# What do children favor as Embodied Pedagogical Agents?

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**Abstract.** Embodied Pedagogical Agents (EPA) are increasingly employed in educational applications, for a variety of users and purposes. However, studies have shown that visual appearance, communicative style, and pedagogical roles of agents impact their acceptance, trust, and user interaction [1, 2, 3, 4]. In this paper, we present a study where 86 primary school children (aged 7-11) chose an EPA to 'accompany' them in their learning of multiplications in the ITS application, *Multipliotest*. The children used two versions of the software, one with an instructor EPA, and another with a learning companion EPA. Additionally, the children selected a visual appearance for each EPA: simplified or detailed, and naturalistic (humanoid-shaped) or stylized (smiley-shaped). Investigations of the possible relationships between pedagogical roles and visual appearance with respect to user preference are outlined, along with the study limitations, and considerations for future work.

**Keywords:** Embodied Pedagogical Agent; visual style; pedagogical role; realism; naturalism.

## 1 Introduction

EPAs can be found in educational software in increasing numbers, and under different visual representations, different communication styles, or adopting one or more different pedagogical roles, within the same application. EPAs are "visually represented, computer-generated characters in pedagogical roles, such as virtual instructors, mentors, or learning companions" [3], usually embedded within the software to aid social and communicative features, [5, 6]. They are used in computer-assisted learning applications for users ranging from children to elderly people, to help them in software navigation, usability, or in learning content or development of meta-cognitive skills [2, 7].

However, studies showed that visual appearance, communicative style, and pedagogical roles of agents impact their acceptance and trust, and change the way people interact with them [1, 2, 3, 4].

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Consequently, there is sufficient research interest and rationale for investigating the effect of design characteristics of EPAs on users. Research on the user interface design of agents, and in the design of comics over the past twenty years, has focused on the impact of the degree of detail and naturalness of the EPA. These factors affect their processing and interpretation by users [8, 9], in addition to self-identification processes, and engagement level with the EPA [10, 11]. Other studies have investigated the impact of 'instructional roles' on learning and motivation for particular age groups [4]. A range of pedagogical roles used in EPAs worldwide, have been classified in Haake & Gulz [3] on the dimension of authority. In Haake & Gulz [3], three EPA factors were studied with children aged 12-15: visual static appearance, communicative style, and pedagogical role. Some interesting and potentially unexpected results were found, such as when female students chose 'learning companions' they preferred more stylized, visual characters. However, as children grow, their interests change. This impacts their ability [12] and willingness [13] to use intelligent environments. Therefore, there is value in investigating user's preferences according to their age and cognitive developmental stage.

In this paper, we present a study where 86 primary school children (aged 7-11) chose an EPA to 'accompany' them in their learning of multiplications in the ITS *Multipliotest*. The children used two versions of the software, one with an instructor EPA, and another with a learning companion EPA. The children selected a visual appearance for each EPA: simplified or detailed, and humanoid-shaped (naturalistic) or smiley-shaped (stylized). At the end of the session, they were asked to choose which type of EPA they preferred, and the reason why. Section 2 illustrates all aspects of the experimental study (study goal, EPA design characteristics, experimental design, participants, and research hypothesis). The results (section 3) are illustrated with their analysis (section 4) as to the possible relationship of pedagogical visual appearance with respect to user preferences. Finally, section 5 describes limitations of the study, and considerations for future work.

## 2 Design of the Experimental Study

### 2.1 Goal of the Study

In this section, the experimental study performed on June 10th 2007 with three French classes from the school 'Jean Zay' in France, is presented. The goal of the study was to investigate users' choice of EPA with respect to their visual appearance and pedagogical role. In particular, possible relationships between these variables were investigated with regards to user preferences.

### 2.2 Participants

86 children aged 7-11 (46 girls, 40 boys) from a French primary school participated in the study. The students came from three classes of two levels (one class of CE1, one class CE1/CE2, and one class of CE2). The majority of students had no familiarity with pedagogical agents comprised of embodied computer characters, but they were all familiar with the pictorial representation of naturalistic characters.

