# Group Laboratory of a Robotics Course in Computer Science Teaching

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## Introduction

Laboratory in teaching computer science is a distinctive teaching activity comparing to conventional science subjects like chemistry and biology (Soll, 2023). Special consideration is desired because the laboratory is often about special computing devices, such as supercomputer and embedded systems (Black et al., 2018). This project explores laboratory practice in teaching algorithms that are useful for controlling physical systems, a mobile robot. The project focuses on group formation in organizing laboratory activities. How groups are formed is known to impact students' perception in programming assignments (Aivaloglou et al., 2021). Working with friends or unacquainted persons might create a different study environment. The laboratory exercises on robots may amplify such impacts for being more demanding about interdisciplinary knowledge, converting algorithmic theory to practice, group cooperation for solving system failures (Krogh & Wiberg, 2015). Computer science students might not enter the course with readiness at a similar level on foundational subjects. It may hence be necessary to group students with complementary skills for progressing the exercises and promoting the important learning paradigm of "peer learning" (Boud, 2001). The project will study whether the strategy of assigning groups by instructor could work in this scenario. Our results find that grouping by accounting for their skill readiness is well received, and potential to create positive impacts on the learning performance.

## Course Overview

The study will be performed in teaching Robotic Experiments (REX), an elective offered in the computer science bachelor program at the University of Copenhagen. The course is given by two teachers and generally takes 30-40 students. The curriculum mixes lecture and laboratory exercise sessions. Lectures about lab setups, rules, and programming interface will be given. On the course day, the lectures are first given in two 45min sessions. This is followed by the laboratory exercising the theory and algorithms taught in the lecture sessions, e.g. computing a collision-free path to driving the robot towards a goal, till the end of the day. The instructors will monitor the activity and provide hints or supervision when the students need help. The exercise groups are consisted of 3-4 students, ensuring each group has their own robot to work with. The groups are formed at the first course, by the students themselves before the 2024 cycle. The groups will not be changed throughout the cours.. The students need to complete 6 exercises, with 2 including hand-in report, that must be approved by instructors. The students will also work towards a final solution that will be taken to a robot competition activity at the end of the course. The competition performance does not count into the final grade. However, the students need to reflect and discuss on their implementation individually in the oral exam, which also covers the theories taught in the course.

In the 2024 cycle, REX takes 32 students and forms 9 student groups due to some late sign-up. Some students are not with the department of computer science, including ones in exchange from abroad universities, studying in a master program or other departments.

## Method

We choose to assess students’ readiness on relevant topics: robotics, programming and physics, and then manually allocate by complementing and balancing each group’s overall acquaintance to these topics. This is done by distributing a questionnaire prior to the course. The students are notified that their response will not impact their final grade. Specifically, we ask them to choose ones that they feel fit their situation from five options like “I have knowledge on the mathematical models of robots”, “I have programmed in related to multiprocess/threads systems”, and “I have completed one year physics course during my high school study”. There are also “none of above applies” options and an open-ended question to allow for further clarification. Refer to the appendix for the full questionnaire. The readiness on each topic is rated by a scale from 1 to 5. For robotics and programming, if two strongly related options are chosen, the student will be given a rate of 5. A rate of 4 will be given if the response includes one strongly related option. The student will be rated with 3 if two weakly related options are there and with 2 if one is ticked. The response of “none of the above applies” will lead to a rate of 1. For physics topic, the rates from 5 to 1 correspond to the experience of studying university-level/three/two/one year/none physics courses.

After the first three weeks of laboratory exercises, students will be surveyed about their opinions on the group experience and their group roles in completing the assignments. The opinions are reflected from a single choice from “Strongly Agree”, “Agree”, “Neutral”, “Disagree” and “Strongly Disagree”. The questions include:

- I feel I am very engaged in the group exercise.
- I feel I am playing an active role in my group.
- I feel I can receive help from my group members.
- I feel I have learnt something from my group members.
- I feel we have good group dynamics.

Their exercise performance will also be evaluated in the form of discussion between the two teachers.

## Results and Evaluation

All 32 students responded to the pre-course questionnaire, with the distribution of readiness levels illustrated in Fig. 1. The average readiness levels for robotics, programming and physics are respectively 2.76±1.15, 3.30±1.35 and 2.82 ±1.51. The sum of three levels for student individuals can range from 4 to 14. The data show a wide spread of levels on all three topics and their sum, highlighting the diversity of students’ background. The students generally lack robotics-related knowledge or project experience. This is consistent to the motivation of adjusting REX contents in the last few years for the accessibility. The students are relatively better prepared on programming, which confirms the dominant demographics of computer science students. Notably, at least one-third of them reported that they didn't gain coding experience outside their curriculum training. The response to physics exposure shows a bipolar distribution. This may reflect the preference of them in choosing subjects during the high school: they either follow a full three-year study or take the minimum required, since physics is not desired for being admitted to the department of computer science.

