office procedure as practical action: Models of work and system design | ACM Transactions on Information Systems (TOIS), 1 (4): 320-328. | Eng. & CS |

## Selected literature

In the following we identify a number of the local STS environments that is may be useful for REELER to engage with.

DENMARK: Centre for Science, Technology and Society studies - Aarhus University

"Science, Technology and Society studies (STS) is an international and interdisciplinary field of research. STS activities at The Department of Information and Media Studies at Aarhus University in Denmark revolve around sociological, anthropological and philosophical theories of relations, networks and constellations spanning traditional distinctions between science, technology and society. That it is neither theoretical possible nor generally desirable to operate with predetermined conceptions of the relation between humans

and technologies, and their respective characteristics, is pivotal for works within this field. The complex intermingling of technological artefacts and human beings must be analysed empirically in concrete situations." (http://sts.imv.au.dk/en)

EUROPE & NETHERLANDS: European Association for the Study of Science and Technology

"[EASST] represents academics and researchers in the fields of science and technology studies, the social analysis of innovation and related areas of knowledge. It brings together a variety of disciplines and many of its members have qualifications in both natural science/engineering and social sciences." (https://easst.net/about-easst/)

DENMARK, GERMANY, UK, & US: Centre for Medical Science and Technology Studies – University of Copenhagen

The aim of Centre for Medical Science and Technology Studies is to foster research into medical and health-related topics from the perspective of science and technology studies (STS). The Centre also supports science and technology studies perspectives on pre- and postgraduate courses at the Faculty of Health Sciences.

[In collaboration with Goethe University, University of Sheffield, and University of California Berkeley]

GERMANY: Frankfurt Kitchen STS – Goethe University

"It brings together a bunch of sociologists, cultural anthropologists, political scientists, human geographers, literary scholars, historians of science and others interested in old debates and new developments in Science and Technology Studies"…"heterogeneous field"…"work ethnographically" (http://www.fb03.uni-frankfurt.de/46226491/STS-discussion-group?)

UK: Medical Humanities – University of Sheffield

"Our fundamental mission is to locate, understand, and privilege what it is to be 'human'… a cross-disciplinary environment enabling teaching and research at the interface between medicine, science, humanities and social science." (http://mhs.group.shef.ac.uk/about-us/)

UK: Science and technology studies – University College London

"The integrated study of: history of science, philosophy of science, science communication and public engagement, science policy, or science and government, sociology of science. STS wants people to think differently about science. We want to understand how science acts as a force in modern society. We want to understand what underpins its successes and failures. We want to understand its boundaries and concentrations." (https://www.ucl.ac.uk/sts)

SWEDEN: Science and Technology Studies – University of Gothenburg

"This research direction seeks deeper understanding of how science, technology and society develop in close interaction with each other. Particularly in light of widespread beliefs about modern civilisation as a vulnerable knowledge and risk society, studies of this interaction have been assigned a central role in social scientific research. Researchers at the Department are engaged in projects focused on subjects including the boundaries between environmental science and environmental policy; materiality and technology in current changes in healthcare systems; user-oriented development of information and communication technology;

and the social dynamics surrounding evidence-based practise."
(http://socav.gu.se/english/research/science-and-technology-studies--sts-)

US: Science, Technology and Society – Harvard

STS explores in rich and compelling ways what difference it makes to human societies that we, collectively, are producers and users of science and technology. STS research, teaching, and outreach offer citizens of modern, high-tech societies the resources with which to evaluate—analytically, esthetically, and ethically—the benefits and the risks, the perils and the promises, of notable advances in science and technology." (http://sts.hks.harvard.edu/about/whatissts.html)

US: Center for Science, Technology, Medicine & Society – University of California, Berkeley

"…the origins, growth, and consequences of scientific and technological knowledge and practice. Focusing on the changing conditions of knowledge production today, cutting-edge theoretical and conceptual inquiry, and engagement with public policy." (http://cstms.berkeley.edu/research/sts/)

US: Science and Technology Studies – Brown University

"…the construction, operation, and dissemination of scientific and technological knowledge. Our faculty come from Africana Studies, American Studies, Anthropology, the Division of Biology and Medicine, Cognitive, Linguistic, and Psychological Sciences, Egyptology and Ancient West Asian Studies, English, Gender and Sexuality Studies, History, History of Art and Architecture, and Philosophy."
(https://www.brown.edu/academics/science-and-technology-studies/)

US: Department of Science & Technology Studies – Cornell University

"…dedicated to research and teaching about scientific knowledge and technology in its social context. The social processes through which scientific and technical knowledge—whether packaged into texts, people, machines, images, or other forms—is created, evaluated, challenged, spread, transformed, and fitted into social relations. The ways people use, reconfigure, and contest scientific knowledge and technology. The normative issues entangled in scientific and technological developments. The place of science and technology in the modern world." (http://sts.cornell.edu/)

### JSTOR search for: "robot*" in journal: Science, Technology, & Human Values (61)

The following abstracts have been selected, for relevance to REEELER, from the 61 results for *robot**.

*Table 4: Selected abstracts from search results for robot* in journal: Science, Technology, & Human Values*

Michael, Mike. 2012. "What Are We Busy Doing?": Engaging the Idiot." *Source: Science, Technology, & Human Values*, 37(5): 528-554.

*[This article addresses robot design as a part of a broader look at speculative design and public engagement.]*

EXCERPT "Now, in the case of both the Neuroscope and Carniverous Domestic Entertainment Robots, the issues raised above have only been hinted at by their designers. Moreover, though they were designed to provoke debate in the publics to which they were presented at various events, apart from a few videoed, informal interviews, and the odd snippets of commentary by members of the public presented on the Web site or in the project's final publication, there was little effort made "systematically" to gauge or record public responses. So despite the claims that this was all "public engagement," it was unlike the sorts of public engagement which is generally familiar to most social science and STS scholars."

ABSTRACT "Engagement events—whether interviews, installations, or participatory encounters—can entail a range of happenings which, in one way or another, "overspill" the empirical, analytic, or political framing of those engagement events. This article looks at how we might attend to these overspills—for instance, forms of "misbehavior" on the part of lay participants—not only to provide accounts of them but also to explore ways of deploying them creatively. In particular, Stengers' figure of the "idiot" is proposed as a device for deploying those overspills to interrogate "what we are busy doing" as social science researchers in engagement events. This interrogation is furthered by considering the proactive idiocy of "Speculative Design's" version of the public engagement with science which seems directly to engender "overspilling." Providing examples of speculative design prototypes and practices, the article develops an ideal typical contrast between social scientific and designerly perspectives on public engagement. It is suggested that speculative design can serve as a resource for supplementing "science and technology studies" (STS) conceptualizations of, and practices toward, public, engagement, and science."

Young, Allan. 2011. "Self, Brain, Microbe, and the Vanishing Commissar." *Science, Technology, & Human Values*, 36(5): 638-661.

*[This article focuses on human consciousness and discusses the limitations of robot AI as an alternative.]*

EXCERPT "Are robots up to the job? Many experts have doubts: "Life-like adaptive behaviour is so far an illusive goal in robot control. A capability to act successfully in a complex, ambiguous, and harsh environment would vastly increase the application domain of robotic devices." Established methods of robot control run up against a complexity barrier, the need to respond effectively to unanticipated and paradoxical situation."

ABSTRACT "In his Treatise of Human Nature (1739-1740), David Hume asked how people succeed in constructing edifices of belief from their limited store of sensory impressions and derived ideas. Hume could adduce no evidence to support the existence of an inner self that intelligently manipulates impressions and ideas. At the same time, he recognized in himself the conviction that there is inner self. Today, there is a growing conviction among cognitive neuroscientists, behavioral scientists, science journalists, and their publics that neuroscience is on the verge of providing us with the ultimate (reductionist) solution to "Hume's problem." This article describes two approaches to this solution."

Selin, Cynthia. 2007. "Expectations and the Emergence of Nanotechnology." *Science, Technology, & Human Values,* 32(2): 196-220.

*[This article describes the contestation of the understanding of nanotechnology – relevant to REELER in that it deals with expectations and imaginations among roboticists and in the public.]*

EXCERPT "'The boundary is permeable between tool and myth, instrument and concept, historical systems of social relations, and historical anatomies of possible bodies, including objects of knowledge. Indeed, tool and myth mutually constitute each other,' (Haraway 1991,164)."

ABSTRACT "Although nanotechnology is often defined as operations on the IQr9 meters, the lack of charisma in the scale-bound definitions has been fortified by remarkable dreams and alluring promises that spark excitement for nanotechnology. The story of the rhetorical development of nanotechnology reveals how speculative claims are powerful constructions that create legitimacy in this emerging technological domain. From its inception, nanotechnology has been more of a dream than reality, more fiction than fact. In recent years, however, the term nanotechnology has been actively drawn toward the present to begin to deliver on the fantastic expectations. This debate over time and timing is loaded with paradox. This work examines how future claims work to define what counts as nanotechnology and reveals dilemmas that accompany temporal disjunctures. Science and politics converge in debates about the future of technology as expectations serve to create and enforce power and legitimacy in the emerging area."

Kleif, Tine and Wendy Faulkner. 2003. "'I'm No Athlete [but] I Can Make This Thing Dance!' Men's Pleasures in Technology." *Science, Technology, & Human Values*, 28(2): 296-325.

*[This article relates gender to technology use and compares casual use to professional use.]*

EXCERPT "There is a continuity between the two groups not only in that male engineers often played with technology as boys but also in that many hobbyist men have jobs in engineering. This in turn reflects a continuity between the

skills that technology hobbyists and professional engineers use. As we have shown, there are also differences between the robot builders and software professionals that shape their subjective experiences of technologies. Technology professionals are a much more homogeneous group in terms of education and employment. Unlike them, technology hobbyists have more freedom to choose what objects to build and continue to enjoy the artifacts once they are built."

ABSTRACT "The pleasures experienced by boys and men who work and play closely with technology have important implications for both gender and technology. This article presents empirical evidence on the topic from two studies: one of hobbyist "robot builders" who build machines for the U.K. television program Robot Wars (Kleif), the other of professional software developers working in a large U.S. corporation (Faulkner). In spite of the obvious differences between these two groups, they experience strikingly similar pleasures-in creating technologies, in their skills and knowledge, and in their intimacy and comfort with technology. The authors discuss available gender-based analyses of men's pleasures in technology, drawing on the empirical material to both challenge and extend these analyses. The authors suggest, tentatively, that technology is a gender-authentic and gender-available avenue for those men who particularly crave certainty because technology appears more certain, easier to understand, and easier to master than other worlds they inhabit."

Elton, Matthew. 1998. "Persons, Animals, and Machines." *Science, Technology, & Human Values*, 23(4): 384-398.

*[This text addresses the ontological distinctions between persons, animals, and machines – from 1998.]*

EXCERPT "And so, when discussing the relationship between persons, animals, and mere machines, we need to be aware of the fact that each term does not merely represent an entity, but an entity and a commitment to a certain way of making sense of that entity, its conditions of being, its conditions of success and failure. If we ask "Can machines think?" or "Can a robot be an animal?" we may be expressing two contradictory commitments at once. If by "machine" we mean something that we view from the perspective of the physics (or design) monitor, then, by definition, machines cannot think. But then our bodies cannot think either. Of course, the term machine or robot sometimes means "artificially engineered device." On this reading, it is not clear how one could resist positive answers to our questions, for the differences between artificially and naturally engineered devices are not nearly so dramatic as we once might have thought. If artificially engineered devices demand description and explanation from the perspective of a biological norm (e.g., a survival norm) or a psychological norm (e.g., unity and continuity of consciousness), then those devices are just as much animals or people as the more familiar DNA-based entities that have been engineered by natural processes."

ABSTRACT "What is the relationship between persons, animals, and machines? The author first presents a form of argument against any attempt to reduce biology to mechanism. He then runs a parallel argument for psychology and biology. But although he tries to resist reduction, he insists that to bring into being a person or an animal requires no more than the construction of a certain sort of machine, or causal engine, such that certain normative standards can be applied to its behavior. If to call an entity a machine is to forego such commitments, then, trivially, no animal or person could be a machine. If the term "machine" implies no more than the presence of a causal engine, natural or artificial, then machines can be, and some are, animals or people."

Forsythe, Diana E. 1993. "The Construction of Work in Artificial Intelligence." *Science, Technology, & Human Values*, 18(4): 460-479.

*[This article argues that designers embed cultural assumptions into their work.]*

EXCERPT "This article takes a case from the expert systems community within artificial intelligence (AI), to examine how particular assumptions held by practitioners come to be embedded in the tools that they construct."

ABSTRACT "Although technology is often viewed as value-free, an anthropological perspective suggests that technological tools embody values and assumptions of their builders. Drawing upon extended field research, this article investigates the construction of work in the expert systems community of artificial intelligence (AI). Describing systematic deletions in practitioners' representations of their own work, the article relates these to both the selectivity of conventional knowledge acquisition procedures and the tendency of expert systems to (in the practitioners'words) "fall off the knowledge cliff. " Although system builders see the latter problem as purely technical, this article suggests that it is also the result of nontechnical factors, including the system builders' own tacit assumptions. This article supports the view that technology has a cultural dimension."

Winner, Langdon. 1993. “Upon Opening the Black Box and Finding It Empty: Social Constructivism and the Philosophy of Technology.” Science, Technology, & Human Values, 18(3): 362-378.