### 2.2 Characters' Visual Appearance and Pedagogical Role:

In Haake & Gulz [3], a theoretical framework is defined to evaluate user's EPA choice along three design aspects: visual static appearance, communicative style, and pedagogical role. In this article, we chose to evaluate the impact of two components of visual static appearance (degree of detail, degree of naturalism) in relation to the EPA's pedagogical role and the communicative style. The results enable comparison with Haake & Gulz's study as to the user's preferences, according to the age of the child-participants.

One contribution of this paper is that our participants differ from the Haake & Gulz's study in culture, and more especially in age: they do not belong to the same Piagetan stage of cognitive development [12], nor to the same stage in Acuff and Reiher's categorization [13]. Children aged 11-15 years relate more strongly to more realistic characters, preferring realistic to fantasy worlds [13], and are able to use abstract thinking to solve problems [12]. According to Piaget [12], children aged 7-11 (within the concrete operational stage) can think logically, but not abstractly. Whilst they can distinguish between reality and fantasy, they are developing beyond a stage where perception is dominant, and thus potentially misled by what they see. According to Acuff & Reiher [13], the youngest of our age group participants are leaving the 'emerging/autonomy' stage to enter the 'rule/role' one. They are no longer dominated by a world of fantasy and magic, where there was a need of stimulation associated with comfort and love. By the age of 8, their interest shifts gradually from fantasy to reality.

For this reason, when considering the degree of naturalism, we chose to investigate the impact the level of anthropomorphism in the design versus a character based on a smiley face. This should help gauge children's interest in interacting with an EPA that is more fantasy-like (smiley-shaped), or more redolent of the real world (humanoid-shaped). The use of children and teachers as participatory-design partners in the design of the EPA's visual appearances for the study will aid in producing a sample of EPAs comprised of graphical components both familiar and appealing to children of this age.

**Visual Appearance: Detailed vs. Simplified, Naturalistic vs. Stylized characters.**

The format of the pictorial representations to be utilized in this study arose out of a participatory design session with 2 teachers and 20 children aged 7-11, different from the child population used thereafter in the study.

During the participatory design sessions the children first perused a collection of pictures taken from Internet picture databases on learning companions and the comic literature. Each child then designed their own instructor and a learning companion. All of the children chose and drew female characters as instructors. When interviewed, they explained that the picture should be as similar to their teacher as possible. The participating school consisted entirely of female teachers, and therefore we chose to propose only one type of humanoid character for the instructor, with a female gender. However, when defining the learning companion, the children drew a mixture of female and male child characters, similar to their age. Therefore two characters will represent each naturalistic condition for learning companions, one of male and of female gender.

The expressive style for the stylized characters is based on *Peanuts* [15] characteristics: simplified, whimsy and humoristic, occupying the bottom right corner of McCloud's design space of iconography [11]. On the contrary, the naturalistic characters' expressive style is based on '*Mangas'* and French Comics: cute, emotional, friendly, which is higher up and to the left border of McCloud's diagram. A majority of French child design partners read the comics *Cédric* [16], or watch its everyday TV animated movie adaptation, and relate this to children's everyday life stories at school. Consequently, at the end of the participatory design session, the participants selected *Cédric* and his friend *Chen* for the naturalistic-styled learning companion.

Figure 1 illustrates the sets of characters the children had to choose from: the four characters grouped on the left representing the teacher/instructor characters, and the group on the right representing the learning companions.

Two approaches were taken to the design of the characters used in the study: varying the axis '*degree of naturalism*', and the '*degree of detail'*. Characters 1, 3, 6, and 8 made use of a stylized (smiley-shaped) representational form, while the other characters (2, 4, 5, 7, 9, 10) made use of a naturalistic one (humanoid-shaped). The characters are again separated in terms of level of detail, with the top row 3D-rendered and detailed, and the bottom row 2D-rendered and simplified.

