A Study of the Botball Kit and Suggestions for Improvement

Alia ElKattan
Hayah International Academy
Cairo, Egypt
aliaelkattan@hotmail.com

***Abstract*— This paper will explore some of the changes that the kit has gone through this year, analyze their effects, and analyze the logistics of obtaining and using a Botball kit. In addition, the paper will provide suggestions on how to improve the Botball kit for 2017 – or later – through both logistical changes and suggested kit parts. The parts are explained both descriptively and through the use of digital 3D models, in addition to their application and usefulness being provided in the paper.**

Keywords—robotics; botball; kit; LEGO; Wallaby

I. INTRODUCTION

The Botball Robotics competition's kit has seen many changes over the years, including changes in the controllers, in the Lego parts, and in plastic and metal parts. As the competition evolves, develops, and spreads into more regions and a wider audience, it is essential for the kit to keep evolving along the way. The 2016 Botball Kit has seen the greatest number of changes in recent years of Botball. It introduced a new controller, the Wallaby, instead of the KIPR Link/CBC 2.0, and the new Create 2 – the newer version of iRobot's programmable robot. The Wallaby came with a different structure, a new software – the online-based KISS IDE replacement – and a removable battery. Changes in the kit did not stop at the robotics controllers, as many changes were present in the remaining kit parts. These included minor – yet significant – changes such as adding the Botball™ logo on cameras and servos, and major changes such as introducing the Omni-wheels, their metal base, and new metal parts to suit the new Create. While these changes were mainly positive, they did come with their disadvantages, thus leaving room for improvement in future Botball kits.

An important aspect of the development of the kit is, undoubtedly, the materials offered in the kit itself. What is often being failed to mention, however, is the logistical aspect to the Botball kit. The kit might be great aid to students in building their pair of autonomous robots, but it also represents a great challenge for teams which are either unable to obtain the kit due to its pricing, or are unable to replace damaged or dysfunctional kit parts – including controllers, batteries, and chargers – till the day of the competition, which places them at a great disadvantage to other teams which have not faced the same obstacles.

II. AVAILABILITY AND ACCESSIBILITY

A. Availability

The availability of the Botball kit represents a major obstacle to many teams, especially with Botball quickly expanding to currently include 321 teams across 16 regional competitions in four continents: North America, Asia, Europe, and Africa [1]. With such wide geographical diversity, the kit becomes less accessible to more people. The Botball Store/KIPR Shop, which previously represented a user-friendly way for teams to obtain the kit, is no longer updated to include the newest kit parts, thus leaving no easy way for international teams to quickly order the parts needed. A simple way to ease the process would be to update the store yearly, with access to international shipping.

B. Accessibility

A major problem with the Botball kit is its limited availability, but even when it is possible for a team to obtain a kit, it might not be accessible, as a result of its lack of affordability. As Botball expands into new regions, it is important to take into consideration the price barrier that may prove to be a difficulty for many teams. Funding for the kits may occur through obtaining sponsors for the competition, as in the case with Botball Qatar, which fully paid for registration and participation of teams, or through teams self-funding and fundraising. In the case of the teams being required to pay for their kits, as in most regional tournaments, the school may volunteer to do so. If not possible, team members can either pay for the kit fees themselves, or raise money through fundraising and sponsorship proposals. The Botball website includes a guide to funding registration and kit fees, which can be accessed through (http://www.botball.org/get-started#fundraising)[2]. Through observations of Botball experiences throughout the years, it has been concluded that it is recommended to go through all possible paths, rather than rely on a single one. Botball, while being a robotics competition, is also about teaching students the skills and lessons that would help them outside the field, and raising

money to reach a certain target is a beneficial experience, though it being exhausting. For teams going through the longer route, it is always important to make sure that the source(s) of funding, whether they are a school or institution, an NGO, or a company, are well aware of the benefits of Botball and are updated of the team's accomplishments and experiences.

