# Exploring the Influence of Group Size and Interaction Rate on Students' Perceptions of Humanoid Robots in Higher Education*

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**Abstract**

This paper addresses the topic of humanoid robots in higher education. Through the playful interaction "Planning Poker with NAO", the use of humanoid social robots is examined with a focus on the impact on the variables of the group size and the amount of direct interaction with the robot. By using a between-groups design with three test groups and pre-experimental and post-experimental-questionnaires the data of 52 participants is collected and descriptively analyzed. Evaluating the data, tendencies can be determined that a lower group size and more direct interaction with the robot results in a positive perception of the interaction and an acknowledgement of the robots' potential benefits compared to human teachers. This paper emphasizes the importance of using standardized surveys to ensure that all participants' attitudes towards robots are measured prior to participating in the study.

**Keywords**

Human-Robot Interaction, Higher Education, Educational Robots, Humanoid Robots, NAO Robot

## 1. Introduction

As digital technologies become more integrated into the education sector, the question arises how humanoid robots can be used in teaching to enrich and optimize the learning process. The use of robots in educational processes is not a new concept, but research in this area is predominantly focused on the primary school sector and less on the higher education sector [1].

The bachelor thesis, which is partially presented here, was dedicated to investigating the potential of humanoid robots in teaching and learning environments in the higher education sector. The aim was to find out what influence the factors "group size" and "amount of interaction" have on the use of humanoid robots in higher education and how students perceive the robot in comparison to traditional teaching methods, using the example of the game "Planning Poker" led by the humanoid robot NAO. The game "Planning Poker", which is normally used in agile project management for effort estimation, was chosen to analyze the participants' perception of the robot in a controlled interaction, following previous research showing the use of robots in agile project management [2, 3, 4] and as assistance in small group facilitation [5].

## 2. Methodology

### 2.1. Participants

A total of 52 participants took part in the study, with a mean age of 22.1 years (SD=2.8) and a gender distribution of 36.5% female, 63.5% male and no non-binary participants. The participants were divided into three groups based on their affiliation to different lectures so that the study could be integrated into the university curriculum, resulting in mixed group characteristics: Group 1 (n=22;

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mean age=21.1, SD=1.6; 31.8% female, 68.2% male), group 2 (n=17; mean age=23.1, SD=3.4; 52.9% female, 47.1% male) and group 3 (n=13; mean age=22.5, SD=3.0; 23.1% female, 76.9% male). All participants have signed a declaration of consent and a data protection regulation.

## 2.2. Study Design

To achieve the research goals, an experiment with a between-groups design was executed. The study consisted of three different experimental groups, which were differentiated by the number of participators (N) and the amount of interaction (I) with the robot:

1. **Group 1 (N+I-)**: This group consisted of a large number of participants (n=22) who had limited opportunities for direct interaction with the humanoid robot NAO. The robot took over the moderation of the game "Planning Poker", without the possibility for participants to communicate physically or verbally directly with the robot, but instead carried out tasks guided by coordinated time intervals.
2. **Group 2 (N+I+)**: The number of participants in this group was large (n=17), but it was possible to interact directly with NAO. The participants were able to communicate verbally and physically with the robot, which allowed increased involvement in the instructed game process by NAO.
3. **Group 3 (N-I+)**: This group (n=13) was divided into smaller groups and had a high interaction rate. Here, the participants had the opportunity to interact with the robot in individual small groups (n=4) in a separate environment.

