YOLO, a Robot for Creativity: A Co-Design Study with Children

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Abstract
This paper describes the design and development of YOLO, a social robot aimed at boosting creativity in children. Creativity is one of the most sought-after competencies as we move from industrialized economies, in which standardized knowledge was imperative, to creative economies, where the ability to innovate is crucial for the workforce. YOLO is a robot to be used by children as a tool to boost new ideas and stimulate their creativity. This paper describes how established educational strategies that enhance creativity were combined with co-designing with children as informants to reach the the prototype design of the robot.

Author Keywords
Creativity; Children; Social robot; Collective creation; Human-robot interaction; Design; Prototype

ACM Classification Keywords
H.1.2 [User/Machine Systems]: Human factors; J.4 [Social and Behavioral Sciences]: Psychology; J.6 [Computer-Aided Engineering]: Computer-aided design (CAD)

Introduction
Creativity is considered one of the highest human cognitive abilities [1]. It is also one of the most sought-after workforce skills as many societies are shifting from *industrialized* to *creative* economies [16]. Despite the lack of

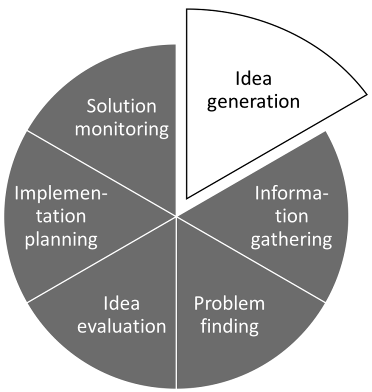

Figure 1: Model of cognitive processes involved in problem-solving tasks [21]. The design of YOLO is dedicated to the enhancement of the cognitive process of *idea generation*.

a full consensus or a unique definition for the concept of creativity, a canonical literature sees creativity as the *"interaction among aptitude, process, and environment by which an individual or group produces a perceptible product that is both novel and useful as defined within a social context"*, [15] related with *"fluency, flexibility, and originality"* of ideas [5]. Due to the variety of definitions, some authors attempted to convey key requirements that should underlie definitions of creativity. With this, they initiated a dialogue towards a standard definition of creativity, stating that *originality* and *usefulness* are the most common occurrences when it comes to defining this concept [18], related with the number of ideas generated [7].

Despite schools being perceived as potentially rich and nurturing environments for enhancing children's creative abilities, research suggests a *"creativity crisis"* in education, in the form of a decline of creative abilities [9], starting at elementary school [2]. Scholars tend to agree that this ability can be nurtured and enhanced throughout life [12], making it important to be stimulated from a very young age.

Vision for YOLO

We present the design and development of YOLO, a social robot developed to boost creativity in children. YOLO is a non-humanoid robot with interactive capabilities that makes use of established strategies for creativity enhancement to boost creativity in children. YOLO was created to engage in playful activities with children and at the same time stimulate them to be more creative. The application scenario for YOLO is a storytelling activity with children, aiming to trigger idea generation and content for the story.

According to literature, idea generation (or *fluency*) is one fundamental creative ability that tends to lead to originality and novelty [5]. With YOLO, we aim to stimulate fluency during the creative process of storytelling. At the same time, we are interested in improving this ability in a group context [19]. Thus, YOLO acts as a playful tool for supporting *idea generation* during the creative process of storytelling of *groups of children*.

Table 1: Design principles of YOLO's creative triggers.

Process	Techniques	Media	Exercises
Idea generation	(1) Related Stimuli (semantic intuition) (2) Remote Stimuli (Nonlogical stimuli)	Robot	Group Imaginative Playful
Creative encounters	Collaborative emergence	Robot	Group
Originality	Motivate new ideas by discouraging repetitions	Robot	Group Imaginative Playful

Design process of YOLO

The design of YOLO included an integrative process of *literature review* and *user-studies of co-design with children*. Therefore, YOLO's design was informed by key concepts of validated creative programs and techniques that elicit creativity, as well as from findings from the co-design studies with children. This enabled an integrative design approach that combined both aspects from theory revision as well as views and preferences of children as they will be the end-users of YOLO .

Figure 2: Co-design study 1: Children animating the paper robot prototype using puppeteering technique.

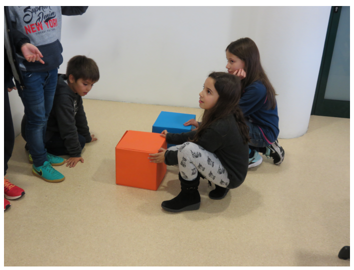

Figure 3: Co-design study 2: Children creating a story together with two robots (blue and orange) that were being animated by two children.

Figure 4: Paper-robot prototype with the basic shape of a cube in two sizes (small and large) that children animated during co-design studies.