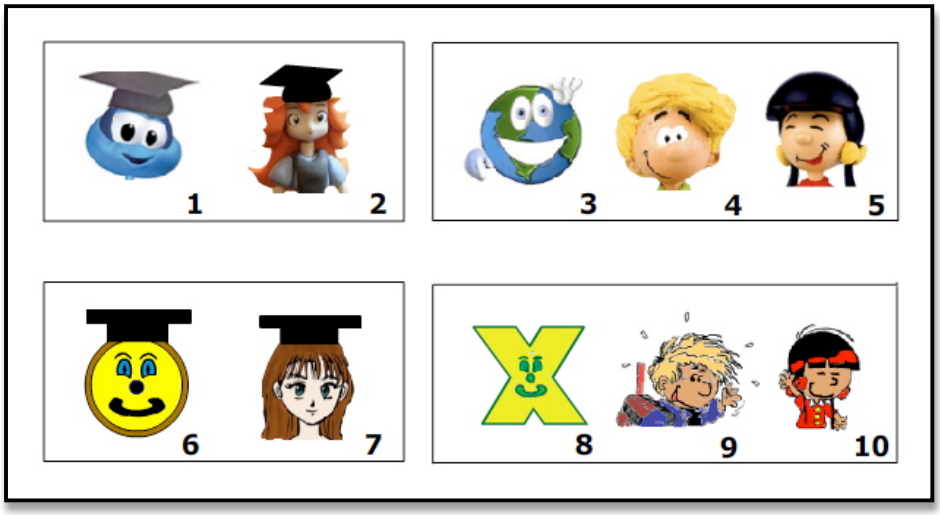


**Fig. 1.** The four sets of characters used in the study: each different in pedagogical goal and visual appearance.

**Pedagogical Role: Instructor/Teacher vs. Learning Companion**

From the categorization of EPA roles in the literature [3, 17], and the studies undertaken on their impact on ITS [4], we chose to investigate two different EPA pedagogical roles:

- An EPA representing an authoritative instructor, with an instructional role of 'expert' as defined in [4], and mainly task-oriented as designed in [18].

- An EPA representing a non-authoritative, collaborative learning companion, with a 'mentor' instructional role, and a combined task-and-relation-oriented communicative style.

The two scenarios of use differed in the interaction with the EPA, but were equal in terms of pedagogical goal and activity architecture: the children could either choose one multiplication (level 1) or all multiplication tables (level 2) simultaneously to test their knowledge against. The only restriction in the game was to choose a unique activity to perform within level 1 and level 2 activities. Each visual representation of the characters was investigated in the scenarios, the interface modulated to integrate their design.

### 2.4 Research Hypotheses

The following hypotheses were studied in this experiment:

Table 1: Hypothesis for the research study.

| |
|---|
| **Hypothesis 1** |
| $Ho^1$: There is no difference in the number of learning companions versus instructors, preferred as an EPA. |
| **H1**: Children will choose the learning companion more than the instructor as the software EPA. |
| **Hypothesis 2** |
| $Ho^2$: When introduced as a learning companion, there is no difference in the number of EPAs being chosen with a humanoid-shaped or smiley-shaped appearance. |
| **H2**: The learning companion version will yield a preference for a smiley-shaped EPA. |
| **Hypothesis 3** |
| $Ho^3$: When introduced as an instructor, there is no difference in the number of EPAs being chosen with a shaped-shaped or smiley-shaped appearance. |
| **H3**: The instructor version will yield a preference for a humanoid-shaped EPA. |
| **Hypothesis 4** |
| $Ho^4$: When introduced as a learning companion, there is no difference in the number of EPAs being chosen with high or low levels of detail. |
| **H4**: The learning companion version will yield a preference for an EPA with low levels of detail. |
| **Hypothesis 5** |
| $Ho^5$: When introduced as an instructor, there is no difference in the number of EPAs being chosen with high or low levels of detail. |
| **H5**: The instructor version will yield a preference for an EPA with low levels of detail. |

Hypothesis 1 relates to the children's final choice, at the end of the session, after using both instructor and learning companion conditions. The hypothesis is concerned with the children's overall preference for either an instructor or learner. It is separated from the other hypotheses, and based on Acuff & Reiher's definition of a developmental stage [13], where children still need support and comfort, and respond more positively to working with a digital peer than an instructor telling them what to do.