*[General STS theory paper.]*

EXCERPT “What do philosophers need to know about technology? What kind of knowledge do we need to have? And how much? Perhaps it is enough simply to have lived in a society in which a wide variety of technologies are in common use. Drawing upon an everyday understanding of such matters, one can move on to develop general perspectives and theories that may enable us to answer important questions about technology in general. The problem is that one's grasp may be superficial, failing to do justice to the phenomena one wants to explain and interpret. One may seize upon a limited range of vaguely understood examples of technical applications-a dam on a river, a robot in a factory, or some other typification-and try to wring universal implications from a sample that is perhaps too small to carry the weight placed upon it.”

Kling, Rob. 1991. “Computerization and Social Transformations.” Science, Technology, & Human Values, 16(3): 342-367.

*[This 1991 text could be used as a parallel, computerization as social transformation : automation/robotization as social transformation.]*

ABSTRACT “This article examines the relationship between the use of computer-based systems and transformations in parts of the social order. Answers to this question rest heavily on the way computer-based systems are consumed-not just produced or disseminated. The discourse about computerization advanced in many professional magazines and the mass media is saturated with talk about "revolution," and yet substantial social changes are often difficult to identify in carefully designed empirical studies. The article examines qualitative case studies of computerization in welfare agencies, urban planning, accounting, marketing, and manufacturing to examine the ways that computerization alters social life in varied ways: sometimes restructuring relationships and in other cases reinforcing existing social relationships. The article also examines some of the theoretical issues in studies of computerization, such as drawing boundaries. It concludes with some observations about the sociology of computer science as an academic discipline.”

Perrolle, Judith A. 1991. “Expert Enhancement and Replacement in Computerized Mental Labor.” *Science, Technology, & Human Values,* 16(2): 195-207.

*[Another computerization:automation parallel, related to work transformations.]*

ABSTRACT “What happens to professional and technical work when it is computerized ? Exploratory analysis of case studies indicates that when expert systems are used to enhance the work of professionals, some tasks of medium- and low-skilled support personnel are integrated into the work of highly skilled experts. Technical workers are thus at risk of having their jobs automated as part of the computer enhancement of professionals. When computerization replaces expertise, job opportunities for medium-skilled personnel shrink and barriers to upward mobility through on-the-job experience are reduced. Entry-level professionals or even technicians with computers can perform tasks formerly done by experienced professionals. But working conditions do not promote the development of expertise and professional judgment among these workers. Thus it appears that routinization, deskilling, and automation are not only the problems of manual laborers in the information age; professional workers are also at risk, in complex ways.”

## SCOPUS search for: “science and technology studies” AND “robot” (22)

A search of SCOPUS for the term “science and technology studies” AND variations on the term “robot” returned 22 hits. These abstracts are shown below.

Jung, M.F., Beane, M., Forlizzi, J., Murphy, R., Vertesi, J. 2017. ”Robots in group context: Rethinking design, development and deployment.” *Conference on Human Factors in Computing Systems - Proceedings*, Part F127655, pp. 1283-1288.

ABSTRACT: Over the last decade, the idea that robots could participate meaningfully in complex human contexts such as groups and organizations has developed from a promising vision into a reality. Robots now assist human collectives in simple tasks such as delivery through complex high-stakes tasks such as disaster response or surgery. Despite this

dramatic increase, not much is known about how these systems affect and interact with the overall task oriented and social functioning of the groups and organizations they are embedded in and how we should design robots to support all aspects of such interactions. This panel brings together experts on design, robotics, organizational behavior, team dynamics and science and technology studies to discuss challenges and opportunities arising from the increased participation of robots in teams groups and organizations.

Stephens, N., Lewis, J. 2017. "Doing laboratory ethnography: reflections on method in scientific workplaces." *Qualitative Research*, 17(2): 202-216.

ABSTRACT: Laboratory ethnography extended the social scientist's gaze into the day-to-day accomplishment of scientific practice. Here we reflect upon our own ethnographies of biomedical scientific workspaces to provoke methodological discussion on the doing of laboratory ethnography. What we provide is less a 'how to' guide and more a commentary on what to look for and what to look at. We draw upon our empirical research with stem cell laboratories and animal houses, teams producing robotic surgical tools, musicians sonifying data science, a psychiatric genetics laboratory, and scientists developing laboratory grown meat. We use these cases to example a set of potential ethnographic themes worthy of pursuit: science epistemics and the extended laboratory, the interaction order of scientific work, sensory realms and the rending of science as sensible, conferences as performative sites, and the spaces, places and temporalities of scientific work.

Messeri, L. 2017. "Extra-terra incognita: Martian maps in the digital age." *Social Studies of Science*, 47(1): 75-94.

ABSTRACT: Science and technology studies (STS) and critical cartography are both asking questions about the ontological fixity of maps and other scientific objects. This paper examines how a group of NASA computer scientists who call themselves The Mapmakers conceptualizes and creates maps in service of different commitments. The maps under construction are those of alien Mars, produced through partnerships that NASA has established with Google and Microsoft. With the goal of bringing an experience of Mars to as many people as possible, these maps influence how we imagine our neighbouring planet. This paper analyzes two attributes of the map, evident in both its representation and the attending cartographic practices: a sense of Mars as dynamic and a desire for a democratic experience of Mars in which up-to-date Mars data can be intuitively accessed not only by scientists but by lay users as well. Whereas a democratic Mars promises users the ability to decide how to interact with the map and understand Mars, dynamic Mars imposes a more singular sense of Mars as a target of continued robotic and maybe even human exploration. Because maps of Mars have a different (and arguably less complex) set of social and political commitments than those of Earth, they help us see how different goals contradict and complement each other in matters of exploration and state-craft relevant both to other worlds and our own.

Palmerini, E., Bertolini, A., Battaglia, F., Koops, B.-J., Carnevale, A., Salvini, P. 2016. "RoboLaw: Towards a European framework for robotics regulation." *Robotics and Autonomous Systems*, 86: 78-85.

ABSTRACT: This paper intends to sum up the main findings of the European project RoboLaw. In this paper, the authors claim that the European Union should play a pro-active policy role in the regulation of technologies so as to inform the development of technologies with its values and principles. The paper provides an explication of the rationale for analysing of a limited and heterogeneous number of robotics applications. For these applications, the following issues are addressed: whether robotics deserve a special case of regulation; the direct and indirect role ethics can play in regulating technology; the transformations of both vulnerabilities and capabilities, and the effects of liability law in favouring the socially relevant applications. In conclusion, a reflection on the possibility to generalize some of the RoboLaw findings to other technologies is proposed, with respect to liability and ethics.

Díaz-Boladeras, M., Angulo, C., Domènech, M., Albo-Canals, J., Serrallonga, N., Raya, C., Barco, A. 2016. "Assessing pediatrics patients' psychological states from biomedical signals in a cloud of social robots." *IFMBE Proceedings*, 57: 1179-1184.

ABSTRACT: This paper describes an on-going research aiming to design and deploy a robotic-pet based intervention integrated to the Child Life program in a paediatric hospital. The purpose is to provide in the personalized health-care network a supplement of smart company to alleviate feelings of anxiety, loneliness and stress of long-term inpatient and their bystanders. The state of the art on companion robots for health related purposes in the long run, ethical concerns in the context of paediatric care and social and technological issues are addressed. A description of

the first implementation phases, findings, lessons learned and future work are discussed under a critical multidisciplinary approach confronting perspectives from social science and technology studies, engineering, psychology and nursery. The overall research questions addressed are: can a cloud of social assistive robotic-pets join the network of well-being supply in a paediatric hospital? Under which technical and social conditions this innovation could be appropriate by the organization and -more importantly- could improve the service?

Kember, S. 2016. "iMedia: The gendering of objects, environments and smart materials." *iMedia: The Gendering of Objects, Environments and Smart Materials*, 1-122.

ABSTRACT: What can queer feminist writing strategies such as parody and irony do to outsmart the sexism of smart objects, environments and materials and open out the new dialecticism of structure and scale, critique and creativity? Drawing on science and technology studies and feminist theory, this book examines the gendering of current and future media technologies such as smart phones, Google glass, robot nurses, tablets and face recognition. Kember argues that there is a tendency to affirm and celebrate the existence of smart and often sexist objects, environments and materials in themselves; to elide writing and other forms of mediation; and to engage in disembodied knowledge practices. Disembodied knowledge practices tend towards a scientism that currently includes physics envy and are also masculinist. Where there is some degree of convergence between masculinist and feminist thinking about objects, environments and materials, there is also divergence, conflict and the possible opening towards a politics of imedia. Presenting a lively manifesto for refiguring imedia, this book forms an often neglected gender critique of developments in smart technologies and will be essential reading for scholars in Communication Studies, Cultural and Media, Science and Technology and Feminism.

Compagna, D., Kohlbacher, F. 2015. "The limits of participatory technology development: The case of service robots in care facilities for older people." *Technological Forecasting and Social Change*, 93: 19-31.

ABSTRACT: The paper examines how participatory technology development (pTD) in the field of ambient assisted living (AAL) is marked by several weaknesses. We will discuss these from a theoretical point of view as well as based on empirical findings of a three-year project dedicated to the achievement of pTD within a representative AAL domain, adopting the scenario-based design (SBD) method. The case study - dealing with the introduction of care robots in a care facility for the elderly - will be examined by an ethnographical qualitative analysis as well as by three theoretical approaches often used in the field of Science and Technology Studies (STS). We combine these three approaches with an ethnographical analysis to achieve a deeper understanding of several difficulties with pTD that are typical in the realization within the AAL field, especially when a mediating method, such as SBD, is adopted. In this respect the theoretical contribution consists of outlining the importance of a strictly bottom-up view on pTD. Finally, we conclude with two general recommendations on how the inclusion of care workers and older people as target groups of pTD within the AAL field can be accomplished more successfully.

Peine, A., Moors, E.H.M. 2015. "Valuing health technology - habilitating and prosthetic strategies in personal health systems." Technological Forecasting and Social Change, 93: 68-81.

ABSTRACT: This paper explores the tensions in ICT-driven personal health systems innovation and the impact of these tensions on valuing health innovation for older people. We regard personal health systems (PHS) as configurational technologies and information infrastructures that need to strike a balance between offering standardized health and care packages on the one hand, and providing options for localization and personalization on the other. We use insights from Science and Technology Studies (STS) to conceptualize the configurational dynamics of PHS innovation and emphasize 'generification work' as an important arena for the development, assessment and adoption of personal health innovations. We explore two research and development projects of PHS service-robot platforms and build on Callon's concepts of 'prosthesis' and 'habilitation' to identify two ideal-typical generification strategies in the projects. A prosthetic generification strategy positions the robot as part of a socio-technical agencement that configures older persons into disciplined agency, while a habilitating strategy speaks to them as active actors in the innovation process. We demonstrate how the designers in both projects were often unconsciously led into a prosthetic strategy despite initial intentions to the contrary. We explain this by mechanisms of personalization, needs capturing and othering. However, elements of habilitating strategies were also present, although in a less articulated form. We identify these elements and argue that in aging societies, health innovations need to pursue prosthesis and

habilitation simultaneously. We conclude our paper with implications for innovation policy and health technology assessment.

Wilkie, A., Michael, M., Plummer-Fernandez, M. 2015. "Speculative method and Twitter: Bots, energy and three conceptual characters." *Sociological Review*, 63(1): 79-101.

ABSTRACT: This paper aims to contribute to recent innovations in social scientific methodology that aspire to address the complex, iterative and performative dimensions of method. In particular, we focus on the becoming-with character of social events, and propose a speculative method for engaging with the not-as-yet. This work, being part of a larger project that uses Speculative Design and ethnographic methods to explore energy-demand reduction, specifically considers the ways in which energy-demand reduction features in the Twitter-sphere. Developing and deploying three automated Bots whose function and communications are at best obscure, and not uncommonly nonsensical, we trace some of ways in which they intervene and provoke. Heuristically, we draw on the 'conceptual characters' of idiot, parasite and diplomat in order to grasp how the Bots act within Twitter to evoke the instability and emergent eventuations of energy-demand reduction, community and related practices. We conclude by drawing out some of the wider implications of this particular enactment of speculative method.

Bloomfield, B.P., Vurdubakis, T. 2015. "Mors ex Machina: Technology, Embodiment and the Organization of Destruction." *Organization Studies*, 36(5): 621-641.

ABSTRACT: The article argues that the organization of destruction requires the same level of attention that organization studies have typically accorded to the organization of production. Taking as its starting point recent debates in the field concerning the embodied character of organizational ethics, the present paper sets out to explore what we might call the contemporary 'automation of warfare' by focusing on the proposed deployment of autonomous robots capable of exercising lethal force while governed by the 'ethical constraints' dictated by the Laws of War. Acknowledging the 'technical' challenges inherent in the development of 'ethical warrior robots', we propose that the importance of such technological fixes for the management of human conflict primarily lies not in their status as (potentially) functional artefacts but rather in their role as material expressions of the moral and philosophical conflicts haunting Atlantic (post?)modernity.

Castañeda, C., Suchman, L. 2014. "Robot visions." *Social Studies of Science*, 44(3): 315-341.

