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Classroom Interior Design: Wooden Furniture Prototype with Feedback from Students and Teachers

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Abstract: Studies indicate that natural wooden materials positively affect students' well-being in classrooms. In addition, students spend a considerable amount of their time in classrooms predominantly seated, making school interiors a suitable place to reduce sedentary behaviors of children. A mixed team of experts in human factors, architecture, design and engineering designed a prototype wooden standing desk for indoor use and formed focus groups with students and teachers to gather feedback on the development process and to evaluate the suitability of the prototype. The prototype desk was well received by the primary school teachers and students. The students appreciated plywood as the main material for the construction of the desk; however, they criticized that the wooden tabletop should be more resistant. The height adjustability of the desk and the tiltable tabletop were the most appreciated features of the prototype. Further studies should be conducted to investigate the optimal material, shape and color of the school desk, especially the tabletop, and additional efforts should be made to design furniture that promotes a less sedentary classroom and improves students' well-being at school.

Keywords: biophilic design; wooden school desk; wood products design; classroom interior; well-being

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1. Introduction

A wooden interior can have a positive effect on people's psychophysical state and cognitive abilities, as well as their sense of comfort and well-being indoors [1]. Studies have shown that the inclusion of wood elements in interior design may improve both satisfaction and the cognitive performance of office workers [2,3]. Similar to office workers in offices, students also spend considerable time in schools. Therefore, the design of school interiors is an important feature that can influence the well-being of students in schools.

There are several good examples of the use of wood in the interior design of schools [4]. Classrooms equipped with wooden floors, ceilings, cabinets and wall panels have been shown to decrease students' heart rates and the perceived stress of interacting with teachers. In contrast, in traditional classrooms with linoleum floors, plasterboard walls and chipboard cupboards, students' heart rates increased and their perceived stress levels did not change over the course of the school year [5]. Furthermore, in classrooms with wooden furnishings, the morning stress peak (measured by the change in heart rate) subsided after arrival at school and did not rise again, whereas in the traditional classrooms a slight stress level persisted in the students throughout the day [6]. Implementation of natural wood elements in the classrooms is also supported by the fact that students who showed a higher level of connection to nature were more innovative and holistic in their thinking [7].

School furniture is an important part of the interior design of classrooms. When designing school furniture, especially school desks, the choice of material is important as students are in constant contact with the seat and tabletop. The literature shows that

contact with natural wood has a positive effect on physiological indicators and human well-being compared to that with plastic [8]. Among the different types of wood, contact (e.g., over 90 s) with untreated wood increased the activity of the parasympathetic nervous system compared to contact with varnished wood [9]. A lower stress level was also found in office workers who worked in an office made of oak wood [10].

When designing school furniture, ergonomic and biophilic principles should be taken into account in order to achieve positive physical and psychological effects on students' health. Furthermore, due to the already known harmful effects of prolonged sedentary behaviors [11], school furniture should allow for more dynamic use and encourage students to move. Standing desks can reduce sedentary behaviors of students in schools [12–14], can increase students' energy expenditure [15] and can be effective in combating obesity in children and adolescents [16]. In addition, the use of standing desks in the classroom appears to be feasible and not detrimental to learning [14].

Studies presenting the school furniture design process are scarce [17–21]. None of these studies describe a design protocol for standing desks (all studies focus on standard seated school furniture design). Furthermore, no study was found that investigated the suitability of a wooden standing desk for schools. Despite the potential positive effects of wooden standing desks in classrooms, their long-term adoption and use remains a challenge. One of the possible reasons for this could be the unsuitable design of the school furniture [22]. With our study, we aim to combine all these aspects: the positive impact of wooden interiors and contact with wood, adjustability of school furniture to minimize the student-furniture mismatch and the positive effects of using standing desks on students' health in the classroom. The novelty of our work is therefore the comprehensive multidisciplinary research that covers different areas, including ergonomics, material suitability, construction and health.

The aim of this study was two-fold. In the first phase, we designed and constructed a prototype of a wooden standing desk. In the second phase, we conducted focus groups with students and teachers to gather user feedback on the development process, and to discuss the advantages and disadvantages of the prototype and the suitability of wood as a furniture material.

