From Zero to Hero - Basic Training Units for Fresh FLL Teams

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Abstract. Training a school team to participate in the First Lego League is not an easy task. It is further complicated by the fact that many teams are formed with just a few weeks time to go between the first training session and the actual competition. We describe parts of a training course designed for exactly this situation to teach three prime objectives for a successful participation as a newcomer team at the FLL: defining realistic goals, building strong and versatile teams and introducing a few important robotics principles by sample experience. In two examples from the actual training set we concentrate on these principles and how the design of the exercise as well as the role of the teacher/moderator can influence the learning curve concerning these objectives.

Keywords: First Lego League, Lego Mindstorms, school, course material, robotics

1 Introduction

The First Lego League [2], an international competition for junior robotics teams based on the LEGO Mindstorms© robotics kit, has probably become the biggest competition of its kind on the planet. Due to the high profile of this modular building box worldwide, figures for participation reach record highs each year. Especially for school project groups, the low entrance level of Mindstorms makes it attractive to consider the participation as a main source of motivation for newly formed work groups.

The main attraction of the competition is the robot game, in which each participating team has to solve roughly 15 tasks – set out on a playing field, which is published two months before the first contest – with their own designed robot and program within a time limit 150 seconds. The interaction with a simultaneously playing opponent is reduced to practically zero. Points are awarded for each completed task based on the difficulty level. This layout further suggests almost ideal circumstances to enter a first robotics project.

As a university project, set up at Heidelberg University to assist high-schools (German: *Gymnasium*) in developing activities and projects in **M**athematics and

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Informatics with applications in **N**atural sciences and **T**echnology, the MINTmachen! Team [1] discovered in the last few years that bringing school project groups from their first steps in robotics to the participation of FLL is nevertheless an ambitious task. We designed a series of introductory learning units to address various aspects of robotics in general and the participation of school teams in FLL in particular to make best use of a short time frame that is more often than not the predominant factor in the organization and execution of such FLL school projects: *From zero knowledge to a successful FLL participation in eight to ten weeks*.

2 Identifying the main teaching areas

The central task in an endeavor is to select the optimal subset of possible educational objectives, which are essential to successfully participate in the FLL robot competition. As any researcher in the field of optimization knows, the answer to *this* question depends heavily on the definition of the term *optimal* - in other words: first we have to define a criterion for optimal participation.

In terms of a newly formed school team, typically around 7th grade (12 years old), we assume the following set of indicators to be a valid set to define a successful participation:

1. Realistic goal: The participants at the table constantly reach a minimum score on the playing field.
2. Distributed assignment: All team members are participating in the team event in some fashion.
3. Robotics 101: First principles of robotic can be formulated by any team member, when talking e.g. to parents and friends about the FLL.

We use the first indicator to make sure that the team is focused on an attainable goal for the competition, which in turn helps a lot to keep the concentration high when planning the series of tasks. From the view of robotics education this indicator also conveys the idea that tasks such as the one given usually result in a fixed series of actions to solve the given problem – much like a computer algorithm solves a programming problem.

The second indicator should guarantee team building aspects in the squad. While some team members have a knack of getting robot building or programming accomplished earlier, faster or more reliable, all kids should learn and understand, that a complex task such as the FLL table cannot be solved singlehandedly by the two most gifted squad members alone.

Concerning the third indicator: Usually Mindstorm robotics is the first contact of kids with the world of programmable, reconfigurable robots. Making sure that basic principles of this scientific area are understood and that links to other natural science subjects are explained as well. Such interdisciplinary aspects of robotics make robotics a great tool to advertise the use of physics, mathematics, information technology and even biology in application areas. As soon as kids understand this

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point, the draw solutions from other areas of expertise into the robotics classroom, making progress faster and solutions more imaginative and reliable.

There are many more criteria which could be considered to define the term of optimal participation. Over the course of the years both as a mentor to school teams in the Rhein Neckar area as well as in my role as a technical judge at FLL competitions, I feel that over-ambition, lack of teamwork and missing robotics basics are amongst the most common reasons why teams perform badly during their first FLL experience or break apart right after the event. So the selection of criteria mentioned in this article is both reasonably well tested (although not scientifically rigidly proven) and refined by personal experience both in the good and the unpleasant effects.