III. Changes In The 2016 Kit

A. *Wallaby*

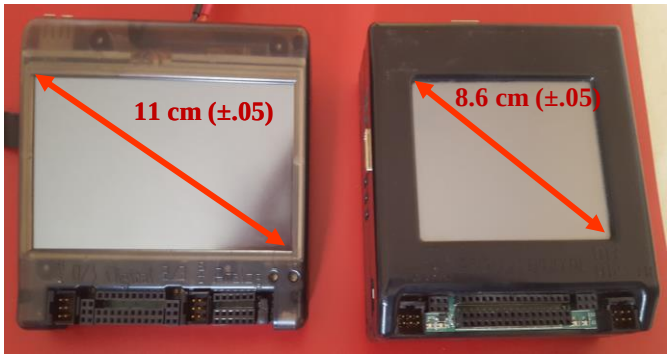

Fig. 1. New Wallaby (left) and old KIPR Link (right)

The most notable change in the new kit has been the Wallaby, introducing a wireless system that replaced the KIPR Link's, which depended on connecting the Link to a laptop with the KISS IDE through a micro-USB connection. The Wallaby is a great improvement from the KIPR Link, as it offers a slimmer, lighter body that takes up less space than the Link. In addition, it is programmable through any device with a Wi-Fi connection, rather than just computers with pre-installed KISS. The Wallaby happens to be much lighter than the KIPR Link. As a matter of fact, it weighs just **195.1 grams**, while the heavier Link weighs **337.9 grams** (with an uncertainty of ±0.1 grams in both calculations).* This means that the newer controller is in fact only 57.7% the mass of the previous controller (the Link being 1.7*x* the mass of the Wallaby). While that is all supposed to simplify the controller and make it more user-friendly and practical in the building, the Wallaby does not come without its disadvantages. While it hosts a slimmer body (fig. 2), it does require an external battery, which actually makes attaching the controller on to the robot build, ironically, less convenient.

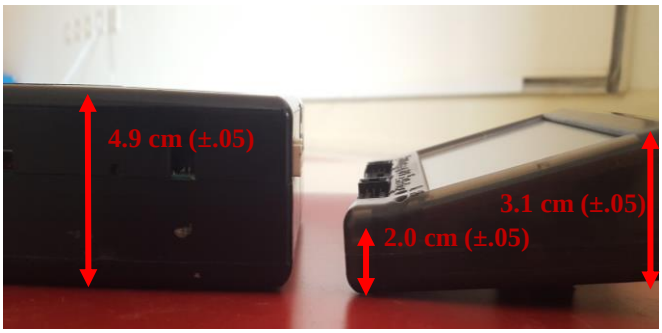

Fig. 2. Wallaby (left) and Link (right)

In addition, wireless programming makes it possible to program from several devices and avoids the hassle of wires and connectors, yet makes saving programs less convenient. With a wireless system, there is no way to directly save the programs on the computer, and they are saved on the Wallaby instead. Not only does this mean that all programs must be periodically backed up on a separate document, but that it is a greater challenge to work on coding when not connected to the Wallaby.

B. *Omni-wheels*

Fig. 3. Omni-wheel [3]

Fig. 4. Wallaby Base for Omni-wheels [4]

The Omni-wheels came as a major improvement in the kit, as it gave Botball students an unprecedented advantage, providing robots with the ability to move sideways and rotate in a way that had not been possible using the regular drive motors. Since the Omni-wheels are often used as three wheels together, the Botball kit adjusted to that, providing a new metal base for the wallaby which has three motor mounts, placed conveniently for the Omni-wheels. This represented a positive example of how a change in the kit was accompanied by changes in kit parts which would suit it, which is what this paper introduces for the Wallaby as well.

IV. Adding Existing Parts to the Kit

As stated in the previous section, the Botball kit still has room for improvement, despite its continuous evolvement. In the coming sections, suggestions for improvement are provided, including ways to overcome the disadvantages that arose with the changes in the 2016 kit.

A. *Ball-Bearing Strips*

An obstacle that often faces Botball students during building and testing robots is friction. The Botball board is one with a rough surface, which further increases the static and dynamic friction between the robot and the board. An example of a robot that would face this issue is a simple demo bot with two LEGO sides attached on the front, designed to contain the poms or other materials on the board. Such robots, as seen in Figure 5, have effectors which have direct contact with the board.

