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Tips, Tricks and Information for the ergonomic design of your laboratory

The advantages of an orderly work situation are obvious: It allows one to keep all required instruments in view and within reach, therefore generating smooth work flow. Instruments and devices do not have to be found and brought to the bench first. Even leaning forward and stretching the upper body in order to reach something violates the ergonomic concept of an orderly workplace. The more chaotic and untidy a workspace, the more unnecessary or even harmful additional movements are required. Finally, an untidy work area can lead to increased mental strain, since constant searching interferes with the concentration required for the actual task at hand.
One solution for lack of order stems from the principles of Kaizen (from the Japanese: "change for the better") which is often employed in production. This Japanese term stands for a stepwise approach, with the help of which increasingly higher standards in the improvement of quality and reduction of waste can be achieved. Thus, Kaizen implies small but nevertheless steady improvements. According to Kaizen, there are seven forms of waste which are to be kept to a minimum: overproduction, waiting times, preventable transports, complex and useless processes, large stock, superfluous movements, as well as mistakes and useless fixes. These forms of waste are universal. They can be identified equally well in a global pharmaceutical or biotech company, in the molecular lab at a University, or in a private home.
In order to reduce these forms of waste, Kaizen offers 4 different sets of rules: Best Point – workplace design, One Piece Flow (flow principle), 5 S-rule and Poka Yoke. The 5 S-rule prescribes 5 simple rules which are to be followed: first, those things which are useless and superfluous are removed from the workplace (Seiri). Those items which are then part of the work area are organized (Seiton). The thus defined workspace should from then on be kept clean and organized (Seiso).
In order to put these points into practice, a personal desire for cleanliness and order needs to be developed and cultivated (Seiketsu). Finally, standards must be defined and implemented for these 5 rules to become habit (Shitsuke).
The rules of Seiton and Seiso imply that means and ways must be found to organize items and, furthermore, maintain that order long term. To this end, deviations should be noticed quickly and rectified immediately and in an uncomplicated fashion. No strictly defined rules apply, as each workplace and each laboratory have their own expectations with respect to order. As such, individual creativity is essential. For example, a diagonal line drawn across the front of a row of binders in sequence will help keep these binders in the correct order. It is easy to spot missing binders immediately. In order to guarantee efficiency in the workplace/laboratory it is further necessary to avoid large stocks of gloves, tips, etc (Seiri and Seiton). Large stocks are one of the 7 types of waste which are to be avoided.
However, this does not imply the complete elimination of stocks; on the contrary, the availability of a certain minimum stock is a prerequisite for efficient work. A simple solution must be found for keeping the necessary stock without over stocking or under stocking. One such solution could be the traffic light system, where the colors green, yellow and red, in that order, represent a decreasing minimum stock. Shelves, drawers, etc. are easily and economically equipped with such a system.

Most laboratories, however, present an entirely different picture: drawers are filled to the maximum with boxes of gloves, tips, etc., in a disorganized fashion. This, however, is a false assumption. It would be much better to note the threat of low supply of various items in drawers, cupboards and shelves via their "traffic lights" and to prevent this occurrence with one trip. When organizing a core workstation (Seiton) with consideration for physical-ergonomic requirements, in addition to the 5-S rules, the Best Point Principle should be consulted as well. This principle of workplace design states that items which are a part of a core work space should be kept in locations which are easiest to reach by the user. Ideally, all items would be within arm's reach. Even in a simple office, this would be difficult to implement, and it sounds like utopia when considering the work space at hand – the laboratory. Therefore, in order to be able to implement the Best Point Principle in the laboratory, it is crucial to sort items into three different areas of reach, according to their frequency of use. The optimum area of reach is equivalent to a radius of the length of a person's lower arm, including the hand, without stretching. This radius is the actual work area. For a range of body heights between 1500 and 1900 mm (4′11″ to 6′3″), this radius is approximately 35 cm (13 ¾″). However, the maximum physiological reach comprises a radius of the length of the outstretched arm without severe leaning forward of the upper body (approx. 50 cm or 19 ½″ for body heights between 1500 and 1900 mm or 4′11″ to 6′3″). This is the ideal area in which items for daily use should be kept. The anatomical area of reach for persons of heights between 1500 and 1900 mm (or 4′11″ to 6′3″) is up to 60 cm (23 ½″) and thus requires leaning forward in order to reach items located within this radius.