ABSTRACT: This article explores the resonating figures of primate, child, and robot in contemporary technoscientific corporealizations of the 'almost human'. We take as our model (in)organism 'Lucy the Robot Orangutan', roboticist Steve Grand's project to create an artificial life form with a mind of its own. One aspect of Lucy's figuration by Grand, we argue, which ties her to Haraway's analysis of the primate, is of the robot as a model for animal, and more specifically (or aspirationally) human, cognition. We follow the trope of 'model organism' as it is under discussion within science and technology studies and as an ironic descriptor for our own interest in Lucy as an entity/project through which to illuminate figurations within robotics more widely. Primate and robot together are forms of natureculture that help to clarify how the categories of animal and machine are entangled, while making explicit investments in their differences from one another, and from the third category of the human. We conclude, again following Haraway, by imagining what other possibilities there might be for figuring humans, robots, and their relations if we escape the reiterative imaginary of the robot as proxy for becoming human.

Lemke, M., Miller, K.W. 2014. "On robots as genetically modified invasive species." Journal of Information, Communication and Ethics in Society, 12(2): 122-132.

ABSTRACT: Purpose: This paper aims to explore similarities and differences between robots, invasive biological species, and genetically modified organisms. These comparisons are designed to better understand the potential effects of robots on human society. Design/methodology/approach: This paper applies established ideas in one discipline - biology - to issues that are less well understood, but actively being studied in another discipline - science and technology studies. Findings: Robots entering human society in large numbers share many of the characteristics of an invasive species entering a new ecosystem. The authors also find that robots have several characteristics that are similar to a genetically modified organism. Taken together, these similarities suggest that society should be cautious about the introduction of large numbers of robots in a short period of time. Originality/value: The approach taken here to assess robots in society by these analogies to ecological processes is, to the authors' knowledge, novel.

Applying ideas from a better-known area to a less well-known area is routine in philosophy, but these particular analogies have not yet been carefully articulated in the literature.

Frennert, S., Östlund, B. 2014. "Review: Seven Matters of Concern of Social Robots and Older People." *International Journal of Social Robotics*, 6(2): 299-310.

ABSTRACT: This article maps the range of currently held scientific positions on matters of concern involving social robots and older people. 345 publications from peer-reviewed journals and conferences were narrowed down to 31 key publications that were studied in detail and categorised into seven matters of concern: (1) role of robots in older people's lives, (2) factors affecting older people's acceptance of robots, (3) lack of mutual inspiration in the development of robots for older people, (4) robot aesthetics, (5) ethical implications of using robots in caring for older people, (6) robotic research methodology, and (7) technical determinism versus social construction of social robots. The findings indicate that older people are implicated but not present in the development of robots and that their matters of concern are not identified in the design process. Instead, they are ascribed general needs of social robots due to societal changes such as ageing demographics and demands from the healthcare industry. The conceptualisation of older people seems to be plagued with stereotypical views such as that they are lonely, frail and in need of robotic assistance. Our conclusions are that the perceptions of older people need to be re-examined and perhaps redefined in order to fairly represent who they are, and that more research on older people as social robotic users is needed.

Ballesté, F., Torras, C. 2013. "Effects of human-machine integration on the construction of identity." *Robotics: Concepts, Methodologies, Tools, and Applications*, 3: 1300-1318.

ABSTRACT: Recent developments in social robotics, intelligent prosthetics, brain-computer interfaces, and implants pose new questions as to the effects of technology on identity, society, and the future of humankind. The authors' standpoint is that such effects cannot be studied separately from their social/cultural context, and thus, this chapter begins by reviewing the existing approaches to the social construction of reality, placing special emphasis on language and its limitations to describe the future. Then, it focuses on the body as the place where the human-machine integration occurs, and describes four levels at which the notion of cyborg has been analyzed in anthropological studies: symbolic, physical, as a permeable layer between nature and culture, and as an intermediate step towards a higher-order existence. The chapter ends up with a word of caution in relation to technological determinism stemming from STS (Science and Technology Studies), as well as the need to establish Relevant Social Groups (RSG) with well-founded criteria that join scientific and sociological academics under a multidisciplinary approach.

Yuan, C.L., Kong, L.S., Zhou, W.L., Yang, J.B. 2013. "New flexible wrist force sensor operated by robot based on parallel kinematic machine." *Applied Mechanics and Materials*, 416-417: 995-999.

ABSTRACT: Thanks to the development of science and technology, studies on robot have seen a huge growth. In this paper, by introducing a new flexible wrist force sensor operated by robot based on parallel kinematic machine, it analyzes the working principle of the sensor and provides detailed design.

Ballesté, F., Torras, C. 2012. "Effects of human-machine integration on the construction of identity." *Handbook of Research on Technoself: Identity in a Technological Society*, 2: 607-624.

ABSTRACT: Recent developments in social robotics, intelligent prosthetics, brain-computer interfaces, and implants pose new questions as to the effects of technology on identity, society, and the future of humankind. The authors' standpoint is that such effects cannot be studied separately from their social/cultural context, and thus, this chapter begins by reviewing the existing approaches to the social construction of reality, placing special emphasis on language and its limitations to describe the future. Then, it focuses on the body as the place where the human-machine integration occurs, and describes four levels at which the notion of cyborg has been analyzed in anthropological studies: symbolic, physical, as a permeable layer between nature and culture, and as an intermediate step towards a higher-order existence. The chapter ends up with a word of caution in relation to technological determinism stemming from STS (Science and Technology Studies), as well as the need to establish Relevant Social Groups (RSG) with well-founded criteria that join scientific and sociological academics under a multidisciplinary approach.

Decker, M. 2012. "Service robots in the mirror of reflective research." *Poiesis und Praxis*, 9(3-4): 181-200.

ABSTRACT: Service robotics has increasingly become the focus of reflective research on new technologies over the last decade. The current state of technology is characterized by prototypical robot systems developed for specific application scenarios outside factories. This has enabled context-based Science and Technology Studies and technology assessments of service robotic systems. This contribution describes the status quo of this reflective research as the starting point for interdisciplinary technology assessment (TA), taking account of TA studies and, in particular, of publications from the ethical and empirical social science perspective. Finally, based on this status quo, evaluation criteria for service robots are developed, which are relevant for further reflective research.

Vertesi, J. 2012. "Seeing like a Rover: Visualization, embodiment, and interaction on the Mars Exploration Rover Mission." *Social Studies of Science*, 42(3): 393-414.

ABSTRACT: Based on more than 2 years of ethnographic immersion with the Mars Exploration Rover mission, this paper examines the representational work and associated embodied practices through which the science and engineering team makes decisions about how and where to move their robots. Building on prior work in Science and Technology Studies on the importance of embodiment to visualization, the paper posits that such practices also contribute to the production and maintenance of social order within the organizational context of the laboratory. It thus places visualization technologies and techniques in the context of the social organization of scientific work, contributing to our understanding of representation in scientific practice.

Komiya, I., Torii, H., Fujii, Y., Hayashizaki, N. 2008. "Relationship between students' interests in science and attitudes toward nuclear power generation." *Progress in Nuclear Energy*, 50(2-6): 719-727.

ABSTRACT: In order to study the following two points, we conducted an attitude survey among senior high school students.Study 1The differences in attitudes between nuclear power generation and other science and technologies.Study 2The relationship between students' interests in science and attitudes toward nuclear power generation. In the questionnaire, the attitudes toward nuclear power generation consisted of four questions: (1) pros and cons, (2) safety, (3) necessity, (4) reliability of scientists and engineers who are involved in nuclear power; and we treat four science and technology issues: (1) genetically modified foods, (2) nuclear power generation, (3) humanoid and pet robots, (4) crone technology. From study 1, on attitude to security toward nuclear power generation, about 80% of respondents answered negatively and on attitude to necessity toward it, about 75% of respondents answered positively. Therefore, we found that the structure of attitude was complicated and that it was specific to nuclear power generation. From study 2, we found students' interests in science that influence the attitude toward nuclear power generation.

Suchman, L. 2006. "Reconfiguring human-robot relations." *Proceedings - IEEE International Workshop on Robot and Human Interactive Communication*, art. no. 4107882, 652-654.

ABSTRACT: This paper explores cultural imaginaries in projects dedicated to the design of human-like machines. Working with discussions of mimesis as developed by anthropologists Michael Taussig [1] and Alfred Gell [2], I look at some exemplary realizations of 'socially intelligent' robots, proposing an approach aimed at demystifying and reenchanting such encounters. This alternative is developed through a close analysis of a project at the intersection of computing and new media art, performance artist Stelarc's Prosthetic Head. Drawing on recent discussions within cultural anthropology, science and technology studies, and feminist theory, I offer some suggestions for how we might differently conceptualize relations between humans and computational machines.

Yamada, Y. 2006. "Skill-Assist and Its Related Safety-Oriented Technology." *Mechatronics for Safety, Security and Dependability in a New Era*, 1-4.

ABSTRACT: This chapter describes a current technology that has been already implemented on the controller of the skill-assist for putting it to practical use and a future safeguarding method that has been developed on a laboratory basis. An important issue on putting skill-assist devices into practice was resolved by attaining a certain level of safeguarding technology that follows the initial productivity enhancement effort of controlling the devices so as to reflect workers desired skills in the statistical sense. It was reported that no accident or system failure has occurred since commencement of the operation. The chapter discusses laboratory-based study concerning safeguarding scheme against human operational sly and how to put human-coexistence type service robots into practice from the viewpoint of science and technology study. 

Pickering, A. 2012. "Cybernetics and the Mangle: Ashby, Beer and Pask." *Social Studies of Science*, 32(3): 413-437.

ABSTRACT: This paper aims to enrich our understanding of the history and substance of cybernetics. It reviews the work of three British cyberneticians - W. Ross Ashby, Stafford Beer and Gordon Pask - paying attention particularly to the materiality of their practice - the strange and fascinating devices and systems that were at the heart of their work - and to the worldly projects they pursued - scientific, technological, artistic, organizational, political and spiritual. Connections are drawn between cybernetics and recent theoretical work in science and technology studies, in the hope of illuminating key features of both. The paper concludes by suggesting that the antidisciplinary impulse of contemporary science studies might find inspiration in the work of cyberneticians - that theory does not have to remain confined to the realm of theory.

## SCOPUS search for: "science and technology studies" AND "artificial intelligence" (12)

A search of SCOPUS for the term "science and technology studies" AND "artificial intelligence" returned 12 hits. Of these, 4 were selected for review. The relevant abstracts are shown below.

Sanz, V. 2012. "How philosophy, science and technologies studies, and feminist studies of technology can be of use for soft computing." *Studies in Fuzziness and Soft Computing*, 273: 89-109.

ABSTRACT: Artificial Intelligence has been one of the fields within Computer Science that has generated more interest and debates among philosophers. Later on, the most recent fields of Science and Technology Studies (STS), and Feminist Studies of Technology (FST) have also shown some interest in AI. In both cases most of the authors have been quite critical about the promises, practices and, particularly, the epistemological basis of Classical AI. The first part of the paper consists on an enumeration of the most important authors and their critiques to AI from Philosophy, STS studies and FST. Since Soft Computing entails important changes with respect to traditional AI approaches, the second part of the paper will be devoted to confront Soft Computing with the previous critiques and challenges to AI and to weight up to what extent Soft Computing could (or could not) answer differently than other AI approaches to these critiques and challenges.

Sanz, V. 2009. "Soft computing confronting philosophical and sociological critiques to classical AI." *2009 International Fuzzy Systems Association World Congress and 2009 European Society for Fuzzy Logic and Technology Conference*, IFSA-EUSFLAT 2009 – Proceedings: 1502-1507.

ABSTRACT: Artificial Intelligence has been one of the fields within Computer Science that has generated more interest and debates among philosophers. Later on, the most recent field of Science and Technology Studies (STS) also has shown some interest in AI. In both cases most of the authors have been quite critical about the promises, the practices and particularly the epistemological basis of Classical AI The first part of the paper consists on an enumeration of the most important authors and their critiques to AI in Philosophy and STS studies. Since Soft Computing implies important changes with respect to traditional AI approaches like Symbolic AI, the second part of the paper will be devoted to confront Soft Computing with the critiques and challenges and to weight up to what extent Soft Computing could (or could not) answer differently than other AI approaches regarding the critiques received.

Fleischmann, K.R. 2009. "Sociotechnical interaction and cyborg-cyborg interaction: Transforming the scale and convergence of HCI." *Information Society*, 25(4): 227-235.

ABSTRACT: This article describes the broadening of the range of issues addressed by human-computer interaction (HCI) in response to ongoing trends of networked and ubiquitous computing. The first trend is the growing scale of HCI, with a transformation of HCI from focusing on individuals to groups to society as a whole, resulting in sociotechnical interaction. The second trend is the increasing convergence of the human and the computer in HCI, leading to cyborg-cyborg interaction. The article considers the social and ethical implications of these two trends, in particular, the growing importance of nonhuman agency, including not only the bioagency of humans and nonhuman animals but also the cyberagency of information technology and the collective agency of networks. The article concludes that bioagency and cyberagency are in the process of converging, leading to growing collaboration not only at and through computers but also with computers.

Giddings, S. 2005. "Playing with non-humans: Digital games as techno-cultural form." *Proceedings of DiGRA 2005 Conference: Changing Views - Worlds in Play*: 1-12.