2. Materials and Methods

2.1. Design Process of the Prototype Construction

With the aim of designing a wooden standing school desk prototype, we assembled a diverse team of experts, including three specialists in human factors, one in architecture, one in engineering, and another in design. Our initial phase involved a review of the scientific literature, in which we analyzed the use of wood in the construction of school furniture and school desk characteristics proven to effectively reduce discomfort and pain among students. Additionally, we examined the school furniture designs published in the scientific literature.

In order to apply ergonomic principles, it is necessary to know the potential body dimensions of students. Adhering to the ergonomic criteria outlined in the standard (EN 1729:2016 [23]), the height of the standing desk is determined by the standing elbow height plus shoe allowance. We conducted additional measurements of Slovenian students' elbow height to investigate if there are discrepancies between the measured elbow height standing of students and measure stated in the standard. The measurement protocol can be found elsewhere [24].

Based on the literature review and conducted measurements, we designed a prototype of a wooden standing school desk. We started with sketches of standing desks and manufactured three different prototypes, presented in Section 3.

2.2. Focus Groups

We conducted two focus groups, one with students and one with teachers. We adhered to the latest revision of the Declaration of Helsinki and received approval from the National

Medical Ethics Committee of Slovenia (approval number 0120-631/2017/2). No financial or other compensations were provided to participants.

We used the convenience sampling method, and a total of nine students and seven teachers actively participated in the focus groups (Table 1). Participants were approached in person. Focus group sessions were held at our research institute, with each session lasting approximately 60 min. Before commencing the discussions, the moderator (N.P.L.) emphasized that every opinion, whether positive or negative, was considered valuable information.

Table 1. Participants' characteristics.

	Students	**Teachers**
n (total)	9 (6 female)	7 (7 female)
n (primary school)	3	3
n (secondary school)	3	3
n (university)	3	1
Age (avg ± sd)	20.2 ± 8.1	44.1 ± 10.1

n = number; avg = average; sd = standard deviation.

Questions posed during the focus groups were organized into five categories (see Table 2) to facilitate the focus group process. Both focus groups started with a presentation of the prototype desk by the moderator. During this presentation, the moderator talked about the purpose of the prototype and provided an overview of its features, such as material, height adjustability, tiltable tabletop and dimensions.

Table 2. Questions for focus groups.

	Students	**Teachers**
Opening question	Could you, please, shortly introduce yourself to the others (name, age, school)?	Could you, please, shortly introduce yourself to the others (name, age, school)?
Introductory question	What were your first thoughts when I presented the prototype of the wooden standing desk?	What were your first thoughts when I presented the prototype of the wooden standing desk?
Transitional question	Why would you like the idea of standing in class instead of just sitting?	Would you be willing to accept the challenge and use this standing desk in your classroom?
Key question	Do you like the material and the shape of the prototype standing desk? Where do you see the biggest advantages and drawbacks regarding the material of the desk? Where do you see the biggest advantages and drawbacks regarding the idea of standing instead of sitting? In which subjects would you like to use this standing desk?	Do you like the material and the shape of the prototype standing desk? Where do you see the biggest advantages and drawbacks regarding the material of the desk? Where do you see the biggest advantages and drawbacks regarding the idea of standing instead of sitting?
Ending question	Thank you for all your thoughts and comments. Is there anything that you would like to add, do you have any final thoughts that you would like to share with us?	Thank you for all your thoughts and comments. Is there anything that you would like to add, do you have any final thoughts that you would like to share with us?

2.3. Data Analysis

For data analysis, we followed the instructions for analyzing focus group data as described by [25]. We recorded the focus groups and then transcribed these recordings. In the next step, we identified the main themes based on the participants' responses (students and teachers combined). We then summarized all the responses for each theme and quoted the most representative responses.

3. Results

3.1. Literature Review

Despite the plethora of school furniture available on the market, only a few prototypes have undergone scientific analysis that aimed to assess their influence on students' well-being. We found five papers describing the design process of a school furniture prototype [17–21]. Four prototypes are mainly made of wood and one prototype [21] is mainly made of plastic. Two school furniture prototypes consist of a height-adjustable desk and chair [18,20], one prototype is designed as a non-adjustable desk with a bench [19], one prototype as a wraparound school furniture [21] and one prototype as a desk with a tiltable tabletop and a chair on wheels with a forward inclined seat [17]. All prototypes except one [18] are based on anthropometric measurements of students. No specific design for a standing desk was found.

