- Botball -
Skills and knowledge throughout the process

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Abstract— **Hard and soft skills are an integral part of the Botball Competition. The following paper tries to define these skills and discusses how they interact within the program, , for example, in the form of teamwork, time management, critical thinking, but also mechanical, craft and IT skills . However, our Botball team has not only dealt with this, but also with how skills and, above all, interest in robotics and programming can be in younger people.**

I. INTRODUCTION

During the preparations for a competition and during the actual competition, one thing is very important. The skills and knowledge that each team member brings. These make us all unique, but also give us the strength to work together as a team to achieve a certain goal.

A targeted use of personal qualities is also very important in regard to the Botball Competition in order to achieve the best possible result.

As a participant group of the ECER competition 2022/23, we have the opportunity to find out what skills and knowledge are needed during the whole process of the competition and to combine all our findings here in this paper.

II. HARD AND SOFT SKILLS: OVERVIEW

A. Hard skills in general

Hard skills, or technical skills, are skills that are acquired in the course of someone's life through a specific education, professional career, private interest or any other experience in life.

Depending on the work to be performed, different hard skills are needed.

Examples of such hard skills are as follows:
- foreign languages
- Adobe Creative Suite
- health care related certifications or licenses
- programming languages (JavaScript, etc)
- website development
- content development
- copywriting
- copyediting
- budgeting
- SEO marketing
- statistical analysis
- user interface (UI) design
- proofreading   [1]

The advantage of these skills is that they can be easily learned, for example, by attending further educational training, and that one can, therefore, stand out from the crowd.

B. Soft skills in general

In contrast to hard skills, soft skills are rather difficult to learn. Soft skills are more interpersonal than technical, they are like personality traits that one possesses or develops over the course of one's life.

As with technical skills, different soft skills are needed for different tasks.

Examples for such soft skills are as follows:
- communication
- ritical thinking
- daptability
- reativity
- roblem-solving
- rganization
- illingness to learn
- eadership
- ependability
- ork ethic
- eamwork
- ime management
- ecision-making   [1]

C. Soft skills in the technical field

As an engineer, it is substantial to have both hard and soft skills. But since hard skills are typically learned, this paper will only discuss the non-technical strengths that are needed in a technical profession to be able to deal with customers or business partners, for example, or to always keep an overview of one's work and deadlines.

Soft skills that are often needed in the technical field are:
- verbal and non-verbal communication
- stress management and tolerance
- public speaking skills and presentation skills
- negotiation skills
- strategic planning
- time management
- creativity and Innovation
- teamwork and interpersonal skills
- research and analytical skills
- organisation skills

- adaptability
- ethics
- dedication and commitment   [2]

III. SKILLS FOR DIFFERENT TASKS

A. Building the gametable

Before dealing with skills that are necessary for the construction of the table, it is worth mentioning that the biggest difficulties for our team were the differences between the metric and the imperial system. We were not able to buy inch sized pipes, because of that we did not have the right sized material which we needed. In addition, we had problems finding the right measures in the building description. The official Botball Discord server was very helpful at this point. There we found data to print some pieces for the table with a 3D printer.
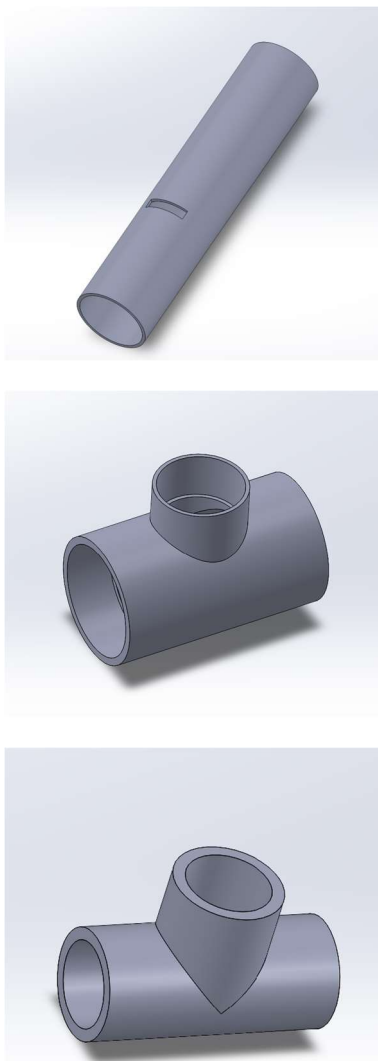
Figure 1: SolidWorks drawings of the parts we previously 3D printed.

