APPROXIMATION OF NET AREA REQUIREMENTS OF SIMULATION FACILITIES FOR HEALTHCARE EDUCATION IN TURKIYE

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ABSTRACT

APPROXIMATION OF NET AREA REQUIREMENTS OF SIMULATION FACILITIES FOR HEALTHCARE EDUCATION IN TURKIYE

Although, simulation in healthcare practice dates back to ancient times, emerging of practical education with simulation has gained its popularity in modern era. In modern approach, education in healthcare is a hybrid model where theoretical and practical trainings are executed together. By the increasing popularity of simulation in healthcare globally, simulation centers and labs around the world became the key facilities for practical sessions to be held. However, no design template or design algorithm is published as a regulation to standardize healthcare education worldwide or locally. Therefore, designing simulation facilities are still challenging for institutions. Despite the fact that the governmental bodies in Turkiye have issued regulations mandating minimum area requirements for the commencement of simulations, the practice of simulation remains a challenging endeavor for institutions within the country.

This study aims to establish a CAD (Computer Aided Design) model based on the governmental regulations of Turkiye, possible student capacities and search for quantitative upscaling methods of area needs for the model that can be adapted to any student capacity by using step function methods. Before calculations, CAD drawings are realized and area dimensions are recorded for the data processing. Afterwards, heterogeneity of increments are homogenized to output a floor function. After outputting functions, area needs for such design versus student capacities more than 240 are extrapolated.

According to the findings, using step function approach for upscaling such model is possible and useful for needs recognition, yet it is not definitive for every occasion due to other concerns of simulation center design such as budgeting, establishment of laboratories in already constructed buildings which pose restrictions on space at design and need of more definitive regulations.

ÖZET

TÜRKİYE'DEKİ SAĞLIK EĞİTİMİ İÇİN SİMÜLASYON TESİSLERİNİN NET ALAN GEREKLİLİKLERİNİN YAKLAŞIK GÖSTERİMİ

Sağlık uygulamalarında simülasyon, antik çağlara kadar uzanan bir tarihe sahip olsa da, simülasyonla pratik eğitimin bir arada kullanıldığı yaklaşım modern çağda popülerlik kazanmıştır. Modern yaklaşımda, sağlık eğitimi teorik ve pratik eğitimlerin bir arada yürütüldüğü bir hibrit modeldir. Sağlıkta simülasyonun küresel olarak popülerlik kazanmasıyla, dünya genelinde simülasyon merkezleri ve laboratuvarları, pratik oturumların düzenleneceği ana tesisler haline gelmiştir. Bununla birlikte, sağlık eğitimini dünya çapında veya yerel olarak standartlaştırmak için tasarım şablonu veya tasarım algoritması yayınlanmamıştır. Bu nedenle, simülasyon tesislerinin tasarımı, kurumlar için hala zorlu bir işlemdir. Türkiye'deki hükümet organlarının simülasyon başlatmak için minimum alan gereksinimlerini belirleyen yönetmelikleri çıkarmış olsalar da, simülasyon uygulaması ülkedeki kurumlar için hala zor bir çaba olarak kalmaktadır.

Bu çalışma, Türkiye hükümetinin yönetmeliklerine, mümkün öğrenci kapasitelerine dayanan bir CAD (Bilgisayar Destekli Tasarım) modeli oluşturmayı ve alan ihtiyaçlarının nicel olarak ölçeklendirilmesi için adım fonksiyonu yöntemleri kullanarak her öğrenci kapasitesine uygun şekilde adapte edilebilen bir model aramayı amaçlamaktadır. Hesaplamalardan önce, CAD çizimleri gerçekleştirilir ve veri işleme için alan boyutları kaydedilir. Daha sonra, artışların heterojenliği homojenize edilerek bir taban fonksiyonu elde edilir. Fonksiyonlar çıktılandıktan sonra, böyle bir tasarım için öğrenci kapasitelerine göre alan ihtiyaçları ekstrapole edilir.

Bulgulara göre, bu tür bir modelin ölçeklendirilmesi için adım fonksiyonu yaklaşımının kullanımı ihtiyaçların tanınması için mümkün ve faydalıdır, ancak bütçeleme, önceden inşa edilmiş binalarda laboratuvar kurulumu gibi diğer simülasyon merkezi tasarımı endişeleri nedeniyle her durum için kesin olmayabilir ve daha kesin yönetmeliklere ihtiyaç duyulabilir.