3 Defining Robotics Lessons

In this section, we give a short overview of some robotics lessons which we defined to be used in the start-up phase of a FLL school team. We understand these units as suggestions to the teachers, which are to be adapted and improved when dealing with the specific team. In the following examples we make reference with regard to the three prime objective indicators defined in the previous session.

3.1 Interplay between Robot and Program

The very first lesson is designed as a direct approach to Mindstorm robotics. Usually all participants are eager to lay their hands on the robot sets and to start building their first animated figure. The enthusiasm and curiosity of this phase is channeled into some simple tasks which show both the potential and the limits of robotics – with one special emphases on the interplay between robot and program

Overview: The participants are separated in groups of four, each mini-team receiving a robotic set, a computer and a work sheet. Each group is subdivided into two builders and two programmers, mentioning that this setting will be turn around in the next lesson. The first task is to build and program a robot which can drive a distance of exactly 1 meter. While the building team gets a rough step-by-step description of a very simple robot (using only one engine, the main brick and 15 LEGO parts), all programmers get a first introduction to the native graphical programming environment.

Time flow: The programming and building task are designed in such a way that both parts of each team roughly reach their respective goals at the same time. As the programming team essentially needs only one program brick, the explanation of the programming environment (setting up a project, saving a program etc.) and the defining parameters (speed, rotation angle vs. time vs. number of rotations etc.) can

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be done in a little detail. Joining the program and robot for a first test is usually an exiting moment. After some reprogramming to complete the task, all teams are to present their result in a team meeting.

Objectives: While the task seems to be fairly easy and straight forward, the lessons which can be learned from it, are much more complex. Never again is the learning curve so high as at this very first hours in the course. The separation of the mini-teams in two groups gives a first indicator that different team roles will exist in the final FLL team. Joining the results from both groups further enhances this experience, contributing directly to objective 2.

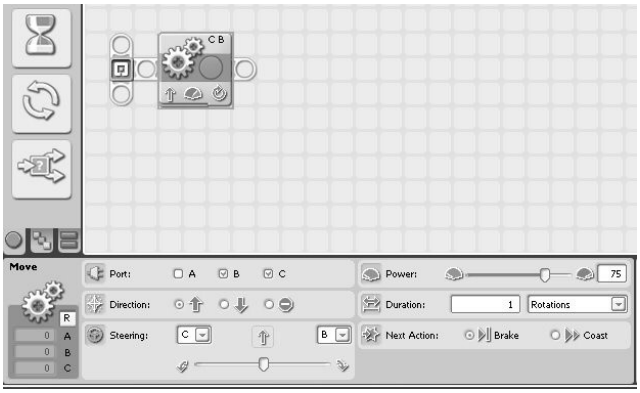

Figure 1: Using only the movement block, the first lesson on robotics programming is usually easy to explain

The fact that the robot cannot do any action without the program, while the program (lacking a virtual training environment) needs the robot to be finally tested, is a vital lesson for any robotics project. Even the most cleverly designed algorithm might fail when transferred to the hardware platform (objective 3) .
While the goal is usually deemed to be too easy to tackle by the kids, the fact that no team usually gets the task right the very first time and even after several revision the final team presentation – which can be done e.g. between two lines exactly 1m apart – will show substantial deficits in some of the mini-teams. Experiences like that should lead to a realistic estimation of the own prowess and shortcomings (objective 1).

Remark: This first lesson can usually be followed by a repetition lesson where the driving exercise is converted from driving a certain distance to driving a specific straight route on the FLL table. Each year the FLL robot game features several tasks which can be accomplished by driving forward (and backward) alone. Actually solving such a (simple) tasks can give a first success to the school team. Asking on the other hand to perform a task involving a curve immediately leads to the shortcomings of a robot with only one engine – it only drives straight, even if the program tries to suggest otherwise using the turn parameter of the movement block, again touching objective 3 and the interplay between program and robot.

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3.2 Speed vs. Precision

The robot base of a FLL team is the key to both high scores and reproducibility of the result. While some general remarks on the layout of a robot with these properties can be taught to the team, a much better setting is to use a competition between the mini-teams to find the starting point for the overall team platform. Our experience is that the platform also depends on the characteristics of the team: their ambition, diligence, and ingenuity.

Overview: The mini-teams get different blue prints (wheeled vs. tank-chain-driven) of two robots. The task to complete is to start in a marked box, circle around a square led out by for posts (empty soft-drink cans will do nicely) and return to the exact starting position inside the box (see figure 2).