Co-design studies with children
As children are the end-users of YOLO , they were included in the design process as informants [3] in two different co-design studies described below:

Co-design study 1 The goal of this study was to include children as co-designers of the *social behaviors* for the robot. To achieve this goal, children were asked to give expression to a prototype of the robot according to selected personality traits, *e.g.*, they were asked to provide movements and sounds for a grumpy/kind, sociable/shy robot. Thus, children gave expression to the robot by animating it according to puppeteering techniques as illustrated in Figure 2.

Co-design study 2 The goal of this study was to involve children in the design of *creative behaviors* for the robot, *i.e.*, different ways of the robot expressing new ideas during storytelling. For this, children were instructed to create a story using a robot-prototype. One of the children was selected to animate the robot and instructed to express ideas *through the robot* by performing only movements and sounds (thus, refraining from using speech to provide ideas). Thus, the group of children together with the robot (that was being animated and controlled by another child), were able to generate ideas for a story. *E.g.,* the child-puppeteer would move the robot in a certain way leading to the other children to interpret its behavior (*e.g.*, children could say *"the robot is afraid"* because the child who is controlling the robot is making it shake) and combine that interpretation in their story (see Figure 3). This way, they were integrating the robot's ideas and building a story together.

A total of 64 children aged between 6-10 years old were organized in groups of 3-4 and the studies were conducted in the school's classrooms. A psychologist researcher with experience in developmental studies with children was in the room where the sessions took place and performed field observations. The most relevant results that informed the design of YOLO are presented in Table 2. During the two co-design studies, children used a low fidelity robot-paper prototype with the basic shape of a cube (see Figure 4). This initial shape was inspired by LEGO™ bricks, nonetheless, the final morphology of the robot changed according to the results collected from the studies and accommodating literature on creativity (see *e.g.*, Figures 5, 6, 7 for the final appearance of the robot).

Literature review on creativity programs and techniques
Systematic literature reviews and meta-analysis on the field of creativity present a wide set of training programs for creativity [11, 17, 20, 21]. These programs were created and validated with the main goal of enhancing creativity. Usually, these programs tackle specific *cognitive processes of creativity* (such as idea generation). To achieve a successful enhancement of creativity levels, specific *techniques* are used (such as ideation, metaphors, brainstorming, etc), delivered using different *media* (*i.e.*, through a lecture, individualized coaching, behavioral modification, etc) in the format of defined *exercises* (such as exercises in groups, written exercises, etc) [21]. In this sense, YOLO is a robot that will incorporate validated creativity techniques for idea generation [23] (see Figure 1), such as *remote stimuli* and *related stimuli* to enhance idea generation by children (see Figure 7) (for a full list, see Table 1).

Table 2: Field observations from the two co-design studies conducted with children, mapped with how these results informed the design of the robot YOLO .

	Field observations from co-design studies	How co-design studies informed the design of YOLO
Social expression	Children were able to conceive different movements for the robot according to the personality traits. They expressed the different movement for different personality traits by animating the robot-paper prototype with different motion amplitude, angles and speed. *E.g.,* a grumpy robot would have a high movement amplitude, spiky motion with serious shapes and high speed (see Figure 8).	Giving the rich set of movement expression, YOLO was created to combine rich movement opportunities, expressed by different standing modes. Thus, the robot can stand in the vertical mode performing rotating movements (resembling a vinyl record) that can be programmed with different speeds. It also has a horizontal mode in which it has non automated wheels so that children can use the robot and express a variety of personalities and emotions (see Figure 6).
Guessing behavior	When the robot gave ideas for the story, children almost always tried to guess which idea the robot was trying to express. As the robot could express ideas only by movement, this resulted in different interpretations from children about what the robot was trying to convey. This result validated the idea that children were able to attribute meaning to the robot's movement when creating a story.	YOLO was designed to accommodate rich and diverse types of movements. Therefore, YOLO has both a vertical and two horizontal standing modes, all of them providing different movements with the potential to elicit ideas. Besides the standing modes, YOLO has the ability to move its strings in a hide-and-show movement (see Figures 5 and 7).
Turn-taking	At times, the interaction between children and the robot was chaotic due to the excitement of the task and because they wanted to share a large number of ideas with each other. In these moments, the researcher intervened to re-organize the flow.	YOLO includes a button in its design that children can click on to ask for ideas to YOLO, or to ask YOLO what it thinks about their own ideas. We envision that because the button can be clicked whenever children decide to and does not obey to strict turn-taking rules, it will have the effect of organizing the interaction and decrease the interference of an adult, proving children more autonomy during their creations

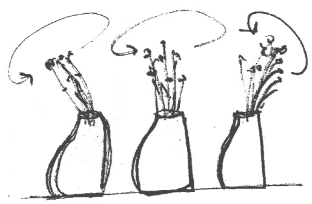

Figure 5: Movement study (1): Rotation movement of YOLO's strings (optical fibers).