ABSTRACT: Game studies has yet to engage with a sustained debate on the implications of its fundamentally technologically based foundation - i.e. the 'digitality' of digital games. This paper calls for such a debate and offers some initial thoughts on issues and directions. The humanities and social sciences are founded on the principle that historical and cultural agency reside solely in the human and the social. Drawing on Science and Technology Studies, Actor-Network Theory and cybercultural studies, this paper argues that a full understanding of both the playing of digital games, and the wider techno-cultural context of this play, is only possible through a recognition and theorisation of technological agency. Taking the Gameboy Advance game Advance Wars 2 as a case study, the paper explores the implications for game studies of attention to non-human agency - specifically the agency of simulation and artificial life software - in digital game play.

## AnthroSource search for: "STS" AND "robot*"

A search of AnthroSource for the terms "STS" and "science and technology" returned the results seen in Table 1. There seems to be a subfield of anthropology called the "anthropology of science and technology" and another termed the "anthropology of technoscience". These subfield terms might be helpful in future searches. STS as an abbreviation returned a mix of results, some results did not relate to the field of STS. We have not yet found a specific search query that returned consistently relevant results, but these results may provide a basis for a more in-depth search. Many of the results for our selected extended search (STS + robot*) returned articles related to the understanding of STS as "sit-to-stand" motion.

We have selected the following abstracts to demonstrate their relevance (or irrelevance) to our searches and/or to REELER's context.

Kirksey, S. E. & Helmreich, S. 2010. "The Emergence of Multispecies Ethnography." *Cultural Anthropology*, 25: 545–576. doi:10.1111/j.1548-1360.2010.01069.x19

*[**STS + robot + ethnography**: This article discusses "multispecies ethnography", referring to nonhuman animals and humans, at the intersection of STS and animal/environmental studies. They draw, in part, on the work of Latour when they make reference to robots treated as nonhuman actors.]*

EXCERPT "Finally—and staying with the theme of security—Jake Kosek zeroes in on the bees Marx used as a foil for humans, examining the militarization of honeybees and the use of "the swarm" as a metaphor by the U.S. military in the "war on terror." Grounding his ethnographic practice in his hobby of bee keeping, Kosek follows bees and mathematical swarming algorithms from public debates in the U.S. Congress to DARPA-funded projects at the Los Alamos National Laboratory to the battlefields of Afghanistan. Engaging with clouds of ideas about swarming, Kosek departs from literal descriptions of bee behavior to wrangle with critical theory on the topic (by Deleuze and Guattari, among others) to describe how swarms have found a place to flourish within the modern militarized state. Teasing out the mimetic logic of Pentagon officials, Kosek finds abundant evidence of terrifying animal becomings. The U.S. government is assembling legions of insectoid **robots** and commanding soldiers to embody the form and tactics of the swarm. Like Hayward, Kosek centers his attention on the sensory differences his subject organisms exhibit from humans—and he shows how these are being exploited and rebuilt for human purposes. A multisensory approach—grappling with unfamiliar sensoriums, with different kinds of touch, smell, taste, and vision—characterizes this multispecies **ethnography**."

ABSTRACT "Anthropologists have been committed, at least since Franz Boas, to investigating relationships between nature and culture. At the dawn of the 21st century, this enduring interest was inflected with some new twists. An emergent cohort of "multispecies ethnographers" began to place a fresh emphasis on the subjectivity and agency of organisms whose lives are entangled with humans. Multispecies ethnography emerged at the intersection of three interdisciplinary strands of inquiry: environmental studies, **science and technology studies (STS),** and animal studies. Departing from classically ethnobiological subjects, useful plants and charismatic animals, multispecies ethnographers also brought understudied organisms—such as insects, fungi, and microbes—into anthropological conversations. Anthropologists gathered together at the Multispecies Salon, an art exhibit, where the boundaries of

an emerging interdiscipline were probed amidst a collection of living organisms, artifacts from the biological sciences, and surprising biopolitical interventions."

Riles, Annelise. 2004. "Real time: Unwinding technocratic and anthropological knowledge." *American Ethnologist,* 31(3): 392–405.

*[**STS + robot + Arendt + ethnography + Latour**: This article focuses on the hierarchy of knowledge, where those in power use experts to validate their own positions. The mention of robot is used as an example of this process.]*

EXCERPTS:

"**Science and technology studies** (STS) scholars have technologically extended this last point to demonstrate how bureaucrats overcome conceptual limits by inventing devices that do the work of technocracy. Bruno **Latour** (1996), for example, has described Aramis, a transportation system for the city of Paris developed by French technocrats, as a continuation of bureaucratic politics by other means. Fabian Muniesa (2000b) describes a technology similar to the one at issue in this article—an automated ''**robot**'' built to match trades at the Paris stock exchange—as ''moral architecture'' developed to do what planning could not: root out corruption in trading. Muniesa goes on to show how, in the end, the **robot**'s algorithmic principles in many respects reproduced both the inequities in the trading system and the knowledge practices of the bureaucrats who sought to regulate them."

"In his classic midcentury critique of U.S. politics, Theodore Roszak assails the technocracy as ''that society in which those who govern justify themselves by appeal to technical experts who, in turn, justify themselves by appeal to scientific forms of knowledge. And beyond the authority of science there is no appeal'' (1969:8). Like other theorists of his time (e.g., Meynaud 1969), Roszak follows Hannah **Arendt**(1976), Herbert Marcuse (1964), and Max Weber (Weber and Eisenstadt 1968) to focus on the way technocratic power is ''the product of knowledge and extraordinary performance'' (Winner 1977:139). Recent work revives this tradition to show, for example, how the assumptions and inner workings of bureaucratic knowledge impede citizen participation (Espeland 1994;Fischer 1990)."

ABSTRACT: ''The Bank of Japan is our mother,'' bankers in Tokyo sometimes said of Japan's central bank. Drawing on this metaphor as an ethnographic resource, and on the example of central bankers who sought to unwind their own technocratic knowledge by replacing it with a real-time machine, I retrace the ethnographic task of unwinding technocratic knowledge from those anthropological knowledge practices that critique technocracy. In so doing, I draw attention to special methodological problems—involving the relationship between **ethnography**, analysis, and reception—in the representation and critique of contemporary knowledge practices."

Hakken, D. 2001. "'Our' Anthropology of Technoscience?" *American Anthropologist*, 103: 535–539. doi:10.1525/aa.2001.103.2.535

*[**"STS" + "machine"**: This article explores the emerging field (in 2001), the "anthropology of technoscience". The author examines 4 texts, including an ethnography of artificial life.]*

EXCERPTS:

"Silicon Second Nature is an **ethnography** of the techno-scientific practices associated with **artificial life** or 'Alife.'"

"His central focus is to specify the ways in which a nationalist discourse on CAD (e.g., as the way to save the competitive standing of the United States) provides an implicit terrain on which students construct an understanding of what CAD is for and how it relates to them (and vice versa). Specifically, as the title implies, he is interested in the way that student's bodies become inscribed in the **machines** and the **machines** in the students' (and others') bodies."

"Moreover, a mature anthropology of technoscience would help contemporary **humans**/cyborgs understand more fully how technoscience practices are implicated in contemporary social change. This anthropology's opportunity to be perceived as significant derives from the popular belief that technoscientific development is driving social formation reproduction toward some new dynamic, for ex-ample, "cyberspace." Thus, technoscience anthropology offers our discipline means to have a substantial impact on social formation reproduction. Yet because potential new social formation dynamic at most exists only in embryo, studying it inherently implicates one in its creation. This imposes a special **ethical** duty on the ethnographer of technoscience, to supplement her explication of practices with her best understanding of what these practices should be like (Hakken 2000)."

Fischer, M. M. J. 2007. "Four Genealogies for a Recombinant Anthropology of Science and Technology." *Cultural Anthropology*, 22: 539–615. doi:10.1525/can.2007.22.4.539

*[**"science and technology" + "robotics" OR "STS" + "machine" + "Arendt":** Anthropology of Science and Technology: an overview of the formation of the field as it is now and suggestion for how it should continue to develop.]*

EXCERPTS:

"Newer work on using living tissue as tools in biology (Landecker 2007 on immortal cell lines), on **robotics** and systems biology (personal communication, Fujimura, April 2007), on genetically modified foods and stem cell research (Jasanoff 2005) cannot be contained within the walls of the laboratory, but necessarily entail cultural and social entanglements."

"The call of and for an Anthropology of **Science and Technology** requires a new generation of robust switches to translate legacy genealogies to public futures. Just as we have moved from Mertonian sociologies of science (stressing the regulative ideals of organized skepticism, disinterested objectivity, universalism, and communal ownership of ideas) to analyses of what scientists actually do (the slogans of the "new sociologies of science," i.e., social studies of knowledge (SSK), and "social construction" of technology [SCOT], and of the anthropologically informed ethnographies of science and technology of the 1990s), so too we need now to formulate anthropologies of **science and technology** that attend to both the cultural switches of the heterogeneous communities within which sciences are cultured and technologies are peopled, and to the reflexive social institutions within which medical, environmental, informational, and other technosciences must increasingly operate."

Glaskin, K. 2012. "Empathy and the Robot: A Neuroanthropological Analysis." *Annals of Anthropological Practice*, 36: 68–87. doi:10.1111/j.2153-9588.2012.01093.x

*[**"science and technology" + "robotics":** This article focuses on social robots and human emotions. It seems close to REELER's empirical context.]*

ABSTRACT "**Roboticists** developing socially interactive **robots** seek to design them in such a way that **humans** will readily anthropomorphize them. For this anthropomorphizing to occur, **robots** need to display emotion-like responses to elicit empathy from the person, so as to enable social interaction. This article focuses on **roboticists**' efforts to create emotion-like responses in **humanoid robots**. In particular, I investigate the extent to which the cultural dimensions of emotion and empathy are factored into these endeavors. Recent research suggests that mirror neurons or other brain structures may have a role to play in empathy and imitation. Notwithstanding this, the effect of sociocultural experience in shaping appropriate empathic responses and expectations is also crucial. More broadly, this article highlights how we are literally **anthropomorphizing technology**, even as the complexity of technology and the role it plays in our lives grows. Both the actual design process and the understanding of how technology shapes our daily lives are core applied dimensions of this work, from carrying out the research to capturing the critical implications of these technological innovations."

EXCERPT "…it would require an embodied and developmental approach. Indeed, such a developmental approach is one that Vernon et al. (2010) take in their "roadmap" to developing cognition in humanoid **robots. Robotic learning** can be "embodied" in the sense that **robots** have mechanical "bodies" that can be covered in "skin" that includes "pain sensors" and "algorithms for learning" (Picard 1997:72)."

Croissant, J. 2003. Review of *Studying Those Who Study Us: An Anthropologist in the World of Artificial Intelligence,* by Diana E. Forsythe. *American Anthropologist*, 105: 412–413. doi:10.1525/aa.2003.105.2.412

*[**"science and technology" + "artificial intelligence"**: This is a book review. The book itself seems to have chapters relevant to REELER.]*

EXCERPT "Organized somewhat chronologically, the lead chapters contain focused studies of **artificial intelligence** (AI) and its cultural definitions of work and of itself. Two of the most significant chapters involve the close examination of culture and values embedded in medical informatics systems. For example, expert systems **designers** consistently blame potential users of their systems for lack of adoption, despite the obvious (to an anthropologist) flaws in the knowledge elicitation strategies. This may lead to less effective systems, for example, the deletion (Forsythe's term) of nurses and patient's perspectives in a migraine information system. The contribution that anthropology might make to system **design** is the core of an exchange between Fortsythe and AI researcher James

Fleck (reprinted from Social Studies of Science). Forsythe rather consistently elided the possibility that the **anthropology of technoscience may offer opportunities for improving technological design**. The potential lies not only in the narrow, instrumental sense often attributed to a corporate anthropology that resembles marketing, but of widespread changes in systems design practices in many fields to provide more robust and useful systems that are effective for the needs of diverse, especially nonexpert, users."

Book: Forsythe, Diana E. 2001. *Studying Those Who Study Us: An Anthropologist in the World of Artificial Intelligence.* Stanford: Stanford University Press.

## AnthroSource search for: "STS + robotics" (42) [selected results including known scholars' names]

Of the 42 results in AnthroSource for "STS" and "robotics", the search terms "Suchman" and "Richardson" appeared in two texts, and "Haraway" in three; none of the texts were authored by the specified scholars. "Sabanovic", "Robertson", "Hasse", and "Alac" did not appear in any of the 42 texts. This suggests that our search string in AnthroSource ("STS" and "robotics") is not returning the most relevant results.

| Additional search terms | AND "STS" AND "robotics" |
|---|---|
| ("Alac" OR "Hasse" OR "Richardson" OR "Robertson" OR "Haraway" OR "Suchman" OR "Sabanovic") | 5 |

Fischer, Michael M. J. 2007. "Four genealogies for a recombinant anthropology of science and technology." *Cultural Anthropology, 22(4): 539-615.*

EXCERPT "The new generation of ethnographies of scientific and technological develop-ments, especially in the worlds outside Western Europe and North America, ispart of a cosmopolitical technoscientific world, where one needs an ethnographic eye to clearly see the political, cultural, technological, financial, institutional, andhuman capital building blocks and barriers….Anthropology per force is becoming a third space, a space of comparativeand entangled frames and of emergent forms of life (Fischer 2003). Differential anddialogic epistemic objects appear in agonistic, competitive and transnational rela-tionships; civics and ethical discourse shift from universal rights and matters of factto matters of concern, ethics of care, living with alterity, and the face of the other(Fischer 2006; Fortun 2007; Haraway 1991, 1997, 2003; Latour 2005a)."