Studies that examined the impact of standing desks for reducing sedentary behavior used manufactured school furniture such as LearnFit (Ergotron, Saint Paul, MN, USA), Stand2learn (College Station, TX, USA), BALT Up-Rite Student Table (MooreCo, Cameron, TX, USA) or AlphaBetter® (SAFCO, New Hope, MN USA). None of these desks are made entirely of wood. Stand2learn and BALT Up-Rite Student Table have wooden tabletops.

Based on the literature review, we identified the crucial elements of a school desk: tiltable tabletop, height adjustability, and the integration of natural wooden materials and shapes. The incorporation of biophilic design principles in educational settings has the potential to enhance the restorative qualities of the environment, helping students to feel less stress and focus on their learning [26]. A tiltable tabletop, ranging from 0° to 20°, allows students to maintain a neutral neck position while reading, writing and listening to the teacher or watching the blackboard. Such tabletops have been associated with increased comfort, improved posture during writing, enhanced student performance and reduced occurrence of pain [27–30]. Aligning with the latest European standard for school furniture (EN 1729-1:2016), we ensured our prototype's tiltable tabletop was adjustable to a horizontal position.

After the literature review, the group reconvened to define the characteristics that would be included in the desk design. In addition to a tiltable tabletop, height adjustability and use of natural wooden material, we identified a pendulum footrest and foldability.

3.2. Construction of the Prototype Standing School Desk

In the first prototype, our primary focus was on the height adjustment mechanism. Given the limited number of power sockets in (Slovenian) classrooms, we decided on a non-electrical mechanism. Adhering to the standard for school furniture, the adjustment system should be user-friendly, allowing students to make adjustments without the use of tools. Additionally, the mechanism should be easily accessible and adjustable from the standard position [18]. To address these criteria, our emphasis was on developing a mechanism that could be adjusted from a standing position, without the need for users to bend or kneel under the desk. The mechanism should also be capable of rapidly changing the desk height without disrupting the teaching process.

The height-adjustment system implemented in the first prototype utilized a pneumatic cylinder, commonly found in height-adjustable chairs (Figure 1). While the system was fast and silent, the high force required to lower the desk height made it difficult to maneuver.

In the development of our second prototype (Figure 2), our objective was to integrate a tiltable tabletop, height adjustability, pendulum footrest, foldability and the use of natural materials. The inclination of the tabletop is managed by a four-level system, enabling an inclination from 0° to 20° by pulling the handle in and out of the pin (Figure 2b,c). The desk can be folded by unlocking the tabletop from the front desk legs, with the legs folding over the axis at their intersection (Figure 2d,e). The prototype is made of spruce. We failed to combine foldability and height adjustment.

Figure 1. The first prototype of the standing school desk.