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LIST OF SYMBOLS/ABBREVIATIONS

floor(x)	Floor function of x
$\lfloor x \rfloor$	Mathematical representation of greatest integer of x
D:	Domain range
g	Initial value of domain range
t	Final value of domain range
a	Variance/rate of change
b	1 divided by step length
h	Coordinate of x-axis
k	Coordinate of y-axis
$\mathbb{R}$	Set of real numbers
$\mathbb{Z}$	Set of integer numbers
Y.Ö.K	Council of higher education of Turkiye
ÇEP	Core education program
HUÇEP	National core education program of nursing education
UÇEP	National core education program of undergraduate medicine education
CPR	Cardio-pulmonary resuscitation
SP	Standardized/simulated patient
OSCE	Objective structured clinical examination
FA Tank	Formaldehyde tank

1. INTRODUCTION

1.1. DEFINITION OF SIMULATION AND USE OF SIMULATION IN HEALTHCARE EDUCATION

At a broader extent, simulation is defined as a technique that creates a situation or an environment mimicking real-life experiences or an event. It can also be referred to artificial representation of the real word. Specifically for simulation in healthcare, simulation is also a technique of education or evaluation of an event occurring maximally mimicking real-life environment and experience to acquire deeper understanding of human systems, learning and assessment[1,2].

Use of simulation for the training of healthcare providers became popular in history continues to be more popular. Two of the main reasons of simulation training becoming more important is patient safety and differentiating learning profiles of the new generations. However, researches for the effect of the simulation training on patient safety and healthcare providing developments are still relatively low in spite of evidence-based learning literature is growing [3]. Furthermore, the other reasons for simulation training becoming more important is that new generations are altering conventional learning methods that so-called "Millennials" often prefer to dive into the subject matter of research and learning in a more personal and interactive manner [4]. It can be understood that new generations prefer more interactive and personal learning profiles. Moreover, as technological developments in computer science, engineering and audio-visual contents continue in a positive increment in logarithmic patterns, newer generations are more adapted to use these tools to acquire knowledge from. Therefore, classical approach to learning from books and theoretical lectures are becoming insufficient for the learners which can be stated as "boring".

Although newer generations' learning profiles change, one more critical perspective of involving simulation type practical education in such professions is to reduce risks in applications of knowledge. High-risk professions are groups of occupations that any inconsistency occurring during the execution of the work can cause human death or even mass catastrophes such as airplane crashes. Therefore, two of high-risk professions can be stated as aviation and healthcare providing. That is why, simulation and practical education becomes more important in these areas for the training of the former professionals. Flight Simulation is a common knowledge that pilots are trained in simulators for different environmental conditions to handle the plane. Furthermore, it is also common that after plane crashes, simulation flights are done in judgement and investigation periods to list the outcomes and increase the understanding of the causes of that specific plane crash. According to statistics, most of the error occurrences and accidents in aviation are caused by personnel [5]. Similarly, another high-risk profession, in healthcare providing most of the cause of deaths are found to be human factors mostly. Roughly, human errors account for approximately 60% of error-related complications in healthcare as an example for anesthesiology [6]. Thus, pilots and physicians are the key elements to be trained well for increasing safety and decreasing death numbers by human factor errors. That is why, medical simulation is gaining importance especially in last decades.

Simulation in healthcare education has its unique approaches as practical trainings aiming for teaching a medical procedure to trainees itself to students, scenario-based training aiming for training professionals and making them to transfer their knowledge under life-like conditions and etc. Henceforth, modern approaches to simulation training are hybrid systems where professional training takes place in both practical sessions and scenario-based training where theoretical and practical knowledge should be used. Therefore, simulation training contents cannot be separated from each other. Another acceptance worldwide is that spaces/facilities where simulation and scenario-based training takes place should be constructed and designed in likeness of real healthcare environments such as hospitals. Furthermore, as hospitals and other healthcare providing organizations involve different types of teams formed of different professions, interprofessional efficacy plays a key role in delivery of safe quality-care [7,8]. Consequently, simulation training facilities seem should be built properly for allowing these interprofessional work style which means that an effective simulation training facility must be designed as an organization consisting of different professional care giver components to improve interprofessional teamwork and communications.