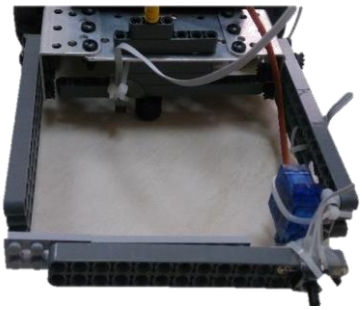

Fig. 5. Robot which would need the strips

Increased friction increases the resistant force opposite to the robot's direction of motion, which often slows the robot down and interferes with its course. A simple solution to overcome that is to add a small LEGO part underneath the structure in contact with the board (such as an axle joiner or bush). By doing so, it decreases the surface area in contact with the board, thus decreasing the fiction and greatly reducing the issues arising from it.

Still, this makes it more difficult to swipe objects from the board's surface, uses up parts for a function they were not designed for, and often ruins the part from the increased contact and pressure on it. A suggested solution to overcome that is to include 'ball-bearing strips' in the kit, or allow teams to separately buy them at their own expense. These strips, illustrated in Figure 6, are very thin strips with openings throughout that include small metal balls similar to that in the caster included in the Botball kit. These, however, are much smaller, which means that when the strip is added to the bottom of the robotic structure, it does not take up a lot of space, while making the robot's movement a lot smoother. The sample part in Figure 6 is the 'Vestil Ball-S30 Ball Transfer Strip with Chrome finish' which could be bought from Amazon.com. However, it is only a way to visualize what the item looks like, but the part used in Botball would be thinner and shorter to fit the LEGO parts used in the kit.

Fig. 6. Ball-bearing strips [5]

The disadvantage of the ball-bearing strips would be their need to be lubricated to reduce friction and enable them to function well, yet their advantages outweigh that minor detail. In addition, a modified ball-bearing strip for Botball would require additional parts, and might therefore require revision of other parts which could be excluded, or would make purchasing the kit a greater burden. [6]

B. Mini-servo bracket

The Botball kit comes with four servo brackets, designed to fit four out of the five servos provided in the kit. That does not represent a problem, however, since it is usually possible to figure a way to attach the fifth servo without its bracket. What does represent a challenge, however, is attaching the mini-servos. While it is also possible to attach mini servos to the available kit parts directly, it would definitely make it easier if a small bracket fit for the mini-servo was provided with the kit. This part would be just like the regular bracket provided in the kit, but smaller to fit the mini-servo, and with smaller holes to fit a small-sized screw that would go through the smaller holes in the mini-servo's body (fig. 7).

The sample servo bracket in figure 7 is the 'Lynx motion Aluminum Servo Bracket ASB-01', and can be bought in pairs of two from RobotShop.com, with product code RB-Lyn-78.

Fig. 7. Mini-servo brackets [7]

V. New Designs

A. Wallaby Metal Base

One of the problems the new Wallaby presents is its external battery, which interferes with the building of the robot. Previously, with the Link, all that was needed to add the controller was to attach it on to the metal base. With an external battery, this simple process becomes more problematic, as teams now need to build a customized base for the Wallaby (fig. 8) that takes into consideration the presence of the battery. While that is a simple task which could be easily accomplished, it still takes up additional unnecessary time and causes teams to use up kit parts that could have been used elsewhere, thus decreasing the benefit derived from the quantity of lego parts provided.

Fig. 8. Demo bot [8]

This could be avoided with a simple solution, which is to alter the design for the metal base in order for it to take into account the battery.

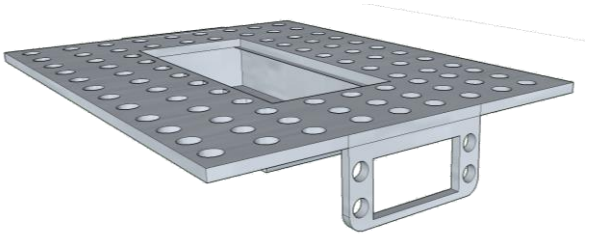

Fig. 9. New suggested metal base

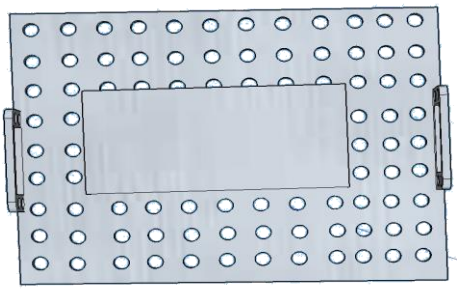

Fig. 10. View of suggested metal part from the bottom

This part would replace the already existing metal base for the wallaby, as it would now be unnecessary.