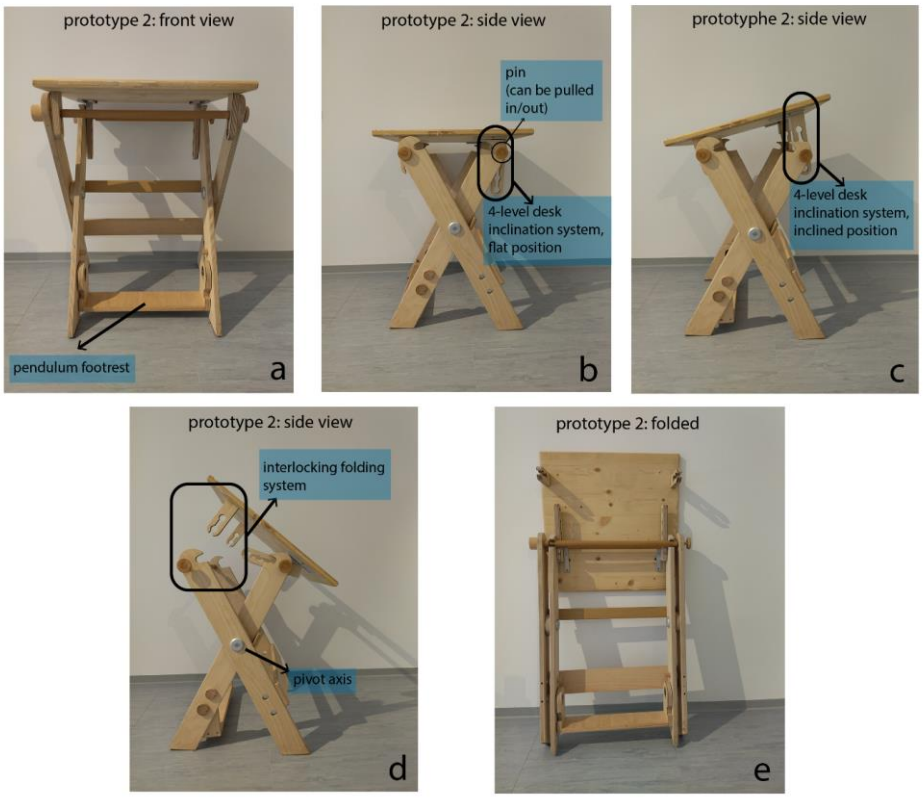

Figure 2. The second prototype of the standing school desk: (**a**) Front view; (**b**) Side view 1; (**c**) Side view 2; (**d**) Side view 3; (**e**) Front view of the folded desk.

During the testing phase, the prototype exhibited instability, and the system for tilting the desktop was cumbersome to handle and enabled a maximum inclination of 20°, at which paper and pencils tended to slide off the tabletop.

Following the construction of the second prototype, our team weighed up strengths and weaknesses of the existing prototypes, aligning our observations with the scientifically supported features and those mandated by the standard. In this evaluation, we classified features into two categories: compulsory and optional. The compulsory features included stability, height adjustability, a tiltable tabletop, and the incorporation of natural wooden materials. Optional features were the pendulum footrest and foldability.

In our third prototype, the height-adjustment system is based on a ratcheting mechanism (Figure 3d). Elevating the desk is achieved by grasping the tabletop and pulling it upwards, with the desk stopping when the height limit of the gear is reached. The desk is lowered using a lever situated on the right side of the desk (Figure 3e). The height adjustment system and tilting of the tabletop are presented in Supplementary File S1.

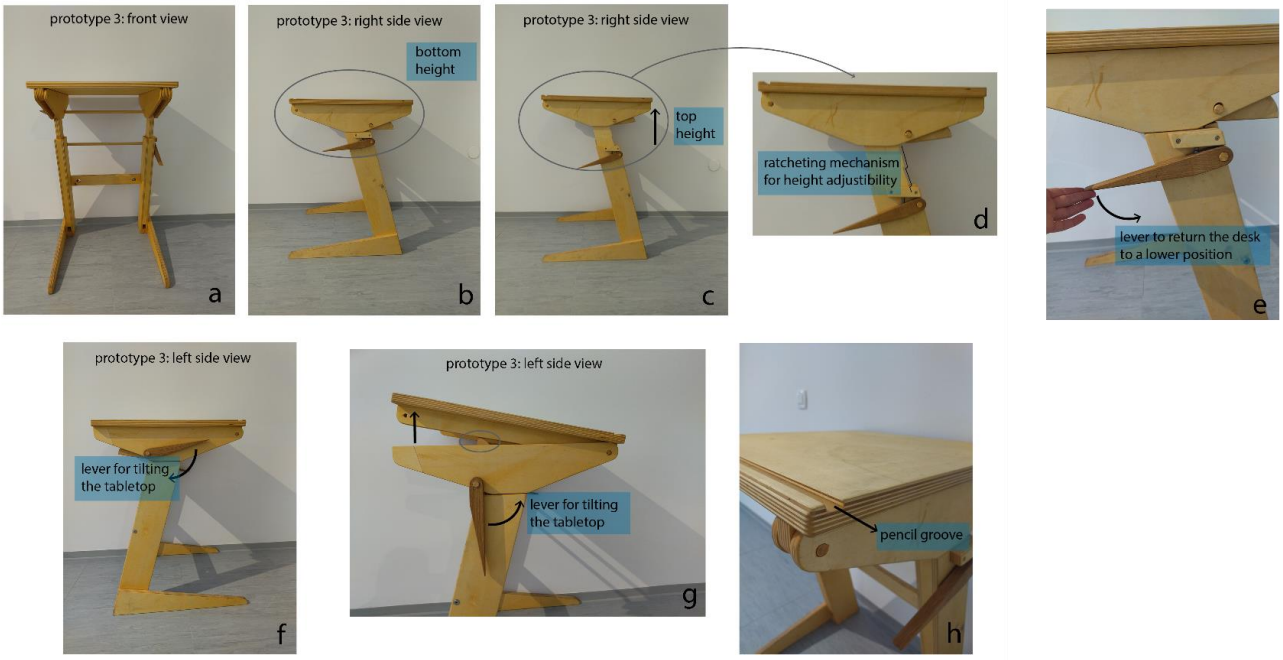

Figure 3. The third, final prototype of the standing school desk: (**a**) Front view; (**b**) Right side view 1; (**c**) Right side view 2; (**d**) Right side view 3; (**e**) Right side view 4; (**f**) Left side view 1; (**g**) Left side view 2; (**h**) Left side view 3.