It is suitable for items used in the long term. It is recommended that one get up in order to retrieve or use them, rather than leaning over to reach. Leaning forward should generally be avoided. Within the entire work area, both hands should be used. This supports coordination and distributes strain between two hands.

Following the successful sorting of items, the ergonomic requirements during sitting and standing need to be considered. This is a part of orientation along the Best Point Principle. Mainly the task and the furniture in the laboratory determine whether one is sitting or standing while working. In fact, a German study of laboratory personnel revealed that approximately half the people sit while pipetting while the other half stands [1]. If one stands exclusively, a chair with a high seat should be used as a sitting-standing support, and ergonomic workplace mats should be used. If one sits without exception, care should be taken to adjust the chair to the individual body height.

The height is to be adjusted to allow the knees to form a 90 degree angle and the lower back to lean against a back rest. To the disadvantage of lab personnel, laboratory benches are often equipped with countless under-desk cupboards which preclude sitting altogether, or allow it only at an angle. From an ergonomic perspective, a combination of standing, walking and sitting is superior, as in this case all stabilizing muscles are in turn activated and relaxed, depending on the state of activity. Hence, it makes sense that following a pipetting task which has been performed while standing one would move to an office area, sit down at a table and record the data into the lab book. This combines ergonomics with responsible laboratory work.

In addition, the introduction of organization is subject to cognitive-ergonomic requirements. These are extensively considered within the Poka Yoke rules of Kaizen. Poka Yoke desires to uncover mistakes in all possible areas of work as early as possible, thus helping prevent them. This is rooted in a form of process visualization, which allows one to recognize the flow and therefore "missteps". Error reduction saves cost, energy and time. Productivity increases. Inevitably, products of higher quality are produced. With regard to the laboratory work space, color coding of pipettes and tips takes center stage. While many manufacturers are now color-coding their tips, not all of these color codes actually help prevent errors. Color codes only make sense if they are visible unequivocally from all work positions. The advantage of intelligent color coding is rooted in minimizing pipetting errors and unnecessary actions, which result from searching for the correct pipette. Apart from color coding, there exist many other aides in the sense of Poka Yoke.

A calibration warning device installed in some electronic pipettes acts as an automatic reminder for calibrations due. Some pipettes are equipped with special mechanisms which protect the volume setting from being changed accidentally. Some electronic dispensers automatically recognize the volume of the tip fitted.

The requirement for order in accordance with the rules of Seiri and Seiton extend beyond the individual workplace and are applied to the structure of the laboratory as a whole. The flow of movement in a laboratory may be compared, in a simplified view, to those in a kitchen. In 1922, the American Christine Fredericks conducted a study to analyze the organization of kitchens. To this end, she pinpointed the paths she took in her kitchen during the preparation of an evening meal with the help of a thread.

The result was a chaotic structure. Based on this observation, she re-organized all utensils and appliances according to the flow during cooking and repeated the experiment. The result was considerable reduction of distance covered and faster preparation of the evening meal. Employing similar studies of the optimization of flow in the kitchen, the German architect Margarete Schütte-Lihotzky designed the "Frankfurt kitchen" in the 1920s. Parallels to the laboratory abound. Apart from over stock, many drawers and shelves contain items (single pieces, etc), the designation of which may be difficult even for a long term member of the laboratory team. Furthermore, products (e.g. samples) are often distributed among several refrigerators. The location of instruments often does not represent the work flow.