In the end, we not only required skills in building the table physically. For most of the problems that arose, we needed skills in math, 3D printing and team playing.

The difficulties with the imperial system were solved fast by copying the part list and changing the measures to the metric system. Thereby we saved a lot of time where we otherwise would have had to calculate each individual measure separately. We first thought our problem would be solved, but after we started building the frame, we quickly noticed that our connectors did not have the right size. So, we had to change all the dimensions during the table build so that everything fit together.

To craft the table, we needed a range of tools which are only / which can only be used by hand, which often led to short pipes or cuts which were not in the right angle. We also had to screw the whole frame onto the table and as our table is already a bit older, we had problems with the screws holding the frame tight. The holes we made in the table often broke and this caused us much trouble and lost time.

To point it out, we learnt how to create something well, even if we did not have the right tools for it. We compensated for this with skills in 3D thinking and a high degree of flexibility

While building the Botball table we could learn the following:

- team management
  - → passing on solutions to other team members in case they would encounter the same problems and sharing it with other team members so they have solutions for issues they could have too
  - → working in pairs and not in too large groups
- searching for information
  - → getting an overview of the construction papers
  - → searching the internet efficiently for measurements and building help.
- crafting the table
  - → using unprecise tools without changing the overall result
  - → using the correct and customized measurements.
- time coordination
  - → identifying what has already been accomplished and what has to be done next.
  - → creating a building plan (timetable).

B. Building the robots

Before we get to the skills needed and learned while building the two robots, we would like to briefly explain difficulties during the construction phase.

Building the robots was a complicated and time-consuming task, as we had to build structurally well-designed and part-saving assemblies. The biggest challenge was that the metal parts did not match the Lego parts, not

even the Lego play lessons from our childhood could help us with that.

In the beginning, we often built unconventional and too complicated constructions of gripping arms, which often used a lot of Lego parts and still did not meet our ideas and requirements.

But soon we had good ideas how to improve our robot constructions and adapt them to our tasks.

Another problem we had to solve was the servos and motors, which become exponentially less accurate with increasing speed and ballast, which played a major role in our design ideas.

Skills we need when building the robots are mainly mechanical. We already have knowledge of mechanics as well as manufacturing technology and machine elements, which we have previously learned in school lessons.

Skills learned during the Botball competition included understanding the proper placement of sensors, motors, and servos, which should work well later. Building the robot in a way that its weight is evenly distributed over its surface and that it is balanced, were also important lessons learned.

C. Programming the robots

One of the most essential hard skills in the Botball competition is programming. The code written must interact with the servos and motors seamlessly and be as accurate as possible when it comes to position finding and gripping arm movement.

- The robots used in the competition are programmed using various programming languages. So, it is important to understand the coding principals such as loops data types and functions. Not being able to apply these principles may result in (may have?) catastrophic consequences such as hardcoding (i.e. the direct interaction with the Kipr Library in the main function, which may lead to an inability to make quick changes).
- We must be able to think through an issue, break it down into smaller components, and write algorithms to solve the problem. This skill is essential for programming the robots to complete various tasks such as navigating through a maze, detecting obstacles, and picking up objects. Examples are the "go to a line" code and the "follow a line code" of every team.
- Debugging is a critical skill in programming, and it is no different in the Botball Competition. We must be able to identify errors in our code and fix them to ensure the robots are working correctly. A large part thereof is the ability to find online solutions quickly and implement them correctly.
- The robots being built for the competition are equipped with various sensors, motors, and other components which are accessed via the library. We, as a team, have to be able to understand the

documentation of the library and use it to interface flawlessly with the various robot components.

On the other hand, we acquired knowledge in the realm of working with imperfect sensors, servos and motors. Motors that do not drive accurately is/was? the most substantial challenge faced by us in the Botball competition. These components can affect the performance of the robots and cause them to behave differently than expected. For example, when programming the robot to drive straight forward without any assistance (line following), it may lean in one direction over time and the direction may not be consistent. To weaken these effects, we learnt to use tactics like driving into the pvc pipes to zero one coordinate and the rotation or to follow a line and do the same.