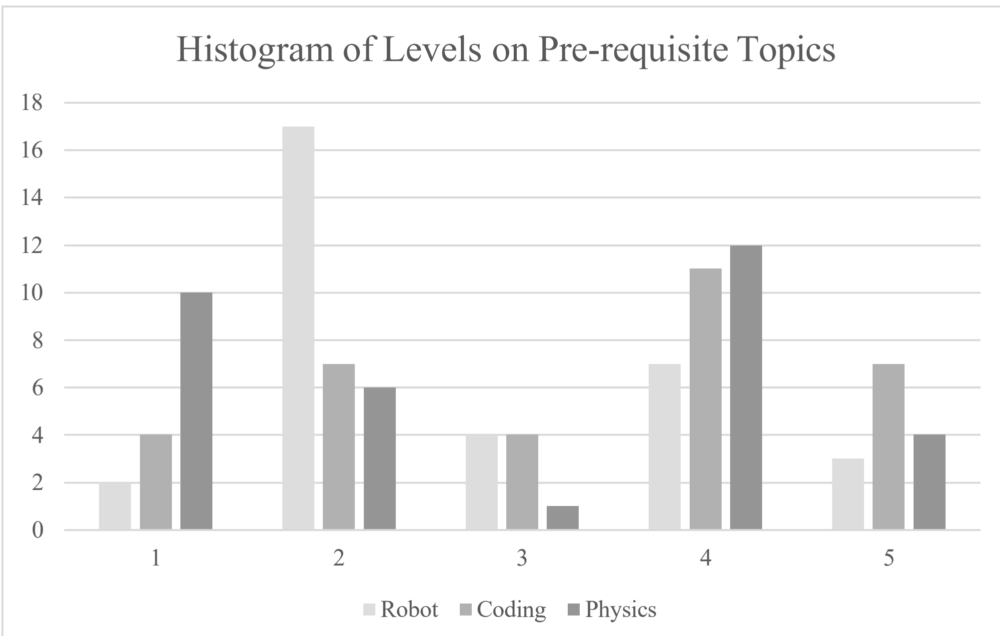


Fig. 1: The distribution of assessed familiarity levels from 1 to 5 on three related topics. X-axis: assessed levels; Y-axis: count.

The data helped the instructor to form 9 groups, of which 5 groups are 4-person and 4 groups are 3-person. All groups result in an average of readiness levels between 2.5-3.0 on robot and physics topics and 3.0-3.6 on the programming topic.

In the group experience survey, 15 students responded with the likert scale distribution depicted in Fig. 2. Four students left the last question on group dynamics blank, possibly because the need of scrolling down to find the question. We found that students are positive regarding their experience on all questions, with over 90% responding "Agree" or

"Strongly Agree". Notably all three students of one group rated 5 on the mutual learning question and they seem well complementing on the assessed topics (4/5/2, 2/2/5, 2/5/4 for robots/coding/physics). The only disagree comes from the group dynamics question. The student had a strong readiness evaluation on all topics (5/5/4) while was grouped with two less prepared (2/1/2 and 2/4/1) due to the balancing strategy. This indicates a caveat of this strategy when the skill gap among the students is so large that organic dynamics are hard to build.