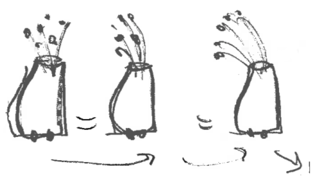

Figure 6: Movement study (2): YOLO's non actuated wheels that are controllable by children.

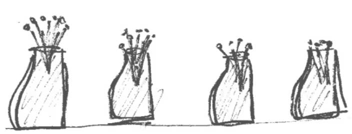

Figure 7: Movement study (3): YOLO's hide-and-show autonomous behavior.

Meet YOLO

For the design process of YOLO a multidisciplinary team of psychologists, mechanical engineers and a computer scientists came together and have followed design techniques that emphasize movement in the robot [8], improvisation, [4], storyboarding [22] and user-studies [6]. YOLO's morphology followed an iterative process involving sketches, 3D modeling and rapid prototyping that encouraged and evoked movement-centric design [8]. Freehand sketches were drawn in order to explore multiple shapes for the robot. Sketches were inspired in real-world objects that were perceived by the authors as candidates for organic shapes and agile movements (see Figures 5, 6 and 7). Also, rapid prototyping enabled us to experiment several mechanical mechanisms. Storyboard techniques was used to explore different application scenarios for the deployment of the robot. In its final morphology, YOLO resembles a sea-like creature with a non-humanoid shape whose design was guided considering the following principles:

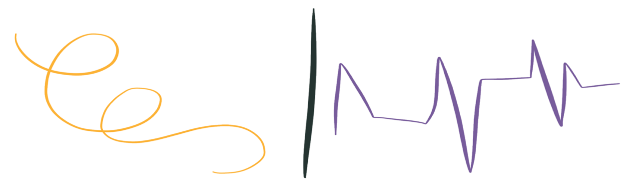

Figure 8: Two examples of movements created by children for the kind (on the left) and the grumpy (on the right) personality traits.

- **Expressive representations.** Since YOLO captures and recognized both the *shape* of the movement and the *speed* of the motion when children move it around, we will use this input to capture the context of the story. The shapes and speed's input were defined according to the results from the co-design study 1. As children act out the story using the robot, the generated movement will thus serve as our input (in the form of shapes and speed), enabling YOLO to react and contribute to the story. YOLO's contributions have the goal to stimulate idea generation (often called *fluency*) and will make use of the *related stimuli technique* (stimuli that is connected to the task) and the *remote stimuli technique* (stimuli that is unrelated to the task) [23] to stimulate ideas from children. Different behavioral expressions of YOLO (sound, colors and movement) will be used as related or remote stimuli. For this, we will develop expressive representations for the different movements that children produce, *e.g.*, if a child moves the robot with high speed in making a curly shape movement and the robot wants to provide a relate stimuli, it will display a given color, sound or movement that relates to this idea. The representations of movement-sound-color are based on the works of Mats B. Küssner [10] on visual representations of shapes and Konstantina Orlandatou on color-sound associations [13]. YOLO will thus display these two idea-generation behavioral triggers along the storytelling process.
- **Creative encounters.** YOLO will be used with groups of 3 children in a storytelling task. Henceforth, it becomes crucial to stimulate group processes of creation (denominated by Sawyer (2009) as *collaborative emergence* processes [19]). To stimulate the contribution of each child for the story creation YOLO will turn to each child during the storytelling activity in order to motivate and empower them to contribute with ideas for the story.

- **Originality.** Creativity is not only about the number of relevant ideas generated (fluency), but also how *original* they are. To design for originality of ideas, YOLO will demonstrate that it does not appreciate repetitions if they are performed too often in a row. Therefore, if children perform the same type of shapes using the same speed more than three times in a row, YOLO will perform a type of "shut-down" behavior in order to motivate children to perform different movements instead and not just repeat what they have performed.

We envision YOLO as a non-humanoid artifact that resemble a toy for children and that behave autonomously. Due to its autonomous behavior, it becomes non totally controllable (such as toys are) and thus fun for children to play with, having the potential to be a conductor of creative thinking. During playful interactions with YOLO, children will likely try to guess what the robot is expressing, enhancing the ingredients in their stories and at the same time not letting them take full control. In this sense, YOLO will not only be used and perceived as a toy that children project their unique ideas on, but additionally as an interactive toy that children can play with and that have a life on its own.

Seymour Papert revolutionized the way we look at education and learning. His vision of education as the center of all growth lead to revolutionary ideas: from computers as tools to learn, from LOGO programming to Turtle creations [14]. Nowadays, technology is indeed part of our lives and robots are being developed at a fast pace to enter in our homes, work places, and schools. The work presented in this paper seeks to provide a new application for robot and to develop them in such a way that they nurture intrinsic human abilities, such as creativity. Our future work includes usability studies of YOLO with children and long term studies in school to investigate if robotic technology can be used to boost creative thinkers.

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