Social Robots for Education: A review

Elective in Artificial Intelligence

Human-Robot Interaction

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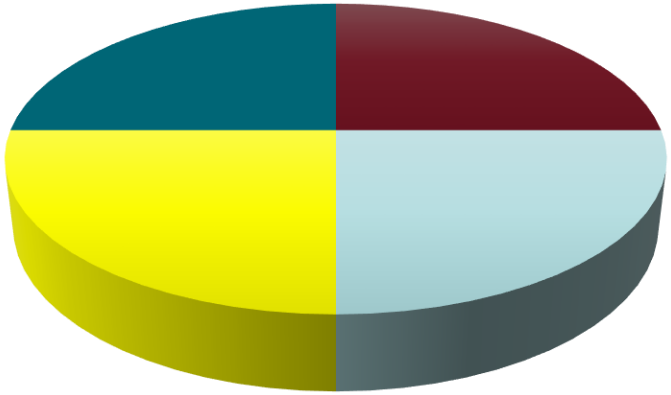
Project Idea: HRI in Education Domain



- Social Robots for Education: A review
- Exploring the Possibility of Using Humanoid Robots as Instructional Tools for Teaching a Second Language in Primary School
- A Robot as a Teaching Assistant in an English Class
- Online Robot Teaching With Natural Human–Robot Interaction

Current Reference

T. Belpaeme, J. Kennedy, A. Ramachandran, B. Scassellati, F. Tanaka
"Social Robots for Education: A review", August 2018, Article in Science Robotics

Presentation Outline

- **Key Questions**
  - Efficacy
    - Common Measures
    - Experiments Designs
    - Efficacy of Robots in Education
  - Embodiment
    - Social Robots VS Virtual Pedagogical Agents
    - Robot Appearance
    - Robot Behaviour
  - Interaction role
- **Key Challenges**
  - Technical challenges
  - Full Set of Challenges
- **Personal Commentaries**

Key Questions

Three Key Questions

Efficacy. What are the cognitive and affective outcomes when robots are used in education?

Embodiment. What is the impact of using a physically embodied robot when compared with alternative technologies?

Interaction role. What are the different roles the robot can take in an educational context?

Efficacy: Common Measures for Determining Learning Outcomes

Cognitive

require a controlled knowledge assessment

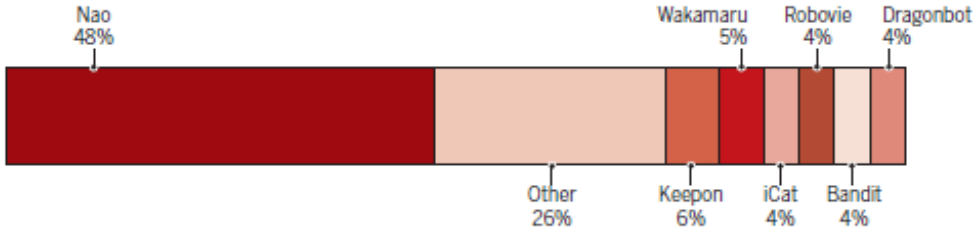
- Learning gain, measured as difference between pre- and posttest score;
- Administer posttest either immediately after exposure to robot or with delay;
- Correct for varying initial knowledge, e.g. using normalized learning gain;
- Difference in completion time of test;
- Number of attempts needed for correct response.

Affective

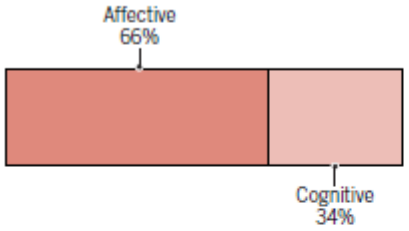
can be measured by using questionnaires and observational studies

- Persistence, measured as number of attempts made or time spent with robot;
- Number of interactions with the system, such as utterances or responses;
- Coding emotional expressions of the learner, can be automated using face analysis software;
- Godspeed questionnaire, measuring the user's perception of robots;
- Tripod survey, measuring the learner's perspective on teaching, environment and engagement;
- Immediacy, measuring psychological availability of the robot teacher;
- Evolution of time between answers, e.g. to indicate fatigue;
- Coding of video recordings of participants responses;
- Coding or automated recording of eye gaze behavior (to code attention, for example);
- Subjective rating of the robot's teaching and the learning experience;
- …