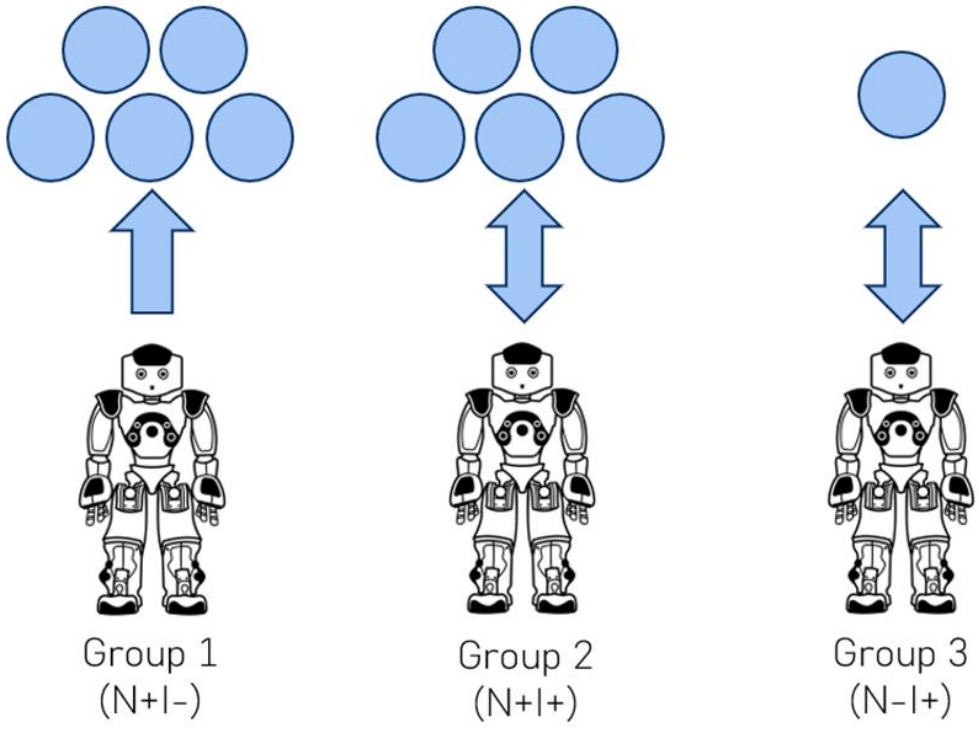


**Figure 1:** Visualization of the experimental set-up of the different groups

Questionnaires were used before and after the experiments to record the students' opinions. The surveys included both quantitative and qualitative questions. They covered aspects such as previous experience with robots, expectations, perceived learning success, motivation, perception of the robot and the perceived benefits between NAO and a human teacher.

Due to its brevity, this extended abstract only highlights selected aspects. In the pre-experiment questionnaire, the GAToR-Scale by Koverola et al. [6] was used to indicate the general attitudes of the participants towards robots. This scale depicts four factors, each with 5 items on a 7-Likert scale on which participants indicate their agreement or disagreement. This pre-experiment survey was important to determine whether the different groups had different conditions from the start, which would make the comparisons between them more complex.

To compare the humanoid robot with a human teacher, Slavik's QAIT model [7] was used with added factors inspired by the questions posed by Ditton and Merz [8]. In this model, the factors "Quality", "Appropriateness", "Incentives" and "Time" (=QAIT) are emphasized as quality determinants for successful teaching and expanded to include the factors "Anxiety" and "Class Management". Participants had to indicate their agreement with two statements per factor on a 7-Likert scale. For example, for factor "Anxiety": (a) Because NAO led the exercise instead of a teacher, I was less afraid of doing something incorrect. (b) If a teacher had led the exercise instead of NAO, I would have been more confident to participate. Statements a and b were each designed to focus on either the robot or the human teacher. By comparing the agreement of the two statements a and b for the specific factor, it is possible to identify preferential tendencies in each factor.

## 3. Results

### 3.1. Pre-Experiment Differences

A direct comparison of the mean values of the experiment groups shows that group 1 (N+I-) and group 3 (N-I+) have different attitudes towards robots, before the experiment started (Table 1). While group 1 and 2 differ only slightly, group 3 has a more positive attitude which shows the higher mean values at the positive factors (P+, S+) and the lower mean values at the negative factors (P-, S-). This means that the data collected should be treated with caution, however, it can still reveal tendencies of new discoveries.

**Table 1**
Group Differences in GAToRS

| | Personal Level Positive (P+) | Personal Level Negative (P-) | Societal Level Positive (S+) | Societal Level Negative (S-) |
|---|---|---|---|---|
| | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD |
| Group 1 (N+I-) | 3.4 ± 0.5 | 3.0 ± 0.9 | 5.0 ± 0.5 | 5.7 ± 0.7 |
| Group 2 (N+I+) | 3.3 ± 0.4 | 3.3 ± 0.7 | 5.3 ± 0.8 | 5.0 ± 0.5 |
| Group 3 (N-I+) | 4.6 ± 0.4 | 1.9 ± 0.9 | 6.3 ± 0.5 | 4.5 ± 0.9 |

### 3.2. Expectations and Perception of the Interaction

The expectations of the interaction with NAO were met by most participants (in total 65.4%), with a total of 19.2% stating that the interaction was worse than expected and 15.4% that it was better than expected, as shown in table 2.

**Table 2**
Expectations of Participants

| Did the interaction fulfill your expectations? | Yes | No, expectations were exceeded | No, expectations were not met |
|---|---|---|---|
| Group 1 (N+I-) | 55% | 9% | 36% |
| Group 2 (N+I+) | 88% | 6% | 6% |
| Group 3 (N-I+) | 54% | 38% | 8% |

There are strong differences in the various experiment groups. While half of the group 1 and 3 say that their expectations were fulfilled, the other half goes in the opposite direction and claims that the expectations were not met (36%, group 1), or were exceeded (38%, group 3). This indicates that with less direct interaction from the robot, while orchestrating a lot of people at the same time, the interaction will not be as good as expected.