The tabletop inclination is continuously adjustable from 0° to 10° by a lever on the left side of the desk (Figure 3f,g). The tabletop adheres to the standard SIST EN 1729:2016, with a depth of at least 500 mm and a width of at least 600 mm. A pencil groove on the lower edge prevents pencils from falling off the desk (Figure 3h). Constructed from plywood, our third prototype was designed with the intent to positively impact physiological indicators and overall well-being and at the same time to be light enough to move.

The prototype desk height range is 850–900–950 mm, to align with standard size mark 4 (desk height 860–900 mm). However, our measurements showed a larger range of 4th grade students' elbow heights (598–942 mm). We also showed that the desk could be used in the 3rd (elbow height 700–918 mm) and 5th grade (791–1004 mm) (Table 3). In the case of using the desk in the abovementioned classrooms, utilizing two desk sizes in classrooms is needed to accommodate all students with appropriate furniture. Characteristics of the final prototype are presented in Table 4.

Table 3. Size marks of the desk by the standard and anthropometric measurements.

Size Mark	**3**	**4**	**5**
Color mode	yellow	red	green
Popliteal height (no shoes)	315–355	355–405	435–485
Stature (no shoes)	1190–1420	1330–1590	1460–1765
Tabletop height ± 20	760 (740–780)	880 (860–900)	1000 (980–1200)
Anthropometric measurements	**Grade 3**	**Grade 4**	**Grade 5**
Popliteal height (avg ± sd (min–max))	349 ± 27 (3173–4147)	364 ± 30 (276–400)	405 ± 28 (358–482)
Stature (avg ± sd (min–max))	1350 ± 68 (1260–1520)	1410 ± 60 (1310–1540)	1500 ± 65 (1360–1670)
Elbow height (avg ± sd (min–max))	792 ± 51 (700–918)	827 ± 30 (598–942)	700 ± 51 (791–1004)

n = number; avg = average; sd = standard deviation; min = minimum; max = maximum.

Table 4. Characteristics of the prototype standing school desk.

Standing School Desk	Characteristics
Tabletop height min.	850
Tabletop height max.	950
Height adjustability:	850–900–950 mm
Tilting of tabletop:	0–10° continuously
Tabletop width:	600 mm
Tabletop depth:	600 mm

Building upon the third prototype, we redesigned the tabletop to follow a more natural and biophilic aesthetic, while also facilitating diverse options as regards the placement of the desk within the classroom environment (Figure 4). Additional figures of the redesigned desk with measures are presented in Supplementary File S2.

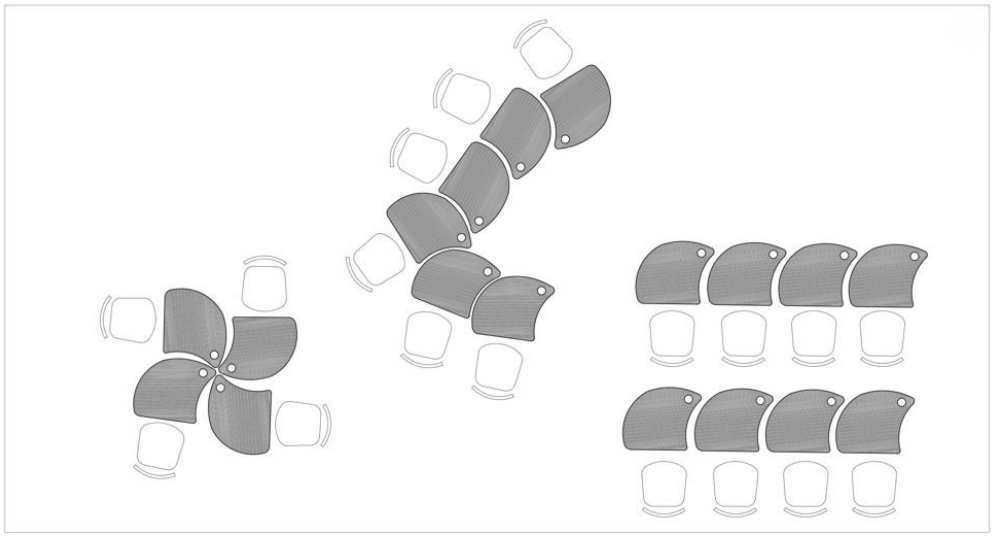

Figure 4. Redesigned tabletop.