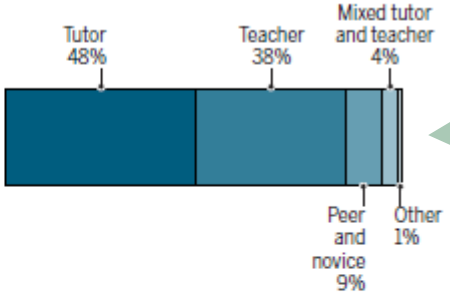
Types of robots used in the studies



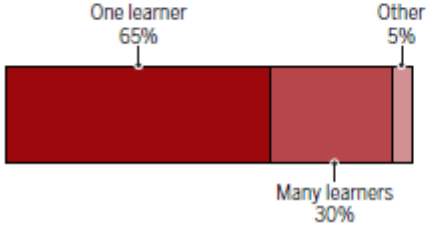
Type of learning outcome studied



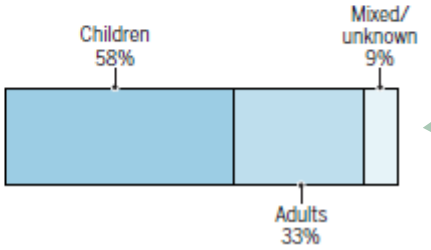
Role of the robot in the interaction



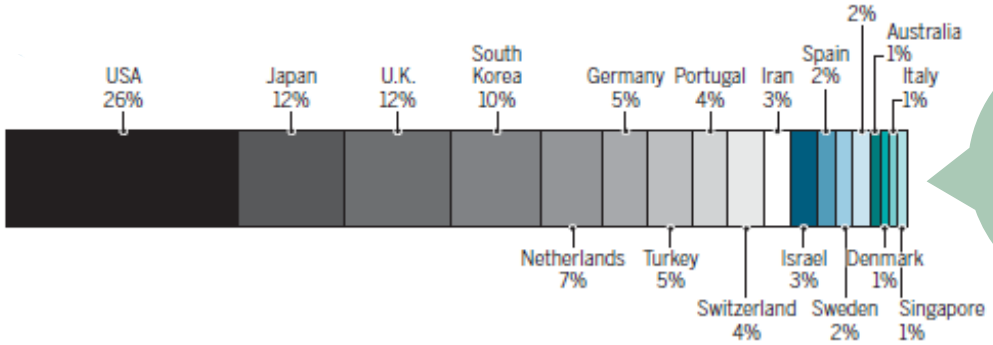
Number of learners per robot



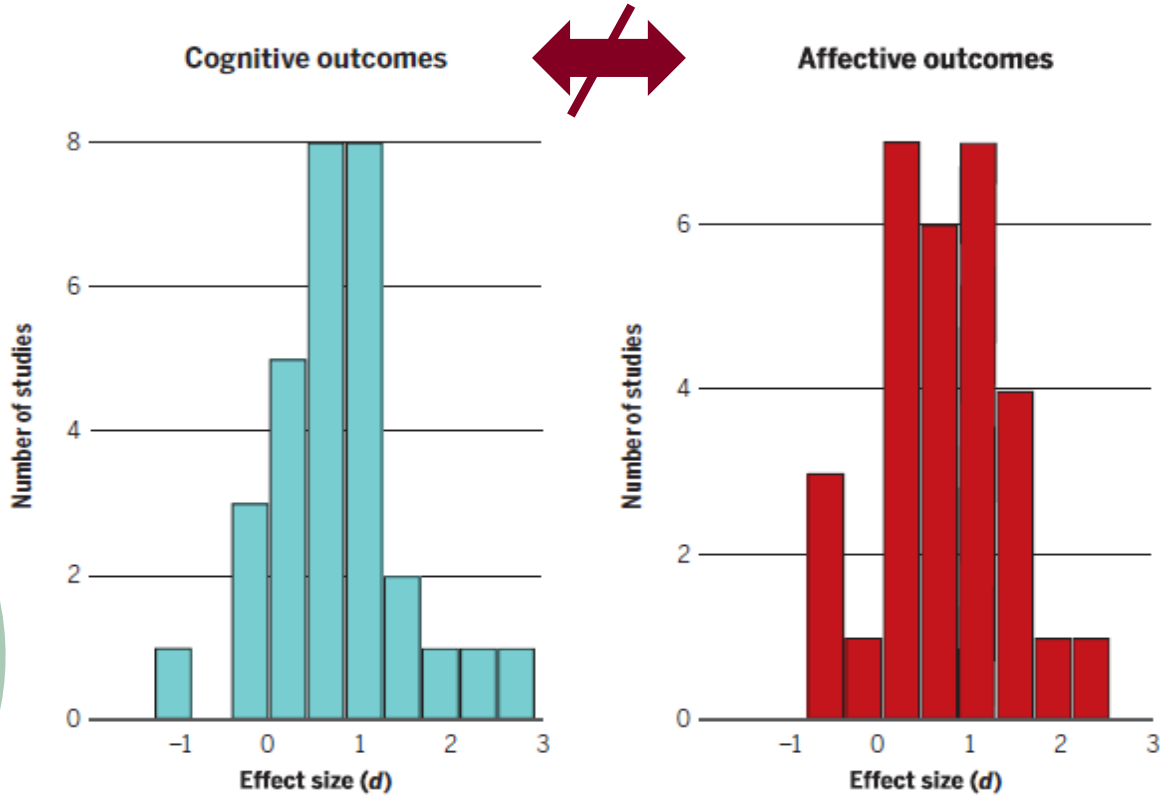
Division between children and adults



Nations where the research studies were run



Efficacy: Efficacy of Robots in Education



A quantitative measure of the magnitude of the experimental effect: the larger - the stronger the relationship between two variables

Histograms of **effect sizes (Cohen's d)** for all cognitive and affective outcomes of robot tutors in the **meta-analysis**

The difference between two means in standard deviation units

A statistical analysis that combines the results of multiple scientific studies

Embodiment: Social Robots VS Virtual Pedagogical Agents

Why do we want to use social robots for education?

