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Improvement Proposals in Student Projects for Prototype Technical Documentation

Laslo Gogolak, Igor Fuerstner
Subotica Tech – College of Applied Sciences, Subotica, Serbia
Subotica Tech – College of Applied Sciences, Subotica, Serbia
gogolak@vts.su.ac.rs, ifurst@vts.su.ac.rs

***Abstract*— Experience shows that technical documentation prepared by students usually does not satisfy the requirements needed to build a product prototype or an actual product, which is ready to be tested and used afterwards. Therefore, despite the fact that the evaluated student project tasks are often graded as excellent ones, and sometimes also rewarded, they have to be reexamined thoroughly and adjusted significantly before they are ready to be used. The paper presents the necessary adjustments that were performed on the technical documentation, which deals with the mechanics of one specific developed product. The developed product, which represents a winning student project, was a mechatronic device that was suitable for exhibition purposes. The product was developed in the context of the competition organized by a company, which produces DC motors and corresponding components. In the paper the modification process is presented, starting with the presentation and analysis of the winning project, followed by the description of performed modifications regarding the technical documentation.**

Keywords— exhibition device; mechatronics; product development;

I. INTRODUCTION

Exhibiting at tech fairs allows the interaction with potential customers, but it also is a great possibility for innovation and actual research results presentation [1][2]. Companies need to arrange their stands creatively to be eye-catching since all their competitors are also present at the fairs. A cleverly and creatively set up stand grabs the attention of visitors. Companies should think of ways to help open conversations with visitors such as a theme or a show promotion. These solutions do not add much to their budget, but they pose a highly effective way of marketing [3]. As it was mentioned above, creativeness is of key importance. Stands do not have to be huge and contain too much text and visual effects; all these need to be chosen carefully to strengthen the image that the company wants to create. In many cases a smaller stand can be more effective and attractive than a huge one. Therefore, a huge budget is not necessary for arranging a successful stand [4].

One of the leading companies in the field of advanced motion solutions and automation, Dunkermotoren GmbH, organized a competition for the students of Subotica Tech in the academic year 2013/2014. The main reason for organizing such a contest is that exhibiting is a popular and useful form of presentation for companies in the field of industrial automation technology. The end result of the contest was to be a developed mechatronic device that was suitable for exhibition purposes. Apart from this, there are other reasons for a company to organize a competition for students, as well. By doing so, students can become familiar with the products produced by the companies. Companies can also benefit by identifying talented students who can be possibly employed by them in the future. Also, this activity can be recognized as a way of linking education and practice.

During the contest, students developed their mechatronic devices based only on the defined general requirements by the company, while the specific requirements had to be defined without active involvement of the company [5]. The contest was finished resulting in six successfully completed projects. One project was chosen as an overall winner [6].

Based on the experience of the authors, it can be shown that technical documentation prepared by students usually does not satisfy the requirements needed to build an actual product or a prototype, which could be tested and used afterwards. Therefore, despite the fact that the evaluated student project was rewarded as the most successful one, it had to be reexamined thoroughly and adjusted significantly before it could be used. There are several reasons for this, such as: lack of time on the students' side, because students have other projects and obligations to finish before their exams start, lack of time on the teaching staff's side, because they usually have to deal with a great number of courses, projects and students, inability to engage the students for longer periods of time, e.g. more than one semester, inadequate knowledge and expertise of the students, etc.

The paper presents the necessary adjustments that were performed on the technical documentation, which deals with the mechanics of the developed device. The paper does not deal with the electronics and informatics part of the documentation.

The remainder of the paper is structured as follows. In the second chapter, a description and analysis of the winning student project is presented, starting with the detailed functional analysis. In the subsequent chapter, the modification process is presented, followed by the presentation of the modified design. Final comments are given in conclusions.

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II. WINNING STUDENT PROJECT

A. Project presentation

The overall winning project is presented in Fig. 1 [5]. The developed device is supposed to work in fully automated mode without interruptions or in a semi-automated mode allowing the visitor to interact with it. To the visitor who visits the exhibition booth, it presents a possibility to win a ball, which is a promotional material with the company's logo.