1.2. PRACTICAL VS SCENARIO-BASED HEALTHCARE EDUCATION

There are several approaches for professions that require simulation training yet up to date approaches are a composition of these techniques where both practical and scenario-based training models are used in joint. Fundamentally, practical training model aims to teach students the practice itself and having them learn several applications to use in real-life. On the other hand, scenario-based education model aims to train students under life-like designed environments by a scenario and teach them by failure method. Further details are to be given in the literature review.

1.3. DESIGNING OF SIMULATION CENTER

It is seen and known that there is no template simulation center design in literature due to necessities of institutions differ from each other. Additionally, education is not standardized to a point that a trainee can use its knowledge worldwide. In aviation and healthcare, this issue is more likely to be standardized everywhere yet more actions need to be taken.

Therefore, simulation centers are designed uniquely for the needs of that specific organization. Furthermore, layout plans such as star-shaped, linear or circular flow layouts as well as content/scope of the simulation facilities differ depending on the architectural aspects of the organizations, educational goals and budgets. Further details and literature review of designing simulation centers are to be given in literature review.

1.4. HEALTHCARE EDUCATION STANDARDS IN TURKIYE (ÇEP + YÖK)

There are different curricula in healthcare education worldwide yet, standards of medical education are standardized to an extent. In Turkiye, there are two layers of standards for a healthcare education organization to begin its training life. First layer is to create proper curriculum based on ÇEP (Çekirdek Eğitim Programı – Core Education Program). Afterwards, as a second layer, institutions have to ensure that minimum space criteria regulated by governmental body named Y.Ö.K (Yükseköğretim Kurulu – Council of Higher Education) are satisfied.

1.4.1. Y.Ö.K's Minimum Space Criteria Regulations

Y.Ö.K' s regulations are standards declared that any institution desiring to start its own training life should comply these rules and build a satisfactory environment for the training to take place. Contents of these regulations involve classrooms, libraries, faculty size to student capacity ratio, practical education space criteria and academic staff numbers which will be mentioned in more detailed in methodology section [9–11]. Any institution that are not fulfilling these requirements declared by the governmental body are not allowed to begin their education life. Therefore, healthcare education institutions in Turkiye are constructed and designed under specific patterns. Y.Ö.K's design considerations are based on 0 to 60 student capacity schools and regulations are given for capacity increments for every 60 students. Summary of these regulations for both medicine faculty and nursing faculty are given at the methodology section. In this study, parts of the document containing practical education space criteria are to be used as a guide in designing phase.

1.4.2. CEP Content and Curriculum Formation

Proper curriculum is the key to quality education. As well, curriculums aim and help institutions and countries to standardize education given to students at the base level. Quality and academic performance of these institutions depend on the design and additive contents on curricula which means that institutions in Turkiye are obligated to provide curriculum defined by the government and allowed to add content to their training structure to develop their curriculum. That is why, both academic performance and quality may vary and depend on the institution itself. However, as it is standardized, a undergraduate students' learning objectives are assessed based on ÇEP after their graduation. ÇEP system provides every student equal education at a base that lets them to start their professional life equally.

There are different ÇEPs for every profession group as well as in healthcare education, every profession/department (e.g.: physiotherapy, nursing, medicine and etc.) have their own

ÇEPs. Also, primary and standard learning objectives of these professions are defined. For this study, ÇEPs of nursing and medicine schools, consecutively HUÇEP (Hemşirelik Ulusal Çekirdek Eğitim Programı – National Core Education Program of Nursing) and UÇEP (Mezuniyet Öncesi Tıp Eğitimi Ulusal Çekirdek Eğitim Programı – National Core Education Program of Undergraduate Medicine Education) are to be used [12,13]. Even if ÇEPs affect the design considerations, as practical education needs are regulated, standardized by Y.Ö.K, these declarations are the primary source for a simulation facility design rather than ÇEPs, even designs are preferred and built around curricula of the institutions around the world [9,10,14–16].

Every ÇEP has its unique learning outcomes and knowledge levels. These outcomes and levels are given on the learning outcomes lists belonging to that ÇEP uniquely. Therefore, as an example, ÇEP dictates that a medicine student should learn basic life support to the degree of level 4 or intraosseous application to the degree of level 2 or a nursing student should learn urinary catheterization to a degree of level 3 before graduation [12,13].