It is generally advisable to keep products and instruments which are always used together in close proximity to one another. The same is true for the storage of parts and items which are functionally related. Samples which are to be measured or processed together should be stored in the same refrigerator. A waterbath/thermomixer should be in the vicinity of a photometer if enzyme activity is to be analyzed. As a positive side effect, the risk of contamination will be reduced. Furthermore, if possible, all work stations within a laboratory are to be organized. This will not only reduce the need for detours, but it also improves safety (toxic substances no longer need to be transported between individual laboratories, etc.). However, his type of laboratory restructuring does not aim to eliminate walking altogether. Walking should always be a part of the daily routine in the laboratory, as it provides natural breaks from repetitive tasks, and it relaxes the stabilizing muscles.
The organization described above can only be maintained over time if a long-term desire for order is created (Seiketsu). Therefore, the introduction of a new ergonomic organizational system requires the participation of all employees involved [2]. Despite the participation-based approach, the realization just how effective a new organizational system can be does not appear by itself. In the beginning phase of the new organization, this realization needs to be supported by the implementation of standards and rules (Shitsuke). During the early phase, clear delegation of responsibilities for the maintenance and reinstatement of order is essential.
The introduction of a schedule for order and cleanliness is helpful. However, the guarantee of cleanliness is subject to large variation according to the understanding and expectations of the individual.
Thus, checklists are still required, which need to be adhered to by the person in charge according to the schedule. For example, this person makes a trip to the storage room as soon as he or she notices the need during regular check of the traffic light system. Further, the location of all individual items must be available to everyone (location of instruments, devices, consumables, chemicals, etc.).
Attitude is the readiness to react to certain environmental stimuli in either a consistently positive or a consistently negative manner. In this case, the affective component plays a major role. It represents the emotional evaluation of an object. In the case where the object to be evaluated is a task or the work in its entirety, the affective component is strongly influenced by the environment. Mainly light, noise and climate play critical roles. Especially during precision tasks such as pipetting, light which is too dim places a strain on the eye muscle (focusing). Therefore, illumination between 500 and 1000 Lux is recommended for office areas and 750 to 1500 Lux for older employees [3]. The higher the demand for precision during the performance of a task, the stronger the illumination required [3].

When working with electronic instruments (e.g. electronic pipettes), the illumination of the display should be adjusted to ambient light conditions. A screen which is too bright irritates the eyes in dark or dimmed rooms [3]. As a rule: Natural daylight is the best and most healthy illumination. With its unique spectrum, it regulates many physiological processes; it is a well known fact that the circadian rhythms of humans and animals are dependent on daylight. Therefore, a laboratory should have a sufficient number of windows.
Furthermore, these windows need to be equipped with blinds against direct sunshine. Nevertheless, artificial light may be necessary from time to time, depending on the time of year and time of day. In addition, rooms without daylight are consciously chosen for certain research projects and the experiments involved therein.

Loud background noise interferes with concentration. If one is subjected to it long term, it may, in extreme cases, lead to cardiovascular disease [4]. For these reasons, the noise level should be kept as low as possible in order to facilitate stress-free and concentrated work. The noise level can be expressed in decibels. The decibel is a relative value, where an increase in 10 decibels is felt to be twice as loud.
Normal breathing has a noise intensity of 10 decibels, whispering is already 20 decibels, and speaking in a low voice is 40 decibels.
Hence, quiet speech is perceived to be 8 times louder than normal breathing. The stress or tolerance level, respectively, is at 60 decibels and is equivalent to loud speech.

During highly concentrated work, an average daily noise level of 35-40 decibels should not be exceeded [3]. For tasks which require less concentration, 55 decibels are not to be exceeded [3].
In terms of climate, a temperature between 21 and 22 °C (but not higher than 26 °C), relative humidity of 40-60 % and air current of 0.1-0.15 m/s (at 21 °C) are considered optimal [3]. Furthermore, air should be free of toxic gases and low in carbon dioxide. Chemical aerosols and dust are also to be avoided. In order to achieve this, opening of windows for 10 minutes every day is recommended [3].

Literature

[1] Bruder R, Richter M, Müller J, Heppener A, 2006: [Development of a basic ergonomic concept for different types of pipettes, internal report to Eppendorf AG, Darmstadt: Institute for Labor Science] [German] Entwicklung eines ergonomischen Grundkonzeptes für unterschiedliche Varianten von Pipetten, Interner Bericht an die Eppendorf AG, Darmstadt: Institut für Arbeitswissenschaft.

[2] Duell, W., 1983: [Participation-based work design. Conditions of successful intervention] [German] Partizipative Arbeitsgestaltung. Bedingungen erfolgreicher Intervention. Psychosozial 20:71-90

[3] Wittig-Goetz U, 2011: http://www.ergoonline.de/site.aspxurl=html/arbeitsplatz/arbeitsumgebung_beleuchtung/laerm.htm
http://www.ergoonline.de/site.aspxurl=html/arbeitsplatz/arbeitsumgebung_beleuchtung/beleuchtung.htm
http://www.ergo-online.de/site.aspxurl=html/arbeitsplatz/arbeitsumgebung_beleuchtung/klima_im_buero.htm

[4] [Government agency for workplace protection and workplace medicine, 2003: Labor science research #124: Monitor work - noise reduction in multi-user offices] [German] Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, 2003: Arbeitswissenschaftliche Erkenntnisse Nr. 124: Bildschirmarbeit – Lärmminderung in Mehrpersonenbüros.

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