B. Wallaby Vertical Base

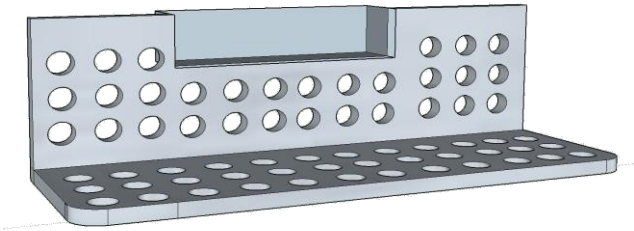

Fig. 11. Base for standing Wallaby

From several years of participating in Botball, our team observed that many teams actually prefer to place the Wallaby standing vertically, which takes up less horizontal space in the robot's build. To accommodate for that as well, the suggested kit part in figure 11 is designed so that the Wallaby would be standing vertically, it's back attached to the vertical side, and its side standing on the base's surface, which can be screwed/attached on to the robot.

C. Sideways LEGO Connector/Axle Joiner

Another suggested kit part for the 2016 Botball set is a connector that would serve to connect two LEGO ("liftarm") parts located horizontally beside each other, as in fig. 11.

Fig. 12. Sideways LEGO Connector

This will differ from any available way to connect the LEGO pieces together, it being an easy, effective way to attach the parts together without taking up too much space. Other parts that could connect the "Liftarms" in this way often only connect the first hole of both parts, which still allows the parts to rotate. Examples of such connectors are the two axle joiners in figures 13 and 14.

Fig. 13. Axle joiner (part #48989) [9]

Fig. 14. Axle joiner (part #32138)

In addition to the fact that these parts allow the liftarm parts to rotate, they also take up space on the top, which becomes unnecessary if a team is not trying to connect parts on both sides of the axle joiners. In the case where the team is trying to connect the 'Liftarm' parts from the bottom (near the surface of the board), the space taken up by the other unused side of the axle joiners becomes especially unnecessary. For that reason, the connector's top (or bottom, depending on placement) would be very thin, as can be seen in fig. 15.

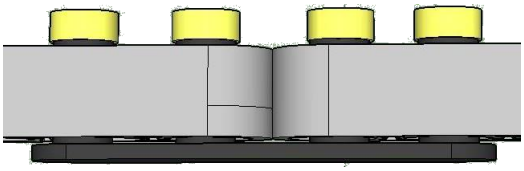

Fig. 15. Side-view of connector

While this part is made up of four small axles all connected side-ways at one end, an alternative part (Fig. 16) would be to have the axles going into the holes in the liftarm LEGO part be like those in the axle joiner, so that the part would not need bushes to close it from the other side, and would not fall off even if placed on its own. Just like this suggested kit part would have many advantages, it is important to consider disadvantages when proposing new kit parts. For example, since the kit part might need to be self-produced, it could raise costs of the kit which might represent further problems for teams.

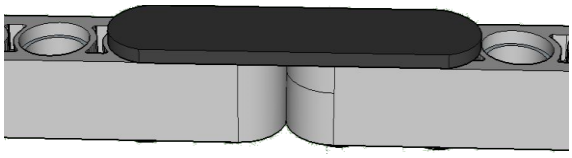

Fig. 16. Proposed axle joiner

VI. Conclusion

The Botball kit is a very important aspect of the competition and the educational experience, and thus it is of utmost significance to constantly pay attention to updating the kit and ensuring the largest number of teams possible are able to access and afford it. On the logistical side, it will benefit many teams to frequently update the Botball store so that it would provide all kit parts, and enhance accessibility of kit parts through the availability of international shipping. It is also important for teams to keep up to date with ways to fund Botball registration through the guidance provided by KIPR, and through each team's independent efforts.

While the Botball kit is one of the best robotics kits, it does require constant updating and evolvement to suit the needs of Botball students. Some updates that could be present in the Botball 2017 kit include adding new metal bases for the Wallaby to take into account its external batteries, as have been done with a new metal base for the Omni-wheels. It would also be beneficial to provide the kit with brackets for the mini-servos, more effective and convenient connectors for the LEGO parts.

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Note: all 3D designs were made using SketchUp Make 2016.

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