All in all, simulation centers to be designed in Turkiye are to be following minimum requirements of space criteria of YÖK and should be capable of servicing for the practical education to satisfy the learning objectives (which can be practically applicable by simulation practice where skills and theoretical knowledge are described as a whole in the document) and capable enough to pass the annual governmental inspections whether the facility is capable or not. Detailed information and learning objective lists of UÇEP and HUÇEP are given in Appendix A.1.1 and A.1.2.

1.4.3. Calculating Size vs Student Capacity in Simulation Facilities

Mathematical applications and converting such studies into mathematical operations have more than one way yet there are type of equations fitting best to a specific situation. As mentioned in section 1.4.1., Y.Ö.K’s standards are given for minimum student capacity range which is 0 to 60 students and only some of the laboratories are to be increased in size depending on the student capacity. Therefore, there are two options that changes can be observed piecewise or by deduction. For this type of study, epagoge style of methodology will be used.

1.5. RATIONALE FOR THE STUDY

This study hypothesizes that depending on the student capacity, changes in facility can be converted into mathematical equations and quantized. Secondarily, for every student capacity, a template of design can be upscaled without interrupting the general layout. Therefore, aim of this study is to create a basic template for approximate net area requirements of a simulation facility minimally fulfilling governmental regulations for serving nursing and medicine schools and derive an equation for upscaling purposes for more crowded student capacities and extrapolate area needs up to 420 student capacities.

2. LITERATURE REVIEW

2.1. HISTORY OF SIMULATION IN HEALTHCARE

Even if simulator history dates back to 1960s, it is thought that simulation history dates back to 300-600 AD Early Classic Maya where a clay sculpture of a human head demonstrating anatomy is found. In addition, in 1027, Wang Wei-Yi (987-1067) the imperial physician responsible for standardizing acupuncture education used the first patient simulator made of bronze to teach surface anatomy and acupuncture sites on the model [17]. Simulators for demonstration purposes were used broadly in history yet the first interactive simulator "Resusci-Anne" was found by a toy manufacturer Asmund Laerdal in 1960s [18]. Afterwards healthcare training with the help of simulators era has begun and today simulation in healthcare yields on simulator technologies and modern teaching methods.

Before 2000s, mannequin simulation training was generally used in emergency, anesthesiology and reanimation where life-threatening events were simulated. After 2000s, high fidelity simulation and adaptation of computer science to technology introduced itself to healthcare education.

2.2. SIMULATION CENTERS AND DESIGNING OF A SIMULATION CENTER IN LITERATURE

Early simulation training facilities were usually a product of individual trainers working in small groups or alone within their departments with the self-developed or adapted commercial products [3,19–21]. In addition to this, simulation centers for healthcare education began to establish in 1990s. Back in those dates, these simulation centers were funded by public, military drug companies, educational funds and revenues obtained from courses. Yet, the real jump in simulation center establishments occurred in 2000's [3]. Most of the simulation centers in the world now are multi-modal, interdisciplinary and suitable for peer-to-peer and interprofessional teamwork.

Simulation center design depends on so many perspectives where architecture, engineering, information technology, medical education, management know-hows have to be collaborated to finalize and establish an effective simulation center design. As different professional approaches are needed, these professionals must be working in teams to create an accreditable and "*best-fitting for goals*" simulation center. Yet simulation centers in healthcare education around the world can be separated into two major categories as scenario-based simulation centers and multi-modal simulation centers. Scenario-based simulation centers and multimodal simulation centers are both used in healthcare education to provide learners with realistic training experiences. However, there are some key differences between these two types of simulation centers.

Scenario-based simulation centers typically focus on creating realistic scenarios or case based learning that simulate patient care situations. Learners are typically presented with a patient history, vital signs, and other relevant information, and are then required to diagnose and treat the patient based on the information presented. These simulations are often designed to replicate real-life situations that healthcare providers might encounter in their practice, and may involve simulated/standardized patients (SP), mannequins, or virtual reality technology. Scenario-based simulation is not defined but the term "*scenario*" specific for healthcare education defined in SSH's Healthcare Simulation Dictionary as;

> The scripts, stories, or algorithms created for instructing the participants, including the simulators (human or robotic), on how to interact with the students(2).