3.3. Focus Groups' Results

3.3.1. First Impressions

Initial thoughts were positive: primary and secondary school students and teachers welcomed the idea of standing desks in the classroom. Primary and secondary school students pointed out that standing gives you more freedom to move other parts of your body, such as your head and arms. In contrast, one university student initially said:

"*Oh no, now we will have to stand*."

Another student said she had to try it out first as she was not sure if standing was more comfortable compared to sitting. A primary school teacher mentioned that she already has a standing desk in her classroom, which she finds very useful for children with "more energy".

3.3.2. Wood as a Material for School Desk

Students liked the visual aesthetics of the wood. One student emphasized:

"*I like that it's made of wood*."

Both students and teachers agreed that the tabletop should be made of a more durable and resistant material than plywood. A primary school teacher explained:

"*Students would write on it and make holes in the tabletop. I think they would destroy it very quickly*."

3.3.3. Advantages and Drawbacks of the Prototype Desk

All students appreciated the height adjustability and the tilting tabletop. However, they said they would only adjust the height if the desk was extremely too low or too high. One student explained:

> "*I really like the idea of the tiltable tabletop. I would use this in all subjects, especially when reading and doing geometry work.*"

The teachers also commented favorably on the height adjustability and inclination of the tabletop. They pointed out that there are considerable differences in height among students. The teachers also noted that the desk contained too many small elements, such as the handles.

> "*Students would hang all sorts of things on the handles and destroy the mechanism.*"

Teachers also emphasized that there should be no holes (when the tabletop is tilted, an empty space appears under the tabletop) as this is dangerous if a finger gets trapped. One teacher also commented:

> "*All those handles and little empty spaces/spots are hard to clean.*"

The university professor added:

> "*The desk should offer both options, sitting and standing.*"

3.3.4. Implementation in the Classroom

Both students and teachers often started discussing how the desk could be used in the classroom after the initial questions. The students said that they would probably use it in all subjects when they lost concentration or felt sleepy, but especially in social science subjects such as languages and during art or music lessons. All students agreed that they would not use it during the morning lessons, but rather in the afternoon when they are already tired and sleepy. One student emphasized that students should use the standing desk in the first grade to get used to it. The primary school teachers agreed that they would use the standing desk in the classroom. They explained:

> "*We often do activities where we cut, glue and the like. These activities are even easier to do standing up.*"

One university lecturer, on the other hand, was not keen on the idea of using the standing desk during lectures and explained:

> "*I do not think (university) students would be willing to stand during lectures. It would be my job to make them stand, and I do not want to do that. Maybe they should use the standing desk at the beginning of the lecture and not in the middle. . . But even then, they would probably prefer to just sit.*"

4. Discussion

This paper presents the design and construction process of a prototype wooden standing desk for schools and the results of focus groups with students and teachers to gather their feedback on the development process and the advantages and disadvantages of the prototype. The prototype standing desk is height adjustable, has a tilting tabletop and is made entirely of plywood. Teachers and students from primary and secondary schools generally welcomed the idea of a wooden standing desk in the classroom; however, they emphasized that the tabletop should be made of a more resistant material.

Natural patterns and the use of natural materials in learning environments encourage a connection to nature and prevents the isolation of classrooms from the outdoor environment [26]. Indeed, children have been shown to favor natural wood materials for school desks, chairs and bookshelves [31]. The material of the tabletop is particularly important as the students have direct contact with the tabletop with their forearms. Both students and teachers agreed that the tabletop should be made of a more durable and resistant material

than plywood. As an alternative to plywood we could use lacquered spruce or oak wood, as the lacquered solid wood has the best properties as a material for the tabletop, with oak wood being the most visually appealing material [32]. Further studies are needed to determine the optimal material, shape and color of school furniture, especially the tabletop, as it has been shown that there are differences in color perception and preference in both young participants [33] as well as adults [34].