Aiken, Jo. 2012. "Integrating Organizational and Design Perspectives to Address Challenges of Renewal: A case study of NASA's post-shuttle workforce transition." *Ethnographic Praxis in Industry Conference,* 2012(1): 163-176.

ABSTRACT "As organizations become increasingly complex and technology-dependent, likewise their challenges become increasingly complex and technology-driven. In the practice of organizational and design ethnography, the elements of organization and technology design overlap. However, a need remains for an explicit framework to deal with the complex challenges of innovation and change faced by contemporary organizations. This need is evident in a case study of NASA's workforce transition as a result of the space shuttle's retirement. NASA's challenge is both organizational and technological – the end of the Space Shuttle Program left the agency without a clear replacement vehicle and the risk of losing an experienced, expert workforce. An integrated organizational and design approach could foster an environment of renewal by involving stakeholders at all levels of the agency and adopting a future-oriented approach to anticipating change."

Kirksey, S. Eben and Stefan Helmreich. 2010. "The emergence of multispecies ethnography." *Cultural Anthropology*, 25(4): 545–576.

ABSTRACT "Anthropologists have been committed, at least since Franz Boas, to investigating relationships between nature and culture. At the dawn of the 21st century, this enduring interest was inflected with some new twists. An emergent cohort of "multispecies ethnographers" began to place a fresh emphasis on the subjectivity and agency of organisms whose lives are entangled with humans. Multispecies ethnography emerged at the intersection of three interdisciplinary strands of inquiry: environmental studies, science and technology studies (STS), and animal studies. Departing from classically ethnobiological subjects, useful plants and charismatic animals, multispecies ethnographers also brought understudied organisms—such as insects, fungi, and microbes—into anthropological conversations. Anthropologists gathered together

at the Multispecies Salon, an art exhibit, where the boundaries of an emerging interdiscipline were probed amidst a collection of living organisms, artifacts from the biological sciences, and surprising biopolitical interventions."

Hess, David J. 2007. "Crosscurrents: Social Movements and the Anthropology of Science and Technology." *American Anthropologist*, 109(3): 463–472.

ABSTRACT "Along with growth and acceptance of the anthropology of science and technology has come a narrowing of focus both topically and methodologically. An alternative topic of inquiry (social movements) and an alternative method (a limited return to nomothetic inquiry) offer potential for research that is relevant to both social change actors and social scientists such as sociologists and political scientists. A comparative analysis of existing anthropological research on science, technology, and social movements provides the basis for limited generalizations regarding the types and circumstances of charged cultural repertoires that both social movements and elites invoke."

Riles, Annelise. 2004. "Real time: Unwinding technocratic and anthropological knowledge." *American Ethnologist*, 31(3): 392–405.

ABSTRACT "The Bank of Japan is our mother," bankers in Tokyo sometimes said of Japan's central bank. Drawing on this metaphor as an ethnographic resource, and on the example of central bankers who sought to unwind their own technocratic knowledge by replacing it with a real-time machine, I retrace the ethnographic task of unwinding technocratic knowledge from those anthropological knowledge practices that critique technocracy. In so doing, I draw attention to special methodological problems—involving the relationship between ethnography, analysis, and reception—in the representation and critique of contemporary knowledge practices.

## AnthroSource search for: "robot" (248) and "robotics" (123) [selected results including known scholars' names]

Separate searches for "STS" and for "robot" returned significantly more results with known scholars' names included. This suggests that the combination of the two search terms "STS" and "robot" excludes certain relevant results. We repeated the search for "robot", to include known scholars' names. Of 248 results for "robot", 57 contained at least one of the specified known STS scholars' names. Selected abstracts are presented below.

| Additional search terms | AND "robot" |
|---|---|
| ("Alac" OR "Hasse" OR "Richardson" OR "Robertson" OR "Haraway" OR "Suchman" OR "Sabanovic") | 57 |

Messeri, Lisa. 2017. "Resonant worlds: Cultivating proximal encounters in planetary science." *American Ethnologist*, 44(1): 131–142.

ABSTRACT "Planetary scientists are adept at producing knowledge about objects that are far removed from their lived experience of place and time. Sometimes, they overcome this distance by positioning Earth as a planet that can stand for other worlds. Encountering Earth becomes an encounter with another planet. When scientists experience the Earthly as otherworldly, they sometimes feel an excitement here described as "resonance." Fully felt resonance is rare, but scientists devote much time and effort to preparing for it so as not to miss its fleeting instances. Just as resonance affords scientists the possibility of experiencing the distant, it also describes moments when the anthropologist is in harmony with what had previously been strange. Thus, resonance is a mode of cognitive and affective reasoning that collapses distance and transforms the similar into the same."

Bernstein, Anya. 2015. "Freeze, die, come to life: The many paths to immortality in post-Soviet Russia." *American Ethnologist*, 42(4): 766–781.

ABSTRACT "Through practices such as cryonics and plans to build robotic bodies for future "consciousness transfer," the Russian transhumanist movement has engendered competing practices of immortality as well as ontological debates over the immortal body and person. Drawing on an ethnography of these practices and plans, I

explore controversies around religion and secularism within the movement as well as the conflict between transhumanists and the Russian Orthodox Church. I argue that the core issues in debates over the role of religion vis-à-vis immortality derive from diverse assumptions being made about "the human," which—from prerevolutionary esoteric futurist movements through the Soviet secularist project and into the present day—has been and remains a profoundly plastic project. [body, immortality, religion, death, transhumanism, cryonics, postsocialism, Russia]

Candea, Matei. 2013. "Suspending Belief: Epoché in Animal Behavior Science." *American Anthropologist*, 115 (3): 423–436.

EXCERPT "In such interactions, an ability to read meerkats' intentions is crucial: "If I hold out the egg box and a female looks at it, I can tell if she's interested or not" (Jo, personal communication, 13 Oct 2011), as another volunteer put it. Elisa made the point uncompromisingly: "They are also living animals, they have feelings. So if you work with them like a machine or robot … it wouldn't work!" (personal communication, 21 Oct 2011). By contrast, during ad lib, the data had to be insulated from such intersubjectivity. Thus, in answer to questions about the attribution of intention or subjective experience to meerkats, volunteers would often note that this was fine "unless it affects the data" (Annie, personal communication, 13 Oct 2011)."

ABSTRACT "In an anthropology that has turned, in recent years, toward the study of human–animal relations, scientific skepticism about nonhuman animal minds has more often been featured as a focus of conceptual critique than of ethnographic exegesis. Decried as the sign of a problematic detachment from nonhumans, such skepticism is often simultaneously presented as an ideological stance by which no one who actually works and lives with nonhuman animals could truly live. In contrast, in this article, I examine attempts to live by such skepticism through an ethnography of two very different British-led research projects in which scientists study animal behavior and cognition respectively. I describe researchers' commitment to engaging in intersubjective relations with the nonhuman animals they study while simultaneously detaching from propositional beliefs about the latter's inner lives. This simultaneously engaged and detached attitude, which I describe as "epoché," challenges descriptions of a settled "naturalist" ontology at play in animal behavior science and offers the potential for a comparative anthropology of doubt and operational skepticism."

Wilf, Eitan. 2013. "Sociable robots, jazz music, and divination: Contingency as a cultural resource for negotiating problems of intentionality." *American Ethnologist,* 40(4): 605-618.

ABSTRACT "In practices that range from mechanical divination in Central Africa to gamelike interactions among jazz students and the development of a jazz-improvising humanoid robot marimba player in the United States, contextually meaningful contingency is widely used as a cultural resource for negotiating problems of intentionality. Whereas anthropologists have been concerned with the use of contingency mostly as a cultural resource for increasing predictability of intentions in conflictual situations, I highlight contexts pervaded by modern normative ideals of creativity in which predictability of intentions constitutes a problem, for which contextually meaningful contingency is used as a solution."

Glaskin, Katie. 2012. "Empathy and the robot: a neuroanthropological analysis." *Annals of Anthropological Practice*, 36(1): 68–87.

ABSTRACT "Roboticists developing socially interactive robots seek to design them in such a way that humans will readily anthropomorphize them. For this anthropomorphizing to occur, robots need to display emotion-like responses to elicit empathy from the person, so as to enable social interaction. This article focuses on roboticists' efforts to create emotion-like responses in humanoid robots. In particular, I investigate the extent to which the cultural dimensions of emotion and empathy are factored into these endeavors. Recent research suggests that mirror neurons or other brain structures may have a role to play in empathy and imitation. Notwithstanding this, the effect of sociocultural experience in shaping appropriate empathic responses and expectations is also crucial. More broadly, this article highlights how we are literally anthropomorphizing technology, even as the complexity of technology and the role it plays in our lives grows. Both the actual design process and the understanding of how technology shapes our daily lives are core applied dimensions of this work, from carrying out the research to capturing the critical implications of these technological innovations."

2011. "The EPIC 2011 Conversation." *Ethnographic Praxis in Industry Conference Proceedings*, 2011: i–439. doi:10.1111/j.1559-8918.2011.00002.x

Helmreich, Stefan. 2007. "An anthropologist underwater: Immersive soundscapes, submarine cyborgs, and transductive ethnography." *American Ethnologist*, 34(4): 621–641.

ABSTRACT "In this article, I deliver a first-person anthropological report on a dive to the seafloor in the Woods Hole Oceanographic Institution's three-person submersible, Alvin. I examine multiple meanings of immersion: as a descent into liquid, an absorption in activity, and the all-encompassing entry of an anthropologist into a cultural medium. Tuning in to the rhythms of what I call the "submarine cyborg"—"doing anthropology in sound," as advocated by Steven Feld and Donald Brenneis (2004)—I show how interior and exterior soundscapes create a sense of immersion, and I argue that a transductive ethnography can make explicit the technical structures and social practices of sounding, hearing, and listening that support this sense of sonic presence."

Hess, David J. 2007. "Crosscurrents: Social Movements and the Anthropology of Science and Technology." *American Anthropologist*, 109(3): 463–472.

ABSTRACT "Along with growth and acceptance of the anthropology of science and technology has come a narrowing of focus both topically and methodologically. An alternative topic of inquiry (social movements) and an alternative method (a limited return to nomothetic inquiry) offer potential for research that is relevant to both social change actors and social scientists such as sociologists and political scientists. A comparative analysis of existing anthropological research on science, technology, and social movements provides the basis for limited generalizations regarding the types and circumstances of charged cultural repertoires that both social movements and elites invoke."

2007. Cover. *Anthropology News*, 48: C1. doi:10.1525/an.2007.48.4.1

Riles, Annelise. 2004. "Real time: Unwinding technocratic and anthropological knowledge." *American Ethnologist*, 31(3): 392–405.

ABSTRACT "The Bank of Japan is our mother," bankers in Tokyo sometimes said of Japan's central bank. Drawing on this metaphor as an ethnographic resource, and on the example of central bankers who sought to unwind their own technocratic knowledge by replacing it with a real-time machine, I retrace the ethnographic task of unwinding technocratic knowledge from those anthropological knowledge practices that critique technocracy. In so doing, I draw attention to special methodological problems—involving the relationship between ethnography, analysis, and reception—in the representation and critique of contemporary knowledge practices.

Kasmir, Sharryn. 2001. "Corporation, Self, and Enterprise at the Saturn Automobile Plant." *Anthropology of Work Review*, 22(4): 8–12.

EXCERPT "This paper is about recent changes in factory work and corporate ideology as I saw them unfold at the Saturn Automobile Corporation, in Spring Hill, Tennessee, where I conducted fieldwork from 1998-99. Like many major corporations, Saturn responded to increased global competition in the late twentieth century by adopting new managerial practices, such as Total Quality Management, team-based production, and worker participation. Many scholars and labor activists have argued that although they appear in the guise of human relations, these post-Fordist management techniques bring speedups, increase stress, and threaten union power, while doing little to actually democratize the workplace or enrich jobs…' And what you say, you can put that into play, you can really actually go out there and give your ideas, and your ideas are accepted and they are actually put into the job and things like that. So you do feel, to me it's more of a personal growth versus just standing in one spot and being repetitious or being more like a robot'."

Allison, Anne. 2001. "Cyborg Violence: Bursting Borders and Bodies with Queer Machines." *Cultural Anthropology*, 16(2): 237–265.

EXCERPT "It is this conceptualization of violent entertainment and the impact it hason youth I wish to challenge in my paper by considering a specific genre—violent cyborgs popularized since the 1980s by such blockbuster hits as RoboCop and Terminator. By almost any definition, these movies are violent. But it is the meaning and organization of this violence I wish to pay attention to here as few in the category of killer cyborg—cyborgs are hybrids of living matter melded with cybernetic devices; and killer cyborgs, often indistinguishable from cyborgs, are cyborgs programmed to fight, kill, or attack—are as neatly and unambiguously drawn as critics like Bok would suggest. Although their bodies both are and bear lethal weapons, the cyborg's identity is complicated beyond that of mere aggressor. Created themselves out of body-parts from dead (often killed) human beings, these cyborgs undergo constant attack and continual reconstruction. Who or what the cyborg is, in fact, is a concern that both troubles and constitutes the plot, and establishing ones identity is a desire that drives as much as eludes the cyborg subject."