Multimodal simulation centers, on the other hand, typically incorporate a wider range of simulation modalities. In addition to scenario-based simulations, these centers may also offer opportunities for learners to practice procedures on models or mannequins, or to use virtual reality or augmented reality technology to practice specific skills or tasks. These centers may also offer opportunities for learners to practice communication and teamwork skills, or to participate in role-playing exercises. Multiple modality (multi-modal) simulation is defined in SSH's Healthcare Simulation Dictionary as;

> *The use of multiple modalities of simulation in the same simulation activity; differentiated from hybrid simulation in that it is not characterized by the combining of one type of simulation to enhance another, but rather the use of multiple types of simulation in the same scenario or place,*

e.g., SP and manikin used in a scenario or a task trainer paired with an SP for venipunture, etc. (SSH)(2).

Overall, while both scenario-based simulation centers and multimodal simulation centers can be effective tools for healthcare education, the main difference between the two lies in the range of simulation modalities offered. Scenario-based simulation centers tend to focus on creating realistic patient care scenarios, while multimodal simulation centers offer a wider range of simulation modalities and may provide learners with more opportunities to practice specific skills or tasks.

At a design phase of a facility there are several key points to pay attention before starting the design:

- Student capacity/quota: How much students are going to use areas?
- Size of an area: If area is predefined, what is the size of an area. If area is not predefined and a facility is not constructed yet, how much area is needed for simulation should be considered where this study focuses on this problem.
- Flow layout: Depending on the student capacity and area, which type of flow layout is needed for such a simulation center design should be considered.
- Staff: There must be enough personnel to keep simulation center running.
- Design: Must not exceed or become unrealistic in budgeting aspect.
- Equipment: To be used in the simulation center
- Number of departments: This facility will serve for their practical training.
- Simulation center type: It can be hospital alike, scenario-based or focused on practical training.

2.2.1. Flow Layouts and Their Role in Simulation Centers

One of the most effective points in simulation center design is deciding the flow layout. It is because of designers should be aware of what simulations are to be taking place in the center, how much student at a time will be using the facility, which areas should not be interrupted by dense traffic and which rooms are to be crowded. Generally, simulation and scenario areas require groups consisting of maximum 10 students to one scenario/simulation station. Student number exceeding 10 in a group causes the simulation sessions becoming low on quality and learning feedback decreases. When these problems are addressed, layout plan (Figure 2.1.) should be decided.

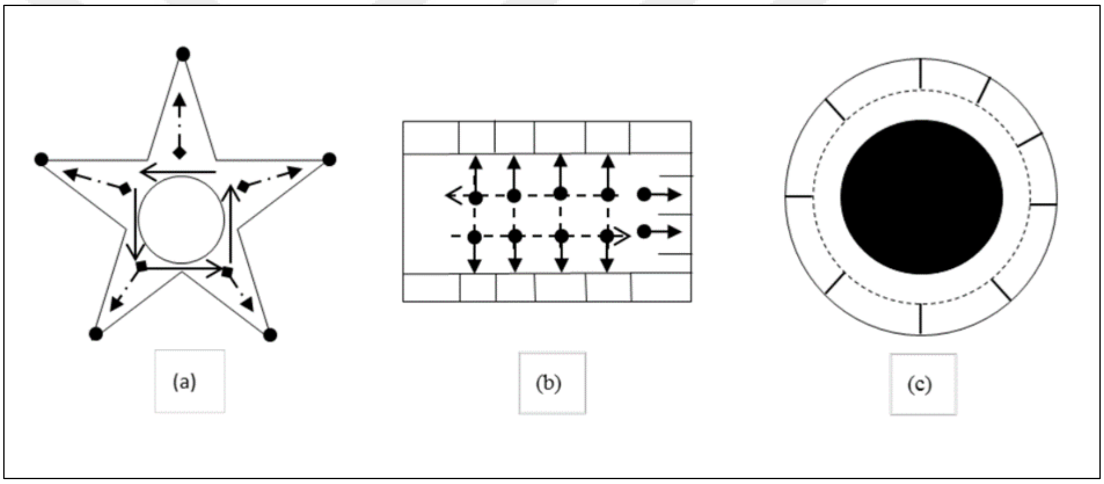

Figure 2.1. Different flow layouts for simulation center. a) Star shaped, b) Linear, c) Circular

Star shape flow layouts are the most complex layouts for a simulation center where a circular flow is generated at the center of the facility and other components of the simulation center (e.g.: emergency scenario, ICU scenario areas) are moved away from the center point. This layout plan can be advantageous where scenario-based trainings require separate applications but if a hospital alike design is considered, flow of joint scenarios could be discrete where scenario transitions can be interrupted.