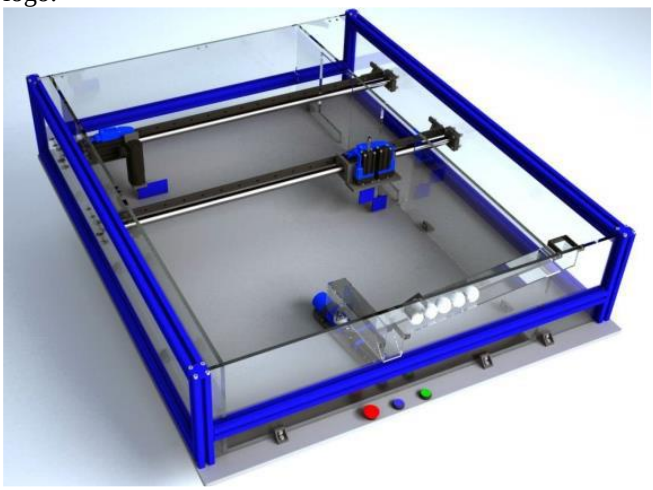

Fig. 1. Winning project

The developed device has a flat surface, which is tilted from the horizontal position like a pin-ball table. It has a launcher mechanism, which can swing left and right and is able to shoot out the ball when the visitor presses the "Fire" button. The visitor wins the ball if the ball reaches the opposite end of the device. Two moving subassemblies, which are moving from left to right (the movements are both linear and rotational), represent the obstacles, which try to stop the ball reaching the opposite end of the device. The balls are supposed to be fed automatically into the launcher mechanism.

B. Project analysis

In order to be able to analyze the presented project, a thorough functional analysis was required [7][8][9][10]. Based on the defined general requirements by the company [5], the performed analysis yielded the functional requirements, which are presented in Fig. 8.

The results of the performed analysis are summarized in TABLE I. Functional requirements that were not satisfied at all are shaded; functional requirements, which deal with the mechanics of the developed device that were not satisfied at all are shaded and italicized; functional requirements that were partially satisfied are underlined; functional requirements, which deal with the mechanics of the developed device that were partially satisfied are underlined and italicized. Based on the analysis of the project, it can be concluded that most of them are partially satisfied. However, there are numerous requirements that were not satisfied at all, such as security measures, dimensional restrictions, guidance and embedding, easy maintenance, etc.

TABLE I. SUMMARY OF PROJECT ANALYSIS

Functional requirement	Result of the analysis
Ensure attracting the attention of visitors	Satisfied
Provide easy handling (by the visitor)	*Partially satisfied* – The presented solution solved the easy shootout of the ball, but did not solve the final delivery of the ball to the visitor
Include appropriate security measures	*Not satisfied* – The presented solution potentially poses an injury risk because the structure is open
Provide full functionality (according to the suggested solution)	*Partially satisfied* – The presented solution provides the basic functionality, but is not adequate for not adequate for intensive exploitation
Set the maximum width and length, taking into account the dimensions of the plate	*Not satisfied* – The presented solution's dimensions are not adequate
Set the height, taking into account the average height of a human	Satisfied
Enable multiple assembly and disassembly of all parts	*Partially satisfied* – All joints can be disassembled, but some of the joints include plastic parts
Minimize the use of machined parts	*Partially satisfied* – There are more nonstandard parts then necessary
Provide appropriate guidance and embedding	*Not satisfied* – The presented solution does not deal with some of the required guidance and embedding
Provide necessary technical documentation	*Partially satisfied* – The technical documentation is not finished in all details
Provide easy maintenance	*Not satisfied* – The presented solution does not solve adequately the storage of the balls neither before nor after they are used
Embed Dunkermotoren brushless DC-motors	*Partially satisfied* – The presented solution embed the required motors, but also embed motors from another producer
Embed Dunkermotoren linear motors and actuators - series ST	Satisfied
Embed Omron controller - NJ series	Partially satisfied – This requirement is not included in this paper because it does not deal with the mechanics of the developed device
Provide control with support of EtherCAT communication technology	Partially satisfied – This requirement is not included in this paper because it does not deal with the mechanics of the developed device
Provide power supply	Partially satisfied – This requirement is not included in this paper because it does not deal with the mechanics of the developed device
Maximize speed (by taking into account the characteristics of the drives)	*Partially satisfied* – The technical solution is not robust enough
Maximize acceleration (by taking into account the characteristics of the drives	*Partially satisfied* – The technical solution is not robust enough
Maximize the parallel motion of the drives	Satisfied - This requirement is not included in this paper because it does not deal with the mechanics of the developed device

Functional requirement	Result of the analysis
Maximize the interdependence between the drives	Satisfied - This requirement is not included in this paper because it does not deal with the mechanics of the developed device
Maximize the visibility of embedded Dunkermotoren and Omron products	*Partially satisfied* – The presented solution ensures the visibility of most of the embedded products
Minimize the visibility of auxiliary parts	Satisfied
Minimize the cost of the device (allowed cost excluding the costs for the rives and the controller is 7000€)	Satisfied

After functional analysis, the mechanic structure of the developed device was analyzed. The results of the analysis are presented in Fig. 2.