As shown in table 3, the interaction was perceived as predominantly "interesting", but also as moderately "exciting" and "motivating". Attributes such as "frustrating" and "disappointing" received low approval, whereby a difference between the experimental groups is clear and experimental group 3 agrees more with the positive characteristics and agrees less with the negative characteristics than the other two experimental groups, which do not differ greatly in their perceptions.

**Table 3**
Perception of the Interaction

| | Interesting | Exciting | Motivating | Frustrating | Disappointing |
|---|---|---|---|---|---|
| | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD | Mean ± SD |
| Group 1 (N+I-) | 4.8 ± 1.6 | 4.1 ± 1.5 | 3.9 ± 1.3 | 2.3 ± 1.2 | 2.4 ± 1.6 |
| Group 2 (N+I+) | 4.9 ± 1.6 | 4.4 ± 1.3 | 4.0 ± 1.5 | 2.2 ± 1.3 | 2.4 ± 1.4 |
| Group 3 (N-I+) | 6.2 ± 0.8 | 5.1 ± 1.3 | 4.8 ± 1.2 | 1.9 ± 1.0 | 1.6 ± 1.1 |

The qualitative questions were able to provide more context to the quantitative data. On the positive aspects the participants described the interaction as something new and "entertaining" but on the negative side it became "monotonous after a long time" due to the repetition of the phases of the planning poker game. The robot was emphasized as "likeable and cute", but sometimes had comprehension problems and was unable to respond dynamically to answers, which was "a bit of a pity". There were also some participants in group 1 who felt that the interaction and use of the robot was "unnecessary" or "just like a radio". This could be part of the reason why 36% of group 1's expectations of the interaction were not met (Table 2).

### 3.3. Potential Benefits of NAO compared to a Human Teacher

Table 4 shows the results regarding the comparison between the robot NAO (R) and a human teacher (H). A higher score indicates that there are advantages over the other.

For items 4, 5 and 6, all test groups agreed more with advantages of NAO than with advantages of a human teacher. These items belong to the factors "incentives", "time" and "classroom management". For these three factors, it can therefore be shown that the students think, that the use of humanoid robots can bring advantages. No clear tendency can be identified in the factors "anxiety", "quality" and "appropriateness", as the assessments of the different groups are very different and the differences between statements R and H are not large enough. However, all test groups show a slight tendency to question the "appropriateness" of the interaction with the humanoid robot and to prefer a human teacher in this factor.

**Table 4**
Perception of Humanoid Robot NAO (R) vs Human Teacher (H)

| | Anxiety | Quality | Appro-priateness | Incentives | Time | Classroom management |
|---|---|---|---|---|---|---|
| | R \| H | R \| H | R \| H | R \| H | R \| H | R \| H |
| Group 1 (N+I-) | 3.1 \| 2.7 | 2.7 \| 3.6 | 2.6 \| 2.8 | 4.0 \| 2.4 | 3.8 \| 3.4 | 4.0 \| 3.4 |
| Group 2 (N+I+) | 2.7 \| 3.2 | 2.4 \| 3.5 | 2.3 \| 2.9 | 3.2 \| 2.2 | 3.8 \| 2.6 | 3.5 \| 3.4 |
| Group 3 (N-I+) | 4.8 \| 1.9 | 4.5 \| 2.8 | 2.7 \| 3.0 | 5.2 \| 1.6 | 4.7 \| 3.5 | 4.1 \| 2.3 |

## 4. Conclusions

The presented work contributes to the research on the use of humanoid robots in higher education. The results show that humanoid robots such as NAO have the potential to enrich university teaching and can therefore be successfully used as a supportive teaching tool in specific scenarios. Critical factors such as group size and interaction abilities need to be carefully planned and adapted to achieve the desired learning outcomes.

Limiting factors in this study were the number of participants, which were uneven in the different groups to be able to conduct the study as part of university class and the different preconceptions of the various groups, which may have had an impact on the perception of the robot. In future studies, a control group, in which the interaction is facilitated by a human teacher to be able to evaluate and more reliably validate the results, should also be included.

Future research should also focus on further refining the best deployment strategies for humanoid robots in different educational contexts and evaluating their long-term benefits.

As this study has shown, it is important that in future research the participants' attitudes are documented. This recommendation applies to all future research with robots, as the acceptance of robots in society changes over time and the use of standardized questionnaires improves the validity of the results and promotes better comparability between studies.

## Declaration on Generative AI

During the preparation of this work, the authors used DeepL for grammar and spelling checks, as well as for translating specific words. After using this tool, the authors reviewed and edited the content as needed and taking full responsibility for the publication’s content.

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