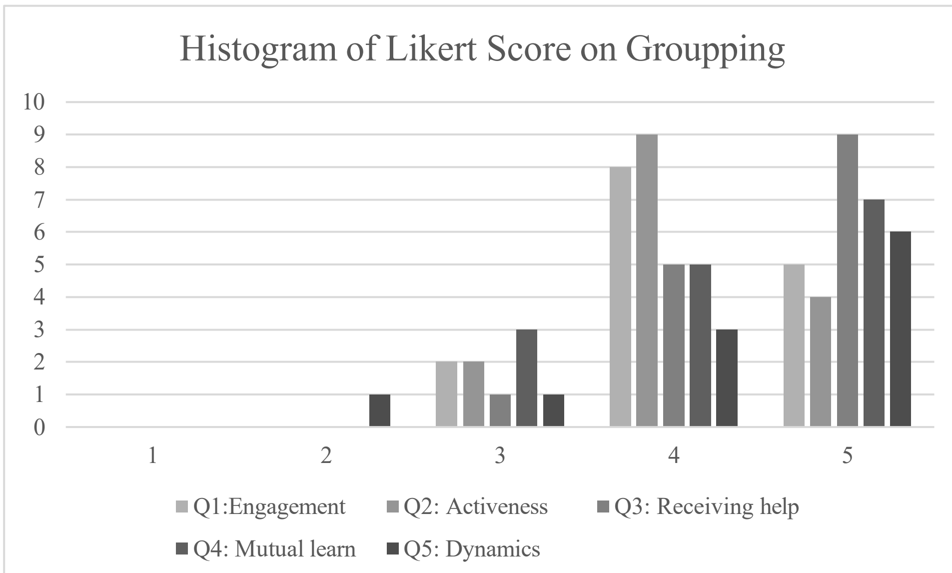


Fig. 2: The distribution of the likert scale responding to the groupping survey. See Method section for the contents of Q1-Q5. X-axis: likert scale – 1 (Strongly Disagree) to 5 (Strongly Agree); Y-axis: student count.

The two instructors discussed their observations on moderating the first 8 exercise sessions. The students didn't make regrouping request for working with acquainted people, which happened in the author's other course when a random grouping strategy was adopted. The inter-group performance gap appeared to be significantly smaller than the last year. Most groups could complete the first 3-4 exercises smoothly, for which two or three groups already started to fall behind the schedule in the last year. We didn't find students who were visibly not participating. This contrasts with a few cases we found last year, for which the instructors had to intervene to avoid them being left out. The evaluation on the hand-in assignment doesn't find much difference on the quality though.

## Discussion and Limitations

The study found that students attending a robotics course can exhibit a diverse background and readiness levels on supporting topics. The students are generally positive towards their laboratory experience when they are grouped with a consideration on the readiness. Comparing to grouping at will, the activities appear to progress better thanks to a smaller performance variance. The findings show an imposed grouping structure has no clear disadvantage in organizing the laboratory work if not benefits it, comparing to grouping at will. However, care may be taken to the skill gaps among grouped students to ensure good dynamics. The study didn't perform a direct comparison on the learning outcomes due to the time limit and the shift of student demographics (language change/open to exchange and master students). Further investigation is also needed for improved grouping strategies, e.g. a finer analysis on skill gaps to promote mutual learning and group dynamics.

## References

Soll, M. (2023). *What Exactly is a Laboratory in Computer Science*. IEEE Global Engineering Education Conference (EDUCON), Kuwait, Kuwait, pp.1-9.

Black, M. (2018). An embedded systems course for cross-interdisciplinary research, *Journal of Computing Sciences in Colleges*, vol. 34, no. 1, pp. 202-209.

Aivaloglou, E. (2021). An Empirical Study of Students' Perceptions on the Setup and Grading of Group Programming Assignments*, ACM Transactions on Computing Education,* vol. 21, no. 3, pp. 1-22.

Krogh, L. & Wiberg, M. (2015). Problem-based and project organized teaching. In Rienecker, L. & Jørgensen, P. S. & Dolin, J. & Ingerslev G. H. (Eds.) *University Teaching and Learning* (pp. 215-227). Samfundslitteratur.

Boud, D. (2001). Introduction: making the move to peer learning. In Boud, D. & Cohen, R. & Simpson, J. (eds), *Peer learning in higher education – learning from and with each other*. London: Kogan Page.

# Appendix

Pre-course questionnaire for assessing the level of familiarity on robots, programming and physics :

**1** 0 points

Regarding the term of "robot", I

- [ ] have some knowledge about the mathematical model of or programmed some types of robots before.
- [ ] have the experience of programming some external devices connected to my computer.
- [ ] have the experience of playing or using some robot-like devices, such as drones or robot vacuum cleaners.
- [ ] have learned about the term mostly from the mass media.
- [ ] have not heard much about the term.
- [ ] None of above apply.

**2** 0 points

Regarding the coding experience, I

- [ ] have the experience of programming microprocessor development boards such as Arduino.
- [ ] have the experience of writing code related to multiprocessing/multithreading/event-handling.
- [ ] have the experience of programming some projects extra to my curriculum.
- [ ] have mostly gained it through course assignments and projects.
- [ ] None of above apply.

**3** 0 points

Regarding the exposure to physics, I

- [ ] have completed or been following physics-related/engineering courses at the university level.
- [ ] have completed three-year study of physics during my high school.
- [ ] have completed two-year study of physics during my high school.
- [ ] have completed one-year or less study of physics during my high school.
- [ ] None of above apply.