Sinha, Arushi. 2000. "An Overview of Telemedicine: The Virtual Gaze of Health Care in the Next Century." *Medical Anthropology Quarterly*, 14(3): 291–309.

ABSTRACT "This article considers the role of telemedicine in the production of biomedical health care using three specific theoretical constructs as lenses through which to examine this phenomenon: (J) Foucault's medical "gaze "; (2) the political economy of health; and (3) deterritorialization and multisite ethnography. This examination focuses first on the changing corporate structure of health care and changing political attitudes toward telemedicine. Second, it documents the current use of telemedicine in prisons, the military, and in cross-cultural settings. Third, it discusses responses to telemedicine of individual physicians, health care staff, and patients, finding that these responses are broadly conditioned by an individual's mode of articulation with biomedical institutions and that they are mediated by personal experience, [telemedicine, telehealth, Foucault, political economy]."

Laughlin, Charles D. 1997. "The Evolution of Cyborg Consciousness." *Anthropology of Consciousness*, 8(4): 144–159.

ABSTRACT "Inspired by Donna Haraway's essay, "A Manifesto for Cyborgs," numerous "cyborg" studies in anthropology, sociology, history and literary criticism have looked at the relationship between humans and technology. A problem with many of these studies is that they use the term "cyborg" metaphorically and fuzzily without an appreciation of the history of cybernetics. This paper will critique both the profound insights and non-trivial distortions engendered by the cyborg polemic. An euroanthropological model of human technics is presented that allows a scientifically useful discrimination to be made between cyborg and non-cyborg (i.e., robot, android, AI, etc.) technologies. Technology is seen as a nonlinear, bidirectional process of penetration in which the body is physically extended outward into the world and the world is physically interjected inward into the body. Four stages of the evolution of the cyborg are defined. Grounded extrapolations are made about the future development of cyborg consciousness and its implications for culture and extraterrestrial anthropology."

Rose, Dan. 1994. "The Evolution of Intervention. *Anthropology and Humanism*, 19(1): 88–103.

EXCERPT "We have invented robots, golems, physical serfs, smart and dumb corporeal agents, assemblages, assemblies, fabrications, cyborgs, androids, gynroids, monsters, helpers, contrivances, appliances, new atomic organization, new molecular structures, new chemical compounds, new cellular formations, new combinations and recombinations of genetic material, all together forming the networks of the nature-machine-and-human planetary society, each process and product designed, engineered, and built to be priced on the market. The intellectual labor for it is widely distributed but also costed for the market; and the market itself becomes a fluctuation constantly reconfigured by the profit-producing fabrications of companies. Humans are the creatures whose destiny is now bound to corporately generated mechanisms and to pure processes of transformation that have caught up the physical human body in the instabilities of invention and design. Heidegger's question of Being has come too late. We can now only ask, What can we become? It is a question simultaneously ethical and technical. It has no ready answer."

Gray, Chris Hables and Mark Driscoll. 1992. "What's Real About Virtual Reality?: Anthropology of, and in, Cyberspace." *Visual Anthropology Review*, 8(2): 39–49

EXCERPT " 'Just what we don't need right now are powerful machines doing things to the world before we have discovered just what it is we ought to be doing to the world.To the medical diagnosticians or surgeons who want to float their vision and manual dexterity and a microscalpel right into an artery or a cornea, teleoperated robots area miraculous aid to alleviating human suffering and saving lives. To those who turn rain forests into plywood, semi-autonomous megadozers are an ideal instrument for efficiently transforming biosphere into greenbacks. The families of bomb-squad experts and firefighters who risk their life and limb might see impervious telerobots as a gift of life. And to those who would rather not risk their own flesh but don't mind spewing shrapnel into the bodies of other human beings, teleoperated gunships are the way to go. The virtues or terrors of VR often seem to depend on who does what to whom with it. (1991: 271)'."

## "STS" (836) [selected results including known scholars' names]

I haven't yet gone through these abstracts. It does not seem likely that a search for STS will return results that are more relevant to REELER, without the search term "robot".

| Additional search terms | AND "STS" |
|---|---|

| | |
|---|---|
| (”Alac” OR "Hasse" OR "Richardson" OR "Robertson" OR "Haraway" OR "Suchman" OR "Sabanovic") | 129 |

## ERIC search for: “STS + robot” (9)

Black, D. & Zeigler, J. “Interdisciplinary Robotic Activity Hones Important Skills.” *Tech Directions*, 71(1): 15-18. http://www.techdirections.com/past-issues.html

ABSTRACT “As educators, the authors believe in guiding students towards the life skills, knowledge, and expertise they need to succeed in life and in the workforce of the 21st century. With that in mind, they have created a project in which students drive their own learning through creativity and collaborative work to develop an efficient product. Through the project, students are exposed to new technology applications, and they become more proficient communicators and advanced problems solvers. The project is an interdisciplinary unit in which students from health and technology education classes apply a variety of skills to create and program a student-designed robot. In the course of assembling and operating a simple robot, students practice critical thinking, creativity, problem solving, use of Web 2.0, and more.”

McDonald, S. & Howell, J. 2012. “Watching, Creating and Achieving: Creative Technologies as a Conduit for Learning in the Early Years.” *British Journal of Educational Technology*, 43(4): 641-651. http://dx.doi.org/10.1111/j.1467-8535.2011.01231.x

ABSTRACT “This paper describes the use of robotics in an Early Years classroom as a tool to aid the development of technological skills in a creative environment rich with literacy and numeracy opportunities. The pilot project illustrates how a three-phase process can result in the development of: (1) emergent literacy and numeracy, (2) digital access for disadvantaged Early Years learners and (3) basic engineering concepts. The pilot study was conducted with a class of 16 students aged between 5 years and 6 months to 7 years, over a 6-week period. During this period, the students were introduced to and engaged in the creation of robots and simple machines via the use of a commercial robotics package. The pilot was designed around three distinct phases: modelling, exploring and evaluating. These phases provided scaffolding for the students to engage with the technology and for the class teacher to develop her own skills. The use of this particular robotics package is unique to Australia, unique to Early Years, and links hands-on, fine-motor development with 21st century learning. The researchers and authors of this paper are currently based at the Australian Catholic University and are involved with projects involving creative, digital technologies, children in the early years of formal schooling, emerging literacy and numeracy for diverse Early Years learners and the development of Science, Technology, Engineering and Mathematics (STEM) subjects.”

## ERIC search for: “STS + robotics” (31)

Hademenos, G., Russell, J., Birch, J., & Wosczyna-Birch, K. 2010 “Robotics on Water.” *Science Teacher*, 77(5): 49-52. doi:10.2505/3/tst10_077_05

ABSTRACT “Engineering Challenge for the 21st Century," a weeklong teacher workshop sponsored by the National Science Foundation, uses project-based learning (PBL) to help students and teachers build science, technology, engineering, and math (STEM) skills. The workshop, hosted by the U.S. Coast Guard Academy in New London, Connecticut, features the Coast Guard Academy Robotics on Water (CGAROW) project. The goal of CGAROW is to stimulate teamwork, foster creativity, encourage strategic planning, and develop practical scientific and engineering aptitude while building robotic crafts. This article describes the teacher workshop, the CGAROW project, and its application to the classroom. (Contains 3 figures.)”

McGrath, B. & Sayres, J. 2012. “Seeking Teachers for Underwater Robotics PD Program.” *Technology and Engineering Teacher*, 71(4): 14-17. http://www.iteaconnect.org/Publications/ttt.htm

ABSTRACT “With funding from the National Science Foundation (NSF), ITEEA members will contribute to the development of a hybrid professional development program designed to facilitate the scale-up of an innovative underwater robotics curriculum. WaterBotics[TM] is an underwater robotics curriculum that targets students in middle and high school classrooms as well as participants in informal learning environments such as summer camps and after-

school programs. The curriculum provides hands-on experience with a variety of concepts in physical science, engineering, and information technology and gives students valuable exposure to other 21st century skills, such as problem-solving, teamwork, creativity, and innovation. External evaluation has demonstrated increased student learning of science and engineering concepts as well as increased interest in engineering careers by students who have participated in WaterBotics[TM]. Originally developed by Stevens Institute of Technology through an NSF Innovative Technology Experiences for Students and Teachers (ITEST) grant in 2006-2010, the WaterBotics[TM] curriculum is being disseminated through four hub sites around the country (in Ohio, Texas, Illinois, and Kentucky) that are delivering face-to-face turnkey training institutes for formal and informal educators. In addition, through a partnership with ITEEA, a hybrid training program--which includes a full-day face-to-face workshop and several online modules--will be developed, pilot-tested, and disseminated. The hub site dissemination as well as the partnership with ITEEA is part of a five-year NSF ITEST Scale-Up grant."

Kim, H., Choi, H., Han, J., & So, H-J. 2012. "Enhancing Teachers' ICT Capacity for the 21st Century Learning Environment: Three Cases of Teacher Education in Korea." *Australasian Journal of Educational Technology*, 28(6): 965-982. http://www.ascilite.org.au/ajet/ajet28/kim.pdf

ABSTRACT "Korean teachers are generally considered well trained to integrate ICT into their teaching since the inception of the first IT Master Plan of Korea in 1996. However, the emergence and adoption of cutting-edge technologies create demands for evolving roles and competencies of teachers in the new knowledge society. Given this changing landscape of teacher education, the purpose of this paper is to explore new educational approaches to enhance teachers' ICT capabilities in the 21st century learning environment in Korea. The literature indicates that the new roles of teachers include new media literacy skills and adaptive expertise with efficiency and innovation. From this perspective, we examined three cases: (1) learning "Scratch" for computational and creative thinking, (2) learning robotics as emerging technology for convergent and divergent thinking, and (3) learning by design with ICT for systems thinking. The new approaches, such as focusing on thinking skills rather than technical skills, and providing various contexts different from ordinary classroom lessons, help teachers to develop adaptive expertise. On the other hand, participants in all three cases indicated difficulties in integrating new ideas, dealing with various course activities, and understanding unfamiliar design contexts in their comprehensive projects. For further studies, it is necessary to investigate learning processes and outcomes of teachers' learning with more depth and a larger number of cases and multiple sources of data to verify the potentials and challenges of these approaches more rigorously."

Black, D. & Zeigler, J. "Interdisciplinary Robotic Activity Hones Important Skills." *Tech Directions*, 71(1): 15-18. http://www.techdirections.com/past-issues.html

ABSTRACT "As educators, the authors believe in guiding students towards the life skills, knowledge, and expertise they need to succeed in life and in the workforce of the 21st century. With that in mind, they have created a project in which students drive their own learning through creativity and collaborative work to develop an efficient product. Through the project, students are exposed to new technology applications, and they become more proficient communicators and advanced problems solvers. The project is an interdisciplinary unit in which students from health and technology education classes apply a variety of skills to create and program a student-designed robot. In the course of assembling and operating a simple robot, students practice critical thinking, creativity, problem solving, use of Web 2.0, and more."

Sahin, A., Avar, M.C., & Adiguzel, T. 2014. "STEM Related After-School Program Activities and Associated Outcomes on Student Learning." *Educational Sciences: Theory and Practice*, 14(1): 309-322. http://files.eric.ed.gov/fulltext/EJ1038710.pdf

ABSTRACT "This study explores the characteristics of after-school program activities at a charter school in the Southeast US highlighting students' experiences with and gains from these after-school program activities. A qualitative case study design was employed to understand students' views and opinions regarding the activities and their learning trajectories. Study data were collected through formal and informal observations, one-on-one semistructured interviews, and field notes. The study's findings indicated that such activities emphasize open-ended and collaborative scientific investigations in Science, Technology, Engineering, and Mathematics (STEM) fields and provided an arena for students to demonstrate various uses of 21st century skills. We have described and explained: (a) the importance of collaborative learning groups, (b) the popularity of after-school program activities, (c) interest in STEM fields, and (d) activities' contribution to developing 21st century skills. These findings show that STEM related activities have the potential to promote collaborative learning and inquiry as well as to contribute to the development of 21st century skills. These findings have also been discussed in light of how STEM related after-school program activities support students' learning."

"Proceedings of the National Technological Literacy Conference." 1994. Edited by Cheek, D.W. & Cheek, K.A. University Park, PA: National Association for Science, Technology, and Society. http://files.eric.ed.gov/fulltext/ED381429.pdf

ABSTRACT "Twenty-six papers illustrate the wide reach of Science, Technology, and Society (STS) studies and education. A sampling of the first section on general STS studies includes: (1) "Technology, You, and the Law" (Kenneth S. Volk); (2) "The People From 'Away': Ending Racial and Economic Exploitation in the Siting of Toxic Wastes" (Glen J. Ernst); (3) "Constructing Space: The Shaping and Uses of the NASA-CIRSSE Two-arm Robotic Tested" (Jeffrey L. Newcomer); (4) "Irradiation of Food" (Martin L. Sage); (5) "Biotech or Biowreck? The Implications of 'Jurassic Park' and Genetic Engineering" (Sharon L. Chapin; Leslie D. Chapin); and (6) "Overcoming Computer Anxiety in Adult Learners" (Mick Lantis; Marilyn Sulewski). A sampling of the second section on energy themes includes: "Incorporating Environmental Externalities into Electricity Markets" (Steven E. Letendre); and "Equity Concerns in U.S. Nuclear Energy Politics" (In-Whan Jung; Young-Doo Wang). A sampling of the third and fourth sections that present articles on STS Collegiate Programs and STS in K-12 education include: (1) "Design Methodology in STS Programs" (Marc J. deVries); (2) "Science, Diversity, and Community: Revitalizing Introductory Science Curricula: An Overview" (Jacqueline Ross); (3) "Trends and Dilemmas in Science, Technology and Society Education within K-12 Schools in the United States" (Dennis W. Cheek); and (4) "Minds 2000+, Internet and Global Change" (James L. Barnes)."