A skill learnt with much more real-world implementations is understanding the influences of the surroundings and time on a sensor. We observed that over time and in different lighting conditions, values of the analogue sensors change, for example, the given value when it is positioned over black tape. To mitigate this error, we got used to check every sensor's reading before a test run when we were in different rooms or some time had passed.

D. Reading and writing documents and the paper

The hard skill of language proficiency is also an important capability in Botball since our entire team consists of Austrians with German as our native language . Our prior knowledge of the English language comes from school lessons, occasional travels, English-language broadcasts or films or articles from the internet.

Especially the understanding of documents and instructions with longer content, such as the "Game Review", or the writing of documentation and the paper led to difficulties in the beginning.

Throughout the process of Botball, we not only increased our vocabulary, but also improved our ability to read and understand factual content more quickly. Our auditory perception of the English language also improved, for example, when watching videos or the "Virtual Botball Tournament".

Understanding and speaking the English language using special Botball terms will be very important, especially at the competition. But already during the preparations for the contest, we can perceive an increasing familiarity with English, partly technical, terms.

IV. Soft skilles used during Botball

Soft skills are a crucial aspect of Botball. It is a prime example of how soft skills can be used to achieve the desired goals. The following are some of the most important ones during Botball:

A. Communication:

Effective communication is an important soft skill that plays a significant role in Botball.

Our team members had to be able to communicate effectively with one another to design, build and program the robots.

It was necessary to establish clear communication lines to ensure that the team is moving forward with the same

goals in mind. Without this skill, misunderstandings could quickly have led to a waste of valuable time and resources.

B. Self-discipline:

Self-discipline is another essential soft skill for the Botball Competition. Because it requires a high level of commitment, perseverance, and self-discipline to overcome the difficult tasks that we have to compete, it is important to remain focused and motivated to ensure that we meet our targets. With self-discipline, we could work more effectively while producing quality work.

C. Teamwork:

Teamwork is one of the most important soft skills that we needed in Botball. We had to work together as a team to achieve our targets, utilizing each other's unique strengths.

We learned how to communicate and collaborate better and how to foster a productive and positive team dynamic. When we worked in harmony, we achieved our goals more efficiently.

D. Time management:

Equally important to teamwork was time management. Our team tried to schedule the time effectively, ensuring that we could complete each task. Because of our proper time management, we could increase our productivity and it reduced a lot of stress. It helped us to achieve our goals and aspirations in time.

E. Criticism:

During Botball, we learned how important it is to give and receive constructive criticism. We used the constructive criticism as a means of learning and improving, which had really helped us to reach our goals.

V. Experiment

A. How easy or difficult is it to increase or consolidate the interest in robotics and the associated soft skills among young people?

One of the most important soft skills that is required to perform/participate in a competition like Botball is the general interest in robotics. Otherwise, one would not enjoy it. It is crucial to have fun with such projects, otherwise one will not cultivate and sustain one's interest in robotics.

Our team members have always been fascinated by robotics; some are more into coding while some are more into building and planning a robot. But what connects us is the huge interest in robotics. We want to focus on how to get people interested or how to strengthen their interest in robotics and everything that is connected to it.

Since we are a government sponsored team, we fortunately had the opportunity to organize a workshop to encourage young people for robotics and coding. All of the students (58 participants, male and female) had taken a survey before and after. The questions asked could be answered with 1=very true to 5=not true.

During the workshop, the participants had to write code to master tasks.

We noticed that initially dispassionate students started to become more interested in the subject.

On the other hand, students that already had worked or had a huge curiosity in this topic could not wait to start

working on it. After you gave them a quick starting lecture they almost worked on their own and did not want to get "disturbed" by the tutors.] Meanwhile, those who were already curious and experienced in robotics were eager to start working on their own and did not want to be disturbed by the tutors.