Challenges

- Expense of additional hardware;
- Need for maintenance;
- Challenges of distribution and installation.

Use of a robot in an educational setting must be explicitly justified

Benefits

- Can be used for **curricula** (e.g. tutoring physical skills: basketball, handwriting, rehabilitation, etc) **or populations** (individuals with visual impairments, children under the age of two) **that require engagement with the physical world**;
- Users show **more social behaviour** (e.g. yield more compliance with tutor's requests) that is beneficial for learning;
- Users show **increased learning gains** (task performance).

Embodiment: Robot Appearance

What exactly it is about the robot's appearance that promotes learning?

iCat robot teaching young children to play chess

A

B

Nao robot supporting a child to improve handwriting

Keepon robot tutoring an adult in a puzzle game

C

D

Pepper providing motivation during English classes

Embodiment: Robot Behaviour

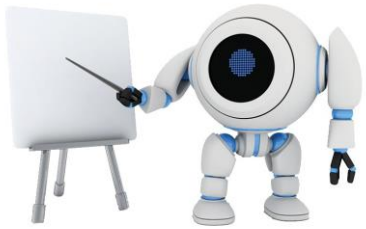
Effectiveness

Almost any strategy or social behaviour of the robot aimed at increasing learning outcomes has a positive effect

Personalization

Personalization is important: adaptive delivery of learning material (as in ITS), but also socially supportive behavior

- Using a child's name;
- Referring to previous interactions;
- Displaying congruent gaze behavior;
- Showing empathy with the learner;
- …



Time Frames

When to limit social behavior to allow students to concentrate on problem solving?

The Other Way Round

What if positive learning outcomes are not directly caused by the robot having a physical presence, but rather the physical presence of the robot promotes social behaviour in the learner?

Interaction Role: Robot Role

Robot as tutor

- provides direct curriculum support through hints, tutorials and **supervision**
- enhances both concentration on learning activities and academic performance
- mostly focuses on one-to-one interactions

IROBI

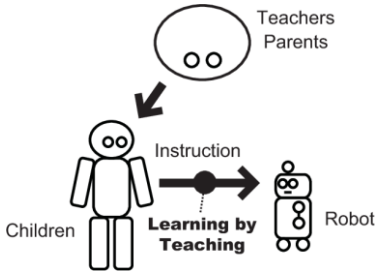
Robot as peer

- robot is presented as a **more knowledgeable peer**, guiding the student along a learning trajectory
- longer periods of attention, faster and more accurate responses

Robovie

Robot as novice

- **involves the learner** making an effort to teach the robot, which has a direct impact on their own learning outcomes
- requiring a higher level of understanding of the material and of the internal representations of their robot partner



Key Challenges

Technical Challenges of Building Social Robot Tutors

Which problems do we face when we want to use social robots for education?

Fluent and contingent interaction between social robots and learners requires the seamless integration of a range of processes in artificial intelligence and robotics

Perception

speech recognition, visual social signal processing

but

alternative input media (such as touch screens)

but

constraints the natural flow of interaction

Action

- conflicting educational theories even in human-based instruction,
- choosing an appropriate emotional support strategy,
- appropriate gestures and gazes, attention-guiding behaviour,
- …

Personalization

- nonverbal behaviour,
- verbal behaviour,
- adaptive content progression

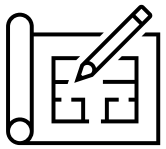
Full Set of Challenges

- Robots for learning require a tightly integrated endeavour which involves solving **technical challenges** and **changing educational practice**;
- Introducing social robots in the school curriculum poses a **logistical challenge**;
- The **generation of content** for social robots for learning is nontrivial;
- Currently, the value of the robot lies in tutoring some **specific skills**, and it is a good question how wide range of roles robots can take up in general;
- For the time being, robots are mainly deployed in elementary school settings, and it is unclear whether the approaches that work well for younger children **transfer to tutoring older learners**;
- There might be other problems specific to social robots that still need to be identified and for which solutions will be needed since the field is **not fully-explored**;
- **Ethical issues**: how far do we want the education to be delegated to machines, and social robots in particular? Might robots lead to an impoverished learning experience?

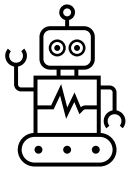
Personal Commentaries

Personal Commentaries

About the Reference Paper. The value of this article consists in its wide coverage of topics and an attempt to aggregate all existence knowledge about social robotics in education domain which is especially useful to create the general impression for the newcomers in the field (and to have a starting point for the project)



About Social Robotics for Education. Despite all the technical, logistical and other challenges and limitations, inside the limited settings where social robots are currently applied, they show the results, comparable with the ones of a human tutor and overperforming alternative learning technologies. Therefore, further exploration of the area is promising.



Thank you for the attention!