Hypotheses 2 to 5 were drawn from theoretical work, field observations when working with our participatory-design partners in the definition of the pictorial

representation, and children's reactions in usability studies with participants of the same age group in the design process of the *Multipliotest* software design. H4 and H5 follow McCloud's theoretical framework [11] where simplified characters amplify the meaning of an image, such as the character's affective components, and therefore afford more powerful social-emotional communications. This may help in the rational aspects of the EPA presented.

### 2.5 Experimental Design and Procedure

The participants were presented with both versions of the *Multipliotest* ITS aimed at helping children learn multiplications: one version with an instructor, and another with a learning companion. The order in which they accessed software was counter-balanced (half of them beginning with the instructor and then the companion, and vice versa). When in front of the software, the children were to choose a character as their EPA given the choices presented in Figure 1, and then performed an activity. They then followed the same procedure for the other condition. Finally, they were requested to choose the EPA they preferred, and explain why it was more appealing to them. In this experimental manipulation, the factors 'pedagogical role', 'degree of detail' and 'degree of naturalism' of the characters act as independent variables, and the user's choice acts as the dependent variable.

## 3 Results

### 3.1 Hypothesis 1: Choice of EPAs in ITS: Instructor or Learning Companion?

Table 2: Test data representing the final choice between instructor and learning companion

| Instructor | Companion | Total |
|---|---|---|
| 21 | 65 | 86 |

A Chi-square 'goodness to fit' test demonstrates that there is a significant difference ($\chi^2$=22.512, df=1, $p < 0.001$) between the expected and observed frequencies, which rejects $Ho^1$: children prefer EPAs in the role of learning companions when working on *Multipliotest*.

### 3.2 Hypotheses 2 to 5: Associations of Pedagogical Role and Visual static Appearance

The test data concerning hypotheses 2 to 5 can be presented in frequencies in a three-dimensional contingency table categorized by the variables: pedagogical role (P), visual style: degree of detail (D), and visual style: naturalism (N).

Table 3: Test data categorized by the 3 variables: P, D, and N.

| | | Naturalism | | |
|---|---|---|---|---|
| **Pedagogical Role** | **Detail** | *Naturalistic* | *Stylized* | Total |
| *Instructor* | *Detailed* | 5 | 18 | **23** |
| | *Simplified* | 61 | 2 | **63** |
| | **Total** | **66** | **20** | **86** |
| *Learning Companion* | *Detailed* | 0 | 1 | **1** |
| | *Simplified* | 5 | 80 | **85** |
| | **Total** | **5** | **81** | **86** |
| | **Column Total** | **71** | **101** | **172** |

*Hypotheses 2 and 3: Association of Pedagogical Role and Level of Naturalism*

With the data separated into the two different pedagogical roles of instructor and companion, a Chi-square 'goodness to fit' test revealed a significant difference in the choice of humanoid-shaped/smiley-shaped visual appearance for both pedagogical roles.

We reject $Ho^2$ and $Ho^3$: The instructor version yields a preference for a humanoid-shaped agent ($\chi_2$=24.605, p <0.001), and the learning companions for a more smiley-shaped appearance ($\chi_2$=67.163, p < 0.001).

*Hypotheses 4 and 5: Association of Pedagogical Role and Degree of Details*

With the data separated into the two different pedagogical roles of instructor and companion, a Chi-square 'goodness to fit' test revealed a significant difference in the degree of detail chosen in the visual appearance for both pedagogical roles.

We can see in Table 3 that for the case of a learning companion, all but one child chose the simplified version of the companion, represented in Figure 1 by the characters 8, 9, and 10.

We reject $Ho^4$ and $Ho^5$: The instructor ($\chi_2$=18.605, p<0.001) and the learning companion ($\chi_2$=82.046, p< 0.001) versions yield a preference for agents with low levels of detail.

# 4 Analysis and Discussion

## 4.1 Hypothesis 1: Choice of Pedagogical Role for EPAs in ITS

At the end of the study the children were asked to provide rationales for the selection of the EPA with the pedagogical role they most preferred using within *Multipliotest*: instructor or learning companion.