Goodnight, R. 1996. "Lifelong Learning for the 21st Century." http://files.eric.ed.gov/fulltext/ED397796.pdf

ABSTRACT "The Lifelong Learning Center for the 21st Century was proposed to provide personal renewal and technical training for employees at a major United States automotive manufacturing company when it implemented a new, computer-based Computer Numerical Controlled (CNC) machining, robotics, and high technology facility. The employees needed training for their new job requirements, including operating the equipment, activating and utilizing the computers, analyzing and diagnosing problems, and making timely repairs. Five statewide schools and three consulting firms provided information about their personal renewal and work oriented programs. Learning needs assessment was conducted on all employees via questionnaires, 84% of which were completed. Results of the first year of the lifelong learning program include: 38 employees took courses towards their high school degree or General Equivalency Degree (GED); 118 began pursuing college degrees; 73 enrolled in basic work-oriented remedial courses; over 400 employees completed technically oriented courses; and over 1,000 employees took part in other training programs. Training took place on-site, through teacher-student interaction, television, the televised Indiana Higher Education Telecommunications System (IHETS), computerized independent study, and selected independent study combined with mentoring. Employees enrolled in programs or took courses with Purdue University School of Technology, Indiana Vocational Technology College, Ball State University School of Technology or Business School, and Penn State University (International Correspondence School)."

Todd, E.S. 1983. "Impact of the "Steel Collar" Revolution and Robotics upon Higher Education." *AIR Annual Forum Paper*. https://eric.ed.gov/?q=%22STS%22+AND+%22robotics%22&pg=2&id=ED232591

ABSTRACT "The need for higher education to plan curricula based upon generalizable human, analytical, and technical skills is discussed in view of historical and economic changes, productivity questions, demographic projections, and employment forecasts. Questions are posed regarding the form of undergraduate education that will best prepare the college graduate for employment in a society marked by high technology and automation and characterized by a more impersonalized, highly efficient work and nonwork environment. The following factors are credited as affecting the implementation of automated equipment and robotics: productivity rates, manpower supply, preparation of manpower, cost of physical capital, cost of human capital, and the state of the art of the technologies. It is concluded that the education of the 1980s, 1990s, and the 21st century must prepare the graduate for growth, adaptability, and further learning. Students must be prepared to be skilled in analysis and problem solving. The new technologies will require a higher level of verbal and mathematical literacy to work in the processing of information. Higher education in the future should contain essential elements for on-the-job scientific and technical training."

"Proceedings of the Annual Technology Literacy Conference." 1992. Edited by Cheek, D. University Park, PA: National Association for Science, Technology, and Society. http://files.eric.ed.gov/fulltext/ED350248.pdf

ABSTRACT "he following papers are included in these proceedings: "Weaving Technology and Human Affairs" (B. Hazeltine); "Positivist and Constructivist Understandings about Science and Their Implications for STS Teaching and Learning" (B. Reeves; C. Ney); "A Modular Conceptual Framework for Technology and Work" (D. Blandow); "A Time of Uncertainty: The Impact of the Open-ended Time Frame on Biomedical Ethics" (P. di Virgilo); "Frozen Rhetoric? Public Impact on the Ice-minus Field Trials" (S. Hagedorn); "Beyond the Right to Die: Reality Versus Abstract Issues" (R. Mellican); "Technology Adoption and Sub-Sahara African Agriculture: the Sustainable

Development Option" (B. Durosomo); "Environmental Commodification and the Industrialization of Native American Lands" (J. Byrne, S. Hoffman; C. Martinez); "A Structural Approach to the Environmental Crisis: Energy, Environment, and Underdevelopment" (K. Ham; R. Wykoff); "After Eve: Various Women's Approaches to Religion, Values, and Science" (M. Hunt); "A Meditation on Fate and Destiny in a Technological Age" (B. Waters); "Developing Intellectual Processes through Technology Education" (S. Johnson); "Problem Solving in Science, Technology, and Society Education within a Middle-Level Science Curriculum" (W. Peruzzi; D. Cheek); "Robotics: STS Curriculum Strands Integrated with Language Arts and Social Studies for Middle/Secondary Students" (A. Stomfay-Stitz); "Science Fairs for Young Children?" (B. Hauser); "Ten Years Later: Have Opinions about the Environment Changed? A Survey of High School Students 1980 and 1990" (J. Barr);"Research, Innovation, and Project Work for Students and Teachers in Secondary Schools in Slovenia" (S. Zakrajsek); "Coupling Teacher Inservice and Student Science Training Programs" (J. Tashiro; D. Elbert-May; P. Rowland); "A National Comparative Analysis of Minority Pre-Service Teachers in Mathematics and Science" (J. Bazler; M. Gonzalez); "Looking at the Earth in New Ways" (M. Passow; D. Kitzmiller; M. Krohn); "Project 2061: A Working Model" (J. Bazler; M. Charles); "Science, Technology, and Political Choice: Part of the Undergraduate Curriculum" (M. Sage); "Identity and Commitment: Information, Rhetoric, and the Recruitment and Retention of Female Engineering Students" (J. Croissant); "Ethics in the Engineering Curriculum" (M. Alfano); "Using Concepts of Technology to Enhance a Writing Assignment" (J. Renzelman); and "Natural Resource Management for 'Autonomy': Lessons on 'Community' through Environmental Education Simulations" (J. Hamilton' G. Vahoviak). The conference program also is included."

Glenn, J.C. 1990. "STS Perspective. Conscious Technology: A Candidate World View." *Bulletin of Science, Technology and Society*, 10(5-6): 251-53. https://eric.ed.gov/?q=%22STS%22+AND+%22robotics%22&pg=3&id=EJ421882

ABSTRACT "Discussed is the blurring of humans and machines into a Conscious Technology civilization. Discussed are the leading indicators of this trend, the explosion of human consciousness, policy implications of this view, and this view as a criterion for policy analysis and future product development."

# vii. HUMAN-ROBOT INTERACTION (HRI)

## Search methodology

In Scopus database a first research has been conducted using the term "HUMAN-ROBOT INTERACTION" to understand the useful time span to be considered for the review. As already said the query has been done considering the term in the abstract, title or keywords.

The results are shown in **Fejl! Henvisningskilde ikke fundet.** (see section Charts and trends) where can clearly be seen that a first movement in HRI field starts in the mid-90s. Furthermore the cut-off year to filter the next queries has been chosen as 2002, in fact in that year can be observed a notable increase in the publication number. Next step will be combine "HUMAN-ROBOT INTERACTION" with secondary terms for a more in depth research.

A first important fact noted in almost all the articles read is the common certainty that more research in HRI is need. Indeed in [Sheridan] is said that: "the needs for research on human interaction aspects and participation in robot research and design are huge", and in [zhang] that: "the relationship between people and robots is still underexplored. There is need to further investigate how robots can be integrated in a natural manner into the environments where people usually frequent and live". Another consideration supporting this argument is that in the analysis of the selected articles a great amount were novel studies. For example [Buchner] is the first including temporal aspect in his analysis of HRI and user experience, [Sequeira] introduce a new restricted-perception wizard-of-oz method for robots' design and [warta] present a new way in which attitude toward robots can be measured.

Meanwhile an interest in the research in HRI is shared both in the industrial world and non-industrial one, is interesting to note the different objectives of this effort. In fact, in the industrial world can be noted that the focus is on the increase of competitiveness, as said in [Buchner]. On the other hand for the non-industrial world the focus is on the user acceptability, the ethical issues arisen, and in particular on human-robot social interaction. For example [Sequeira] says that a further research in how to develop and sustain effective social interaction with robots is needed.

In order to reach these challenging objectives many articles present different ways in which they can be reached with a new design approach. Indeed the necessity of changing the design process to tackle new issues is frequently recognized, e.g. [Romero] says: "socio-technical transformation towards the factory of the future will need new design and engineering philosophies for twofold 'human-centric' and 'cyber-physical' production systems where automation, robotics, and other advanced manufacturing technologies are seen as possibilities for the further enhancement and augmentation of the human's physical, sensorial and cognitive capabilities rather than for unmanned, autonomous factories. [Sequeira] as already said present a new version of wizard-of-oz methodology with restricted-perception, in his paper the design process is subdivided into data collection, strategy extraction, and strategy refinement. Core concept of the methodology is the restriction of wizard's, i.e. the person controlling the robot in the data collection phase, senses to better map the identified social interaction strategies to robot's actions. The result of evaluation phase demonstrates how the user is positively engaged with the robot.

Considering the design process as user-centered represent the main trend of HRI. Slightly different from his is [Cheon] that moves the focus on roboticist values and how they are embedded in robots, in fact the author itself says: "[t]his perspective would go beyond the user-centered view that dominates much of HRI literature". In his paper a more in depth study of roboticist is presented and eventually a value sensitive design (VSD) approach is advocated to improve robots uptake. Analysing interviews done to famous roboticists interesting results have been inferred, the most important is that roboticists rarely talks about values and ethics, probably, [Cheon] says, is because they are influenced by their background, i.e. engineering. From this result emerges the necessity of VSD, especially because "[w]e lack any design frameworks or guidelines for responsible robot design". The objective of this design process is to integrate values into conceptual, empirical and technological investigation. The conceptual part has the scope of investigate "where possible values are identified and redefined as a new concept appropriate to the target context", indeed "depending on contexts and agents, the same value could have diverse meanings". The empirical investigation has the scope of assess values embedded in technologies, here the author makes an interesting digression about robot definition arguing that "cultural and spiritual values (e.g. mind, emotions) should be acknowledged as one of components in the definition of robot. This may facilitate not only the development of a standardized definition among the same culture but also an understanding of robots in different cultures". The last part, i.e. technological investigation, allows to evaluate how conceptualized values are identified throughout one's interaction with the technology, this is carried on including final users in the design phase.

## Database queries

Finally, a table reporting the numeric results of all the research is presented:

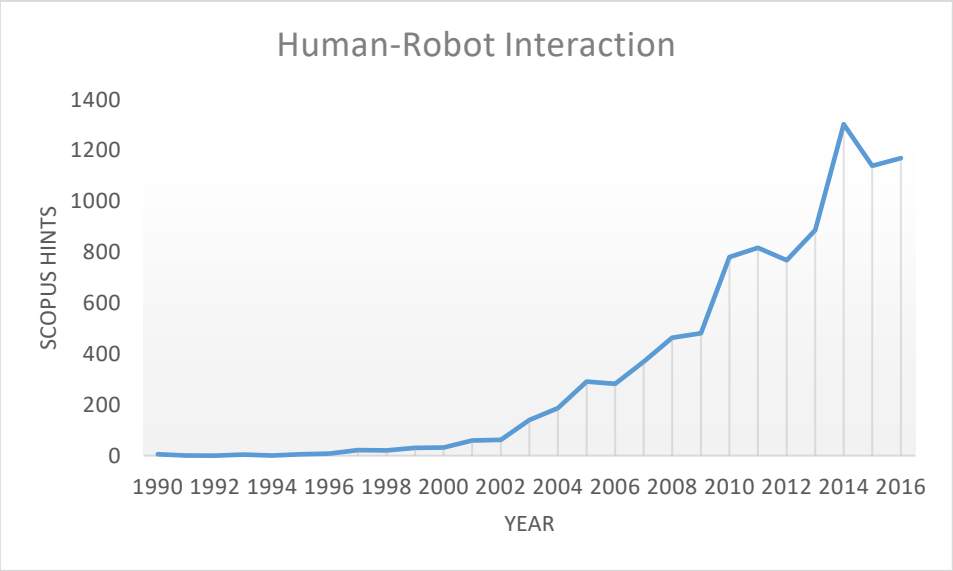
| Search Queries in Scopus | SCOPUS hits |
|---|---|
| **"human-robot interaction"** | |

| | |
|---|---|
| Publication year > 1983 | 9,832 |
| **“human-robot interaction” AND “artificial intelligence”** | |
| Publication year > 2002 | |
| AND Search term in the title | 2 |
| AND Search term in keywords | 524 |
| AND Search term in abstract | 165 |
| AND Search term in abstract, keywords, title | 756 |
| **“human-robot interaction” AND “human”** | |
| Publication year > 2002 | |
| AND Search term in the title | 1,799 |
| AND Search term in keywords | 8,411 |
| AND Search term in abstract | 4,302 |
| AND Search term in abstract, keywords, title | 9,561 |
| **“human-robot interaction” AND “ethics”** | |
| Publication year > 2002 | |
| AND Search term in the title | 2 |
| AND Search term in keywords | 37 |
| AND Search term in abstract | 15 |
| AND Search term in abstract, keywords, title | 61 |
| **“human-robot interaction” AND “collaborative learning”** | |
| Publication year > 2002 | |
| AND Search term in the title | 2 |
| AND Search term in keywords | 15 |
| AND Search term in abstract | 3 |
| AND Search term in abstract, keywords, title | 15 |
| **“human-robot interaction” AND “user”** | |
| Publication year > 2002 | |
| AND Search term in the title | 37 |
| AND Search term in keywords | 1,045 |
| AND Search term in abstract | 1,031 |
| AND Search term in abstract, keywords, title | 2,670 |
| **“human-robot interaction” AND “learning”** | |
| Publication year > 2002 | |
| AND Search term in the title | 97 |
| AND Search term in keywords | 985 |
| AND Search term in abstract | 497 |
| AND Search term in abstract, keywords, title | 1,399 |
| **“human-robot interaction” AND “intelligent autonomous system”** | |
| Publication year > 2002 | |
| AND Search term in the title | 0 |
| AND Search term in keywords | 0 |
| AND Search term in abstract | 1 |
| AND Search term in abstract, keywords, title | 1 |
| **“human-robot interaction” AND “cyber physical system”** | |
| Publication year > 2002 | |
| AND Search term in the title | 0 |
| AND Search term in keywords | 11 |
| AND Search term in abstract | 2 |

| | |
|---|---|
| AND Search term in abstract, keywords, title | 11 |
| **“human-robot interaction” AND “anthropology”** | |
| Publication year > 2002 | |
| AND Search term in the title | 0 |
| AND Search term in keywords | 0 |
| AND Search term in abstract | 7 |
| AND Search term in abstract, keywords, title | 8 |
| **“human-robot interaction” AND “ethnography”** | |
| Publication year > 2002 | |
| AND Search term in the title | 0 |
| AND Search term in keywords | 5 |
| AND Search term in abstract | 3 |
| AND Search term in abstract, keywords, title | 10 |

*Table 5 Researches' results*

## Charts and trends




The secondary words chosen to sharp the research in Scopus are: ethics, collaborative learning, anthropology, ethnography, cyber physical system, learning, intelligent autonomous system, user and artificial intelligence.