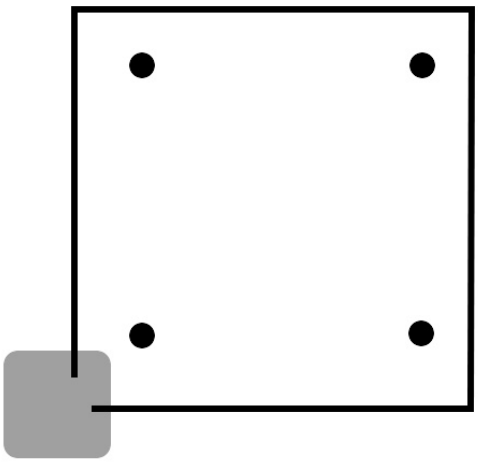

Figure 2: The round trip around the four corners of a square is used as an exercise in both precision and speed.

Time flow: The tasks for the builders and the programmers are already a lot harder in this exercise. Do not expect to finish this within a team meeting of 60 minutes – even in 90 minutes a successful completion is tough. The building team decided which of the two robots to realize. While the wheeler looks more familiar, some technically inclined groups usually attempt to build the tank-chained propulsion as an exercise. In the programming part, the moderator can easily introduce the concept of iteration to the programmers. Even the use of self-defined super blocks (drive and turn) can be

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accomplished to further structure the programs and pave the road for per-task super blocks.

Objectives: The teams should agree on the question how the comparison of results can be accomplished. A touched can might bring a time penalty to the team, to be added to the overall task time. The precision of the final position with respect to the starting configuration has also to be determined. In a final competition between the mini-teams, these regulations can be enforced by the moderator in much the same way as a FLL judge performs at the competition. All these actions will lead to the understanding of the subtle difficulties in an apparently straight-forward task (objective 1).

By the the time of this exercise, specialists might already emerge for both the building and the programming part. The moderator should also have look for possible organizers (as team captains) and rules advocates (e.g. for documentation). An important role is to finally stand at the table to place and start the robot. While the top FLL teams usually have experts for this job as well, the regulations of FLL (best run of three tries counts) allow for several team members to take up this role during the competition. When the moderator finally introduces the solidification of the team roles, we made the experience that many groups have a natural tendency to distribute the roles amongst themselves based on the talents of the team members. Seemingly inferior tasks such as documentation can be upgraded by constant reference to experimental result sheets etc. by the moderator (objective 2).

The introduction to cogwheels and transmissions is a necessary element for understanding gearings. Additionally, the use of tank-chains furthers this concept and brings up the discussion of precision vs. speed. This topic is a prime dilemma in FLL teams where more often than not the precision finally triumphs over sheer speed. Especially junior teams can profit from the slower but more reliable chain-driven basis, as they will usually not be able to tackle more than six to eight tasks on the table, given that the preparation phase is only a few weeks. Fewer tasks lower the need for top speed of the robot since finishing the task set ahead of time does not yield any bonus points. Directly linked to this question is the problem of reproducibility, which can be picked up as a theme by the moderator: The competition of this exercise decided by the mean (median?) of three test runs performed by each team. This reduces the chances to win by a lucky strike and binds the teams to a more reliable design. Issues such as lowering the center of gravity or the footprint of the robot are advanced topics, which also can be linked to this exercise (objective 3).

4 Summary and Conclusion

We presented a flash insight into the design of course material for the introduction of school teams to the FLL. Through the definition of the three main objectives to define realistic goals, assign roles to encourage team building and to introduce basic robotics

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concepts to the team members, we were able to focus our course exercises and teacher's handbooks to lead to a better first experience at the FLL competition.

The material is constantly revised by the MINTmachen! team, where teacher students and lecturers work to improve both the technical content and the didactical concepts of the course work. The FLL teams of Carl-Benz-Gymnasium, Ladenburg (2007, 2008, 2009, 2010), St.Raphael-Gymnasium, Heidelberg (2007, 2008) and Heinrich-Böll-Gymnasium, Ludwigshafen (2010) were and are using the materials for training purposes. As but one example, the team “Berthas Hühner” (the name refers to Bertha Benz, wife of Carl Benz) a girls-only-team of the CBG, Ladenburg, was very successful at several regional qualifiers in Speyer and Mannheim, showing that robotics is a topic that has a lot of appeal to girls as well.

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