The results (H1) show a statistical preference in children's choice of learning companion as EPAs. The reasons behind this choice given by the participants were that they could relate more to the learning companion, and 'trusted' the characters to

help them. The instructors were seen as too formal as characters, and most children felt 'judged' by them.

Children's preference for a 'peer' feature to a more formal "instructor" one is in line with Acuff & Reiher's [13] categorization of children by developmental stage with children aged 7-11 years: they prefer to work in pairs or in groups, and this holds here even though the peer is not physically with them, but digitally represented.

Teacher's interviews on the subject revealed that the instructor figures probably represented themselves to the children, along with their style of interaction during a learning session: In their class, when children work in groups they help each other; while when interacting with their instructor, at the teacher's intervention, they only follow the teacher's instructions and advices, but are not looking for extensive and individualized help.

### 4.2 Hypothesis 2 and 3: Association of Pedagogical Role and Level of Naturalism

The evaluation of H2 and H3 revealed that children conveyed a preference for more naturalistic instructors (humanoid-shaped), and stylized learning companions as EPAs.

Children's preference for more stylized learning companion is coherent with the results of H2 in Haake & Gulz's study [3]. However, unlike their non-significant result when considering the instructor separately, we have here significant results: more naturalistic visual appearance is preferred. This could be related to the difference in experimental design: in this reported study, children chose the characters while distinctively knowing their role, the characters displayed were not the same in each condition, and were especially designed with this role in mind. For this reason, children may have adopted more naturalistic instructors to be closer to the more formal social role of the instructor, i.e. closer to the reality of the class teacher.

Similarly, the choice of more stylized (smiley-shaped) learning companion could be explained by children's view of the EPA in a more relational social role, like an imaginary friend that needs to be more imaginary than realistic. This corresponds with Reeves and Nass's [20] Media Equation theory of transference of real world relational strategies into a 'virtual world' – aka computerized learning environment.

The choices made could also relate to the age group of the study participants. Children of this age frequently watch animated movies or read comics, where the simplification of details emphasize the meaning or semantic association of the images [11], therefore bringing the user closer, or more associated with the learning companion, and keeping a sense of fantasy, detaching themselves from a totally realistic setting unlike older children.

### 4.3 Hypothesis 4 and 5: Association of Pedagogical Role and Degree of Detail

The evaluation of H4 and H5 revealed that children conveyed a preference for simplified characters for both pedagogical roles. Children's preference for more simplified agents may relate to McCloud's theory [11] that such design characteristics emphasizes social-emotional expression, and facilitate self-identification and immersion into the character of the story.

Results for H3 and H5 concerning the learning companion also correspond with the field observations of Haake & Gulz's study [3], that when the EPA is associated to a 'friend', they tend to select more simplified and cartoonish characters rather than a more detailed and naturalistic one.

## 5 Conclusion and Future work

This paper reports interesting findings related to the preferences of 7 to 11 year old French children on the appearance of EPAs, according to two pedagogical roles: instructor and learning companion.

Some results in this study were similar to Haake & Gulz's study [3] on older children from a different nationality, such as the preference of more stylized EPAs as learning companion agents (H2). Other results, however, seemed specifically related to our participants' age group or cultural background (H4, H5), and school learning practices (H1).

Several potential limitations of the study relate to the scope and generality of the results. One limitation is that the children tested the interaction with the agent for a limited amount of time, and within a specific scenario. Although the study is similar in scope to other studies in this area, in advance of making claims about the generality of the results, further studies over a longer time period, and under different conditions of use are necessary. Furthermore, only two pedagogical roles have been studied here, and it would be interesting to investigate other roles used in the design of EPAs within ITS applications. Validity of the study results may also be limited to the design of EPAs for French children aged 7 to 11 years, a replication of this study with different user groups (in age and/or culture) may produce different results. It is also necessary for us to undertake further studies to identify the impacts of the different factors of visual appearance and any associated actions of the characters.

Other future work includes investigating age and gender differences in choices of EPA's appearance, actions and pedagogical roles. We believe this work in the design of EPAs for ITS may result in EPAs that are more appropriate for the children.

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