The average score for the question "Are you interested in robotics?" was around 2 before the workshop. Afterwards it went up to 1.77.
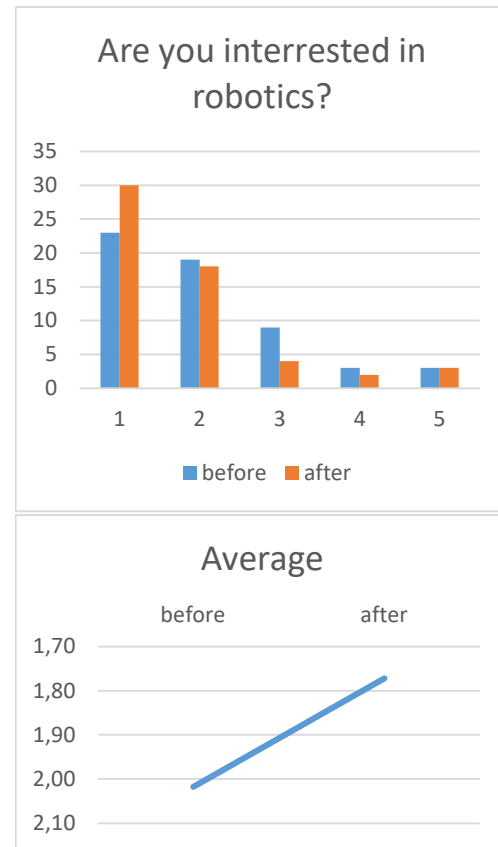

Figure 2: Diagram showing the responses to the question "Are you interested in robotics?" before and after our workshop.

That shows that such little effort pays offs. The youth just must come in contact with this subject to drastically increase interest.

The question "Is it easy for you to understand different robotic parts?" showed another promising trend.
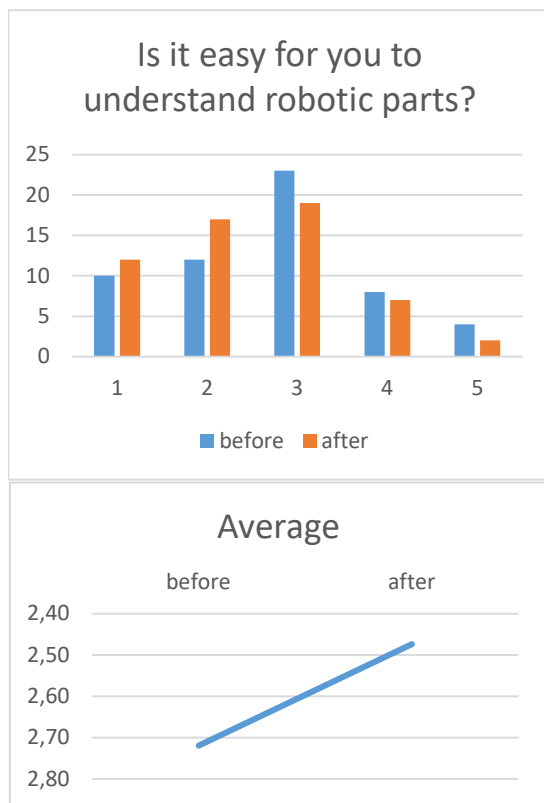

Figure 3: Diagram showing the responses to the question "Is it easy for you to understand robotic parts?" before and after our workshop.

After just two hours of mostly learning on their own, they had greatly increased their ability to understand the different robotic parts by just working with them. It is almost unbelievable how 12 – 14-year-old children can learn on their own.

So, it can be noted that just working and learning on their own in small groups is a very efficient way to increase the interest of young people in robotics and coding.

VI. Conclusion

All the hours we spent working together and the lessons we learned while working with younger students, were the best way to test our limits and ensure successful progress. We can conclude that it is the often so inconspicuous soft skills that play a big role in working together, the most important skill for a good progress is communication.

Often, well-intentioned advice is taken negatively, leading to arguments that are not necessary. Communication, also in the form of criticism and discussion, is the key to all the success we have experienced in the past.

Communication is essential for planning a strategy, building the table and the robots, creating successful documentation and papers, coding as a team, and achieving good competition results.

VII. References

[1] B. Long, Hard Skills vs Soft Skills: Definitions & Examples, https://insightglobal.com/blog/hard-skills-vs-soft-skills/ (Accessed February 18th 2023)

[2] Glassdoor Team, The Most In-Demand Engineering Soft Skills, https://www.glassdoor.com/blog/guide/engineering-soft-skills/ (Accessed February 18th 2023)