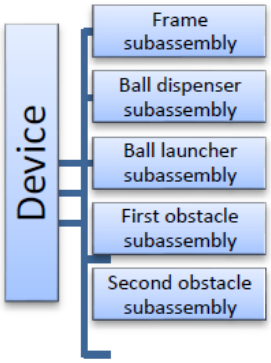

Fig. 2. Mechanic structure of the developed device by students

Based on previous analyses it can be concluded that considerable modifications were required to be able to obtain the appropriate documentation that enables the prototyping of the device.

III. MODIFICATION PROCESS

A. Modified mechanic structure of the device

According to defined functional requirements, the mechanic structure of the device was modified. The modified mechanic structure is presented in Fig. 3.

The frame subassembly was divided into three subassemblies. By this, the structure is modified so as to be able to store the disused balls and to be able to deliver the ball just won ball to the visitor, thus allowing for easier handling. Also, this modification facilitated the maintenance of the system. The ball dispenser subassembly was divided into two separate subassemblies, the ball feeder subassembly and the ball launcher subassembly. By this, the number of balls that could be loaded into the device increased considerably. Also, the embedded motor from another producer was left out, while a linear ST series motor was introduced. This modification facilitated maintenance, as well. Through these modifications it was ensured that only motors from Dunkermotoren GmbH were used [11][12].

All moving elements were redesigned in order to be guided. The dimensions of the device were adjusted to comply with the plate provided by Dunkermotoren GmbH. the plate was incorporated into the design. This enabled the use of Dunkermotoren's standardized protective barrier, which was used for exhibition purposes. By this, the security measures were satisfied. The whole frame subassembly was rearranged by using different profiles and different profile connections. This increased the overall strength and stability of the construction. All joints were redesigned, which allowed the possibility of multiple assembling and disassembling. Also, the use of standard parts was increased, and the number of parts suppliers was reduced to one supplier of frames and auxiliary components [13], one supplier of fastener elements [14], one supplier of couplings [15], one supplier of rotational bearings [16] and one supplier of linear bearings [17].

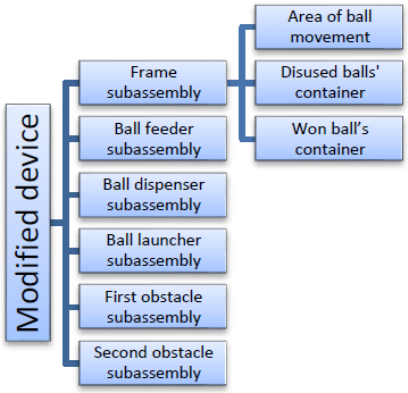

Fig. 3. Mechanic structure of the modified device

By this, the functional requirements were satisfied almost entirely. The results of the analysis of the modified project are summarized in TABLE II. Functional requirements that were not considered in this paper were omitted.

TABLE II. SUMMARY OF MODIFIED PROJECT ANALYSIS

Functional requirement	Result of the analysis
Ensure attracting the attention of visitors	Satisfied
Provide easy handling (by the visitor)	Satisfied
Include appropriate security measures	Satisfied
Provide full functionality (according to the suggested solution)	Satisfied
Set the maximum width and length, taking into account the dimensions of the plate	Satisfied
Set the height, taking into account the average height of a human	Satisfied
Enable multiple assembly and disassembly of all parts	Satisfied
Minimize the use of machined parts	Satisfied
Provide appropriate guidance and embedding	Satisfied
Provide necessary technical documentation	Satisfied
Provide easy maintenance	Satisfied
Embed Dunkermotoren brushless DC-motors	Satisfied
Embed Dunkermotoren linear motors and actuators - series ST	Satisfied
Maximize speed (by taking into account the characteristics of the drives)	Satisfied