Teachers and students welcomed the height adjustability of the standing desk. Our aim was to develop a mechanism that works without electricity and is easy to use; however, teachers pointed out that the mechanism has too many handles and holes that are difficult to clean, and that it could be potentially dangerous as students, especially primary school students, could get a finger caught in it. Our adjustable mechanism was made entirely of wood, which could also be less durable than a mechanism made of other materials, such as aluminum or plastic. Determining the most practical and durable adjustment mechanism requires further investigation.

We have performed anthropometric measurements of students to gain their body dimensions and to compare the measured body dimensions with the body dimensions, stated in the standard. Indeed, we found some discrepancies. For example, the popliteal height range was greater in the measured group of students when compared to anticipated measurements in the standard. This indicates that at least two sizes of furniture, as suggested by the standard, should be placed in the classroom. Lesser deviation from the standard was found for stature height. In our opinion, the greatest advantage of the anthropometric measurements performed is the information of the elbow height standing, which is needed to define the height of the standing desk, especially because this measure is not provided in the standard.

In our study, primary and secondary school teachers showed willingness to encourage students to use standing desks in the classroom, while the university professor did not welcome the idea of using standing desks during lectures. This could be due to the different tasks performed in primary/secondary schools compared to those in universities. As the teachers mentioned, they would use the standing desks for activities such as arts and crafts (cutting, gluing), while such activities are not usually conducted at the university where students are mainly listening. It should be noted that the university professor came from the field of psychology and professors from other fields, such as design or art, might have a different opinion.

Further on, the main goal of interventions using standing desks is to reduce the amount of time students spend sitting. As Broeke et al. [35] explain, time spent sitting is not a behavior, but a result of behavior, and the transitions from standing to sitting and vice versa are the fundamental behavioral units that underlie sitting, and therefore serve as clear target behaviors that can be modified in research and interventions. Therefore, identifying tasks that can be performed while standing (e.g., reading) is critical to the long-term implementation of standing desks in the classroom. With the feedback from the participants taking part in our focus group, the use of standing desk is more convenient during humanities and arts lessons (e.g., language, music and art lessons) and more suitable for afternoon lessons when students are tired and sleepy.

The conducted study has several limitations. The main limitation is the sample size of participants taking part in focus groups (9 students and 7 teachers). By conducting only two focus groups (one with students and one with teachers) we most likely did not reach saturation, and by conducting additional focus groups we could obtain other aspects and ideas from the users. Hence, no final conclusion on the suitability of the standing desk prototype can be drawn on the basis of our focus groups. We have designed a prototype standing school desk intended for use in regular schools. We have not considered solutions that would allow disabled students to use the furniture. Therefore, the prerequisite for using this prototype standing desk is the ability to stand independently. As the user has to actively change the height of the desk, the students should also have no visible or motor limitations.

Further studies should investigate the optimal material, shape and color of the school desk, especially the tabletop. Determining the most practical and durable adjustment mechanism also requires further investigation. In addition, the ergonomic design of high chairs should be considered, which would allow for short standing breaks and eventually increase the number of transitions from sitting to standing and from standing to sitting. In addition, studies should focus on what arrangement of sitting and standing desks is most appropriate in the classroom and what tasks can best be accomplished in the classroom when standing desks can be used. For future development and research, we see the design of user-centered furniture for students with disabilities as an important aspect that should be considered.

5. Conclusions

The aim of this study was to design a prototype of a standing school desk that takes into account the positive effects of wood in interiors and enables the interruption of long-term sitting with standing. Following the construction of the prototype, we conducted focus groups with students and teachers to gather user feedback on the development process, the advantages and disadvantages of the prototype and to discuss the suitability of plywood as a furniture material.

The prototype of the standing desk is height-adjustable, has a tilting tabletop and is made entirely of plywood. It should be noted that only a small group of students and teachers participated in the focus groups. Nevertheless, the tiltable tabletop and the height adjustability were the most appreciated features of the prototype. The students and teachers also liked the overall design and aesthetics of the plywood; however, they pointed out that plywood is too soft to be used as a material for the tabletop and that the adjustment mechanism should be safer to use for younger children (without holes and handles).

The study conducted is one of the few that combines the research of wood, ergonomics and health in the school environment. The results provide a good starting point for further research in this area.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/buildings14072193/s1. File S1: Videos of the final prototype of the standing school desk; File S2: Measures of the redesigned final prototype of the standing school desk.

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