Linear flow layouts are the fastest way to handle student trafficking that all application areas are at the same place, yet transitional scenarios of hospital alike configurations may be interrupted due to the traffic flowing at the middle point of the facility. Also entrances and exits are on the same place. Therefore, in spite of being the fastest flow layout, linear flow is not optimally appropriate for scenario-based and joint/multimodal simulation centers.

Circular flow is one of the best traffic controlling layouts that students can be separated in two directions following 180-degree arc and exiting from the other end. This layout can also be configured as 360-degree flow by putting entrance and exits at the same area. Traffic flow rate would be slower and this layout is one of the most suitable design for a hospital alike scenario-based simulation centers yet lacks the easier accessibility where students would have to reach for the other end just for a specific simulation session.

To sum up, there are no optimal layouts for simulation centers to be designed on. Especially, as it is discussable, centers using different layouts jointly for specific areas could benefit from both traffic control and simulation flow. Thus, combining layouts with just like the simulation practice of practical and scenario-based simulations executed together in an optimal simulation center could also benefit efficacy of the simulation sessions, flows and management of such center.

Carla Talal Dleikan from American University of Beirut has realized a study in designing of a simulation center for the institution’s needs by using star shaped layout on a 600 m2 area. In this example the simulation center was control room centered and simulation areas distributed around this center. Thus increased the flow capacity of the simulation center. Furthermore, scenario-based hospital alike simulation center’s efficacy with such type of layout have increased because of the closeness of the scenario areas. Flow system was more of circular flow-based layout [16,22].

For the simulation centers having broader range of components such as number of scenario-based training areas like emergency room, delivery room, ICU and etc. it is possible to configure such flow layouts yet in smaller size practices and facilities trying to keep compactness, ensuring these types of layouts become more challenging and design forces itself naturally to a linear or half-circular flow layout due to lack of additional rooms.

2.3. STUDY DESIGN AND SETTING

As it is mentioned in literature review, simulation center/laboratory design phase is the first and most important concern for the facility to have mobility, availability and upscaling functions in terms of space, researching opportunities and educational properties. Additionally, as simulation centers facility design should be based on the needs of certain institution, there can be no standardized design for all organizations yet fulfilling fundamental requirements of a facility to be ran because budgeting and targets of educational entities may vary to their needs. Thus, in this study, governmental standard declaration document of simulation facility requirements for medicine and nursing schools is set as a primary resource and guide for the design phase [10,11]. Summarizing of Core Requirements for a Simulation Facility for both Medicine Faculty and Nursing Faculty Based on Governmental Standards

Within the limits of governmental standards, summary of minimum requirements is listed as follows:

- Medical Faculty
    - Anatomy and Dissection Rooms
        - Total of 5 tables as 1 master and 4 student tables where 30 students can work simultaneously
        - Student table number should increase as 1 for every 60-student increment (e.g., 4 tables for 0-59, 5 tables for 60-119, 6 tables for 120-179 student capacity)
        - Cadaver preparation room: should be enough to operate and store needs of anatomy room (minimum 2 cadaver storage unit with an increment of +1 cadaver storage unit for every 60 students)
    - Anatomic Models Room
        - With enough space and functional area.

        - Maximum of 10 students per table
    - Medical Education Labs
        - Basic Skills Labs
            - Space organization is left for staff to design itself
            - There should be enough space and models to operate an education; suturing, injection, airway, CPR, Nasogastric Tube and urinary catheterization models
        - Simulation Labs (Simulated Patient (SP) Lab)
            - Minimum 2 SP rooms up to 60 students (should be 3 for 60 students) with a +1 increment for every 60 students.
            - Rooms should be a basic outpatient room that has patient chair, doctor table and PC with hospital software installed, patient examination table and storage units for devices like stethoscope, ECG. Additionally