Functional requirement	Result of the analysis
Maximize acceleration (by taking into account the characteristics of the drives	Satisfied
Maximize the visibility of embedded Dunkermotoren and Omron products	*Partially satisfied* – The presented solution ensures the visibility of most of the embedded products
Minimize the visibility of auxiliary parts	Satisfied
Minimize the cost of the device (allowed cost excluding the costs for the rives and the controller is 7000€)	Satisfied

B. Presentation of the modified device

The modified device, i.e. the mechanic structure of the modified device is presented in Fig. 4. The frame subassembly, which contains the area for ball movement and two containers, is presented in Fig. 5. The ball feeder subassembly is presented in Fig. 6, while the ball dispenser subassembly is presented in Fig. 7.

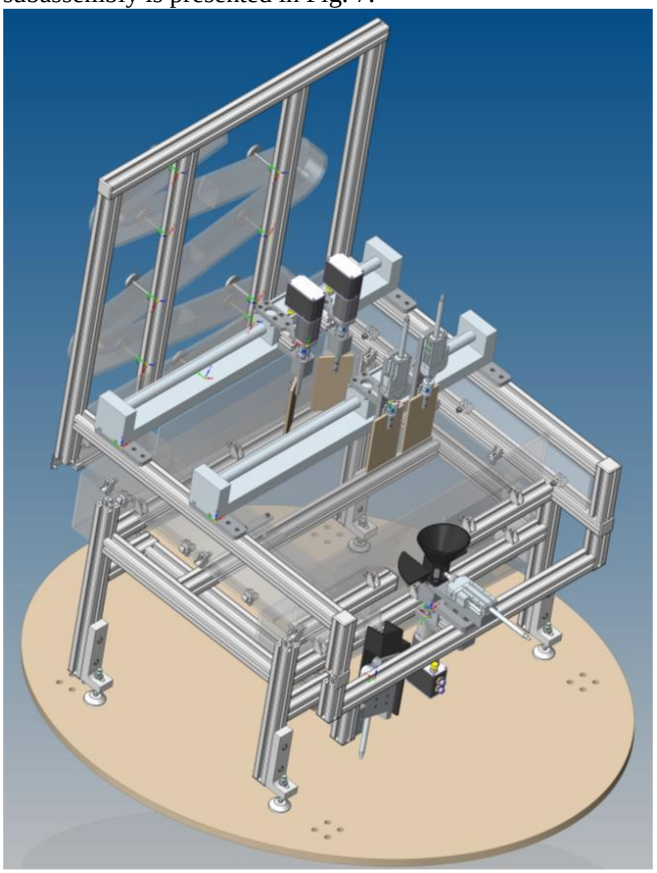

Fig. 4. Mechanic structure of the modified device

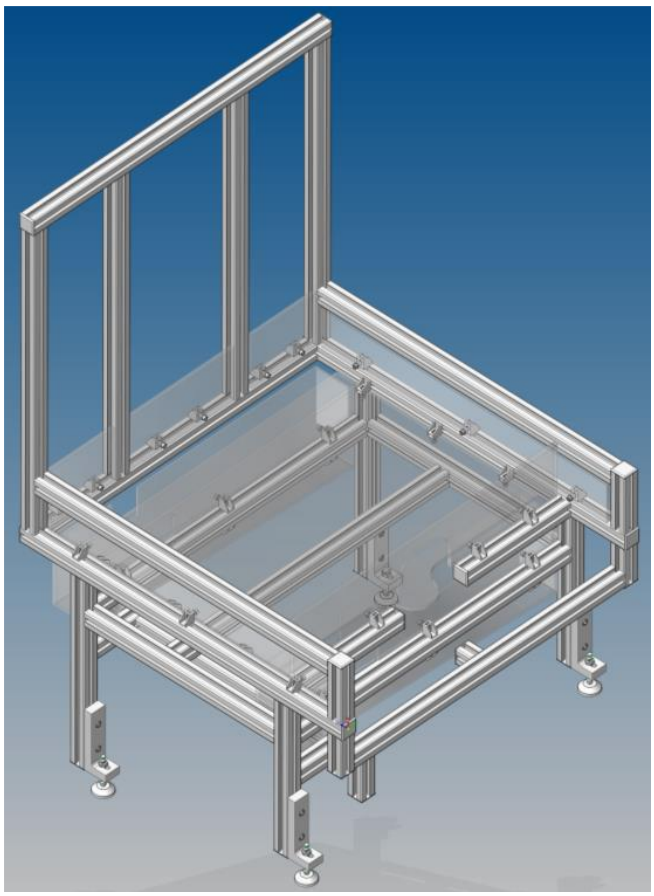

Fig. 5. Frame subassembly

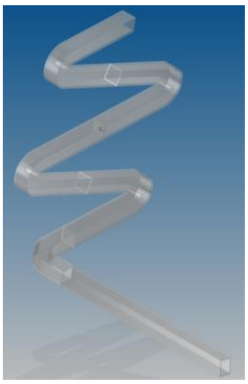

Fig. 6. Feeder subassembly

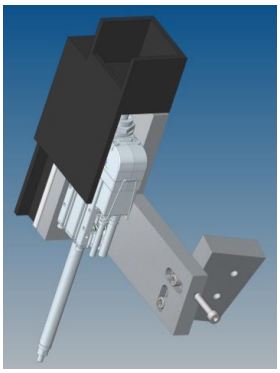

Fig. 7. Ball dispenser subassembly

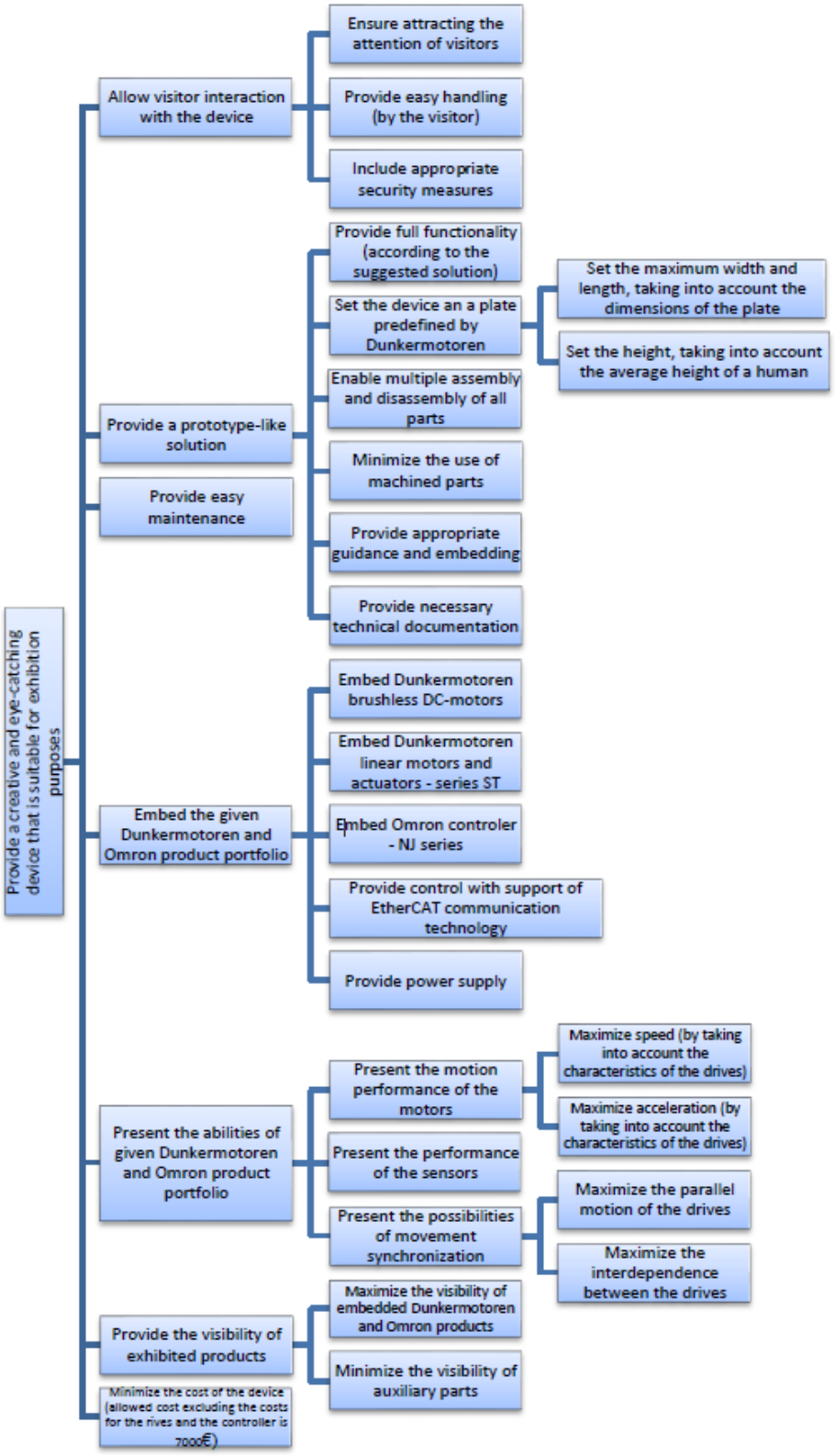

Fig. 8. Functional requirements

The ball launcher subassembly is presented in Fig. 9.

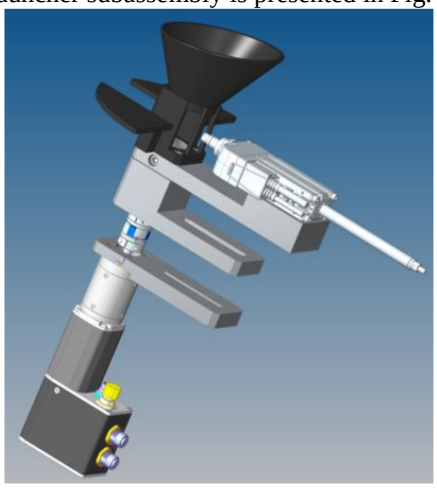

Fig. 9. Ball launcher subassembly

The first and the second obstacle subassemblies are presented in Fig. 10.

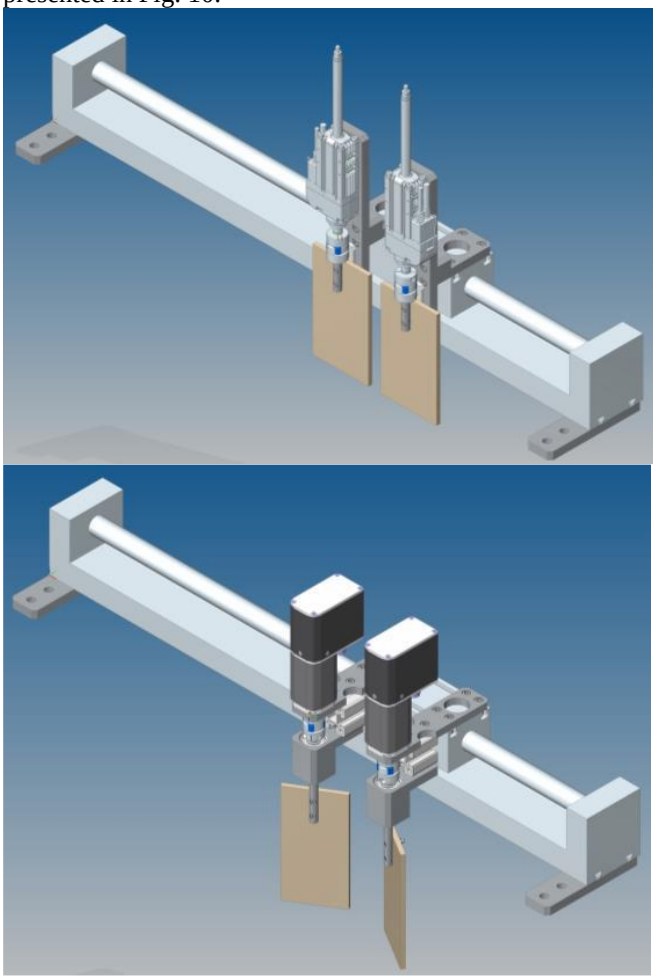

Fig. 10. First obstacle subassembly

IV. CONCLUSIONS

The paper presented the necessary adjustments that were performed on a specific student project to make the technical documentation prepared by the students suitable for producing a real product prototype. The project represented the winning project of a student contest, which had to result in a developed mechatronic device that was suitable for exhibition purposes.

In the framework of this paper, the emphasis was placed on the mechanics of the device, while problems related to electronics and informatics were not considered and dealt with.

The results of the performed analysis of the function and of the structure of the developed device showed that the prepared technical documentation had to be modified significantly to meet the requirements.

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