Below the meaningful results of the researches in Scopus of “Human-Robot Interaction” with the terms just listed are depicted. The green, red and blue lines represent respectively the query in the keywords, abstract and title.

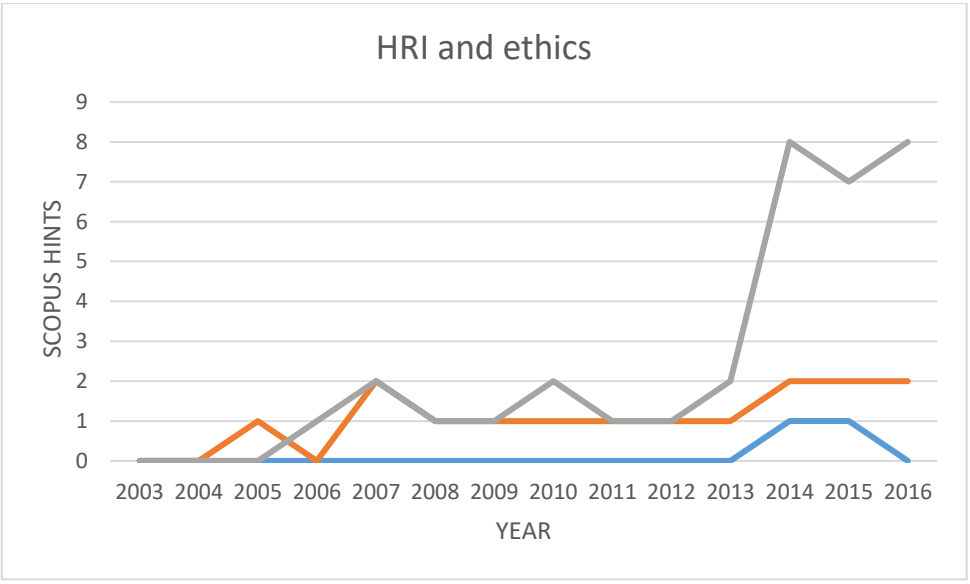



*Figure 1 Number of results in Scopus for "Human-Robot Interaction" and “ethics”*

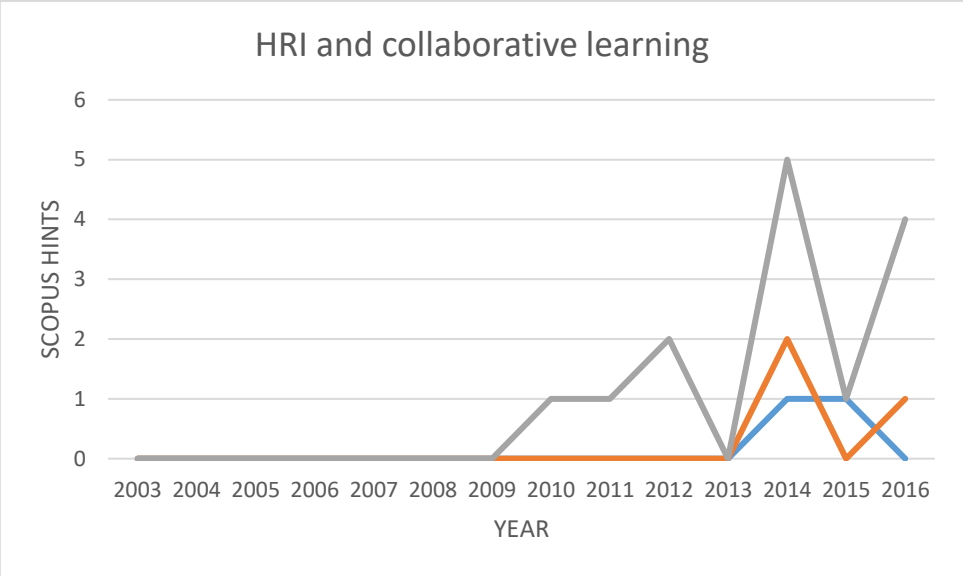



*Figure 2 Number of results in Scopus for "Human-Robot Interaction" and "collaborative learning"*

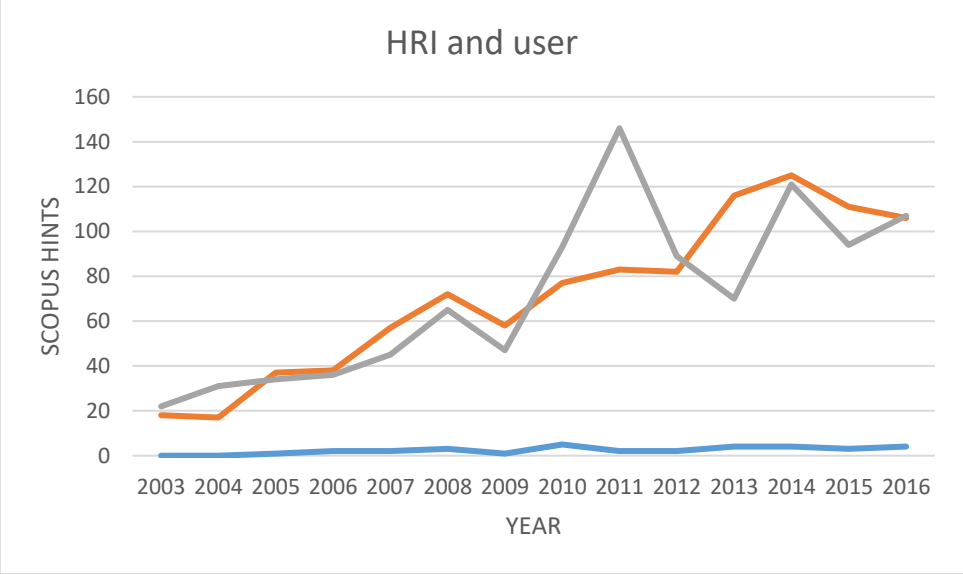



*Figure 3 Number of results in Scopus for "Human-Robot Interaction" and "user"*

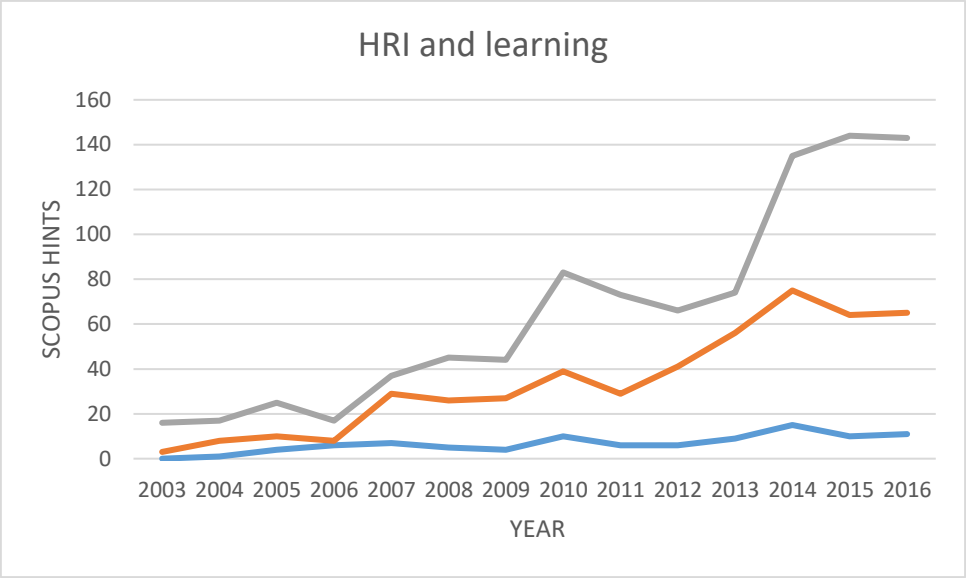



*Figure 4 Number of results in Scopus for "Human-Robot Interaction" and "learning"*

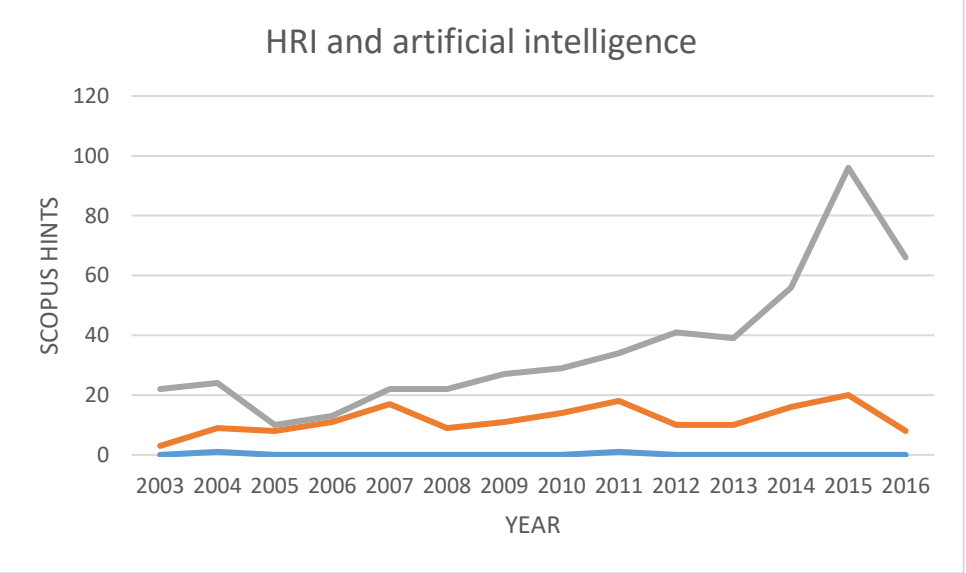



*Figure 5 Number of results in Scopus for "Human-Robot Interaction" and "artificial intelligence"*

One first consideration that can be done is regarding the increasing interest in Human-Robot interaction field. Even though the number of articles are not large, e.g. in field as ethics (Figure 2), there is a positive growth meaning that REELER's questions are posed in the right moment.

## Selected literature

The articles taken in consideration for the review are reported below:

| **An investigation of the use of robots in public spaces** |
| --- |
| This project explores the use of robots in public spaces, such as shopping malls, parks, hospitals and universities. The project is situated in the fast growing area of human-robot interaction in the broad sense, and, more specifically, in the context of social robots. We seek to understand the social acceptability of robots and how we can make robots fit into |

| |
|---|
| public spaces. In this research, we have conducted two studies using different data collection methods, and targeting two different populations. The results of our studies show that in general flying drones are perceived in a positive way by people. People suggested that they would be comfortable having them around if the flying drones have strong safety mechanisms and any personal data captured is protected by an official, government based agency. We believe that given their positive responses, flying robots can be suitably integrated in open public areas. |
| **I Don't Always Have Positive Attitudes, but When I Do It Is Usually About a Robot: Development of the Robot Perception Scale** |
| The increasing use of robots and their role in society has important implications for research and development in human-robot interactions (HRIs). The purpose of the present study was to develop a new measure to assess attitudes toward robots in HRIs. Measures of attitudes humans have "about" robots are relatively uncommon. Those that exist have potential problems limiting utilization in research evaluating the human element in HRIs. The Robot Perception Scale (RPS) was developed to redress this gap by examining a new set of factors in unique ways. The RPS consists of two subscales in which participants rate their agreement with statements concerning general attitudes toward robots and attitudes toward human-robot similarity and attractiveness. Findings provide preliminary support for a robotic perception scale that can be used to further our understanding of robots engaged in a variety of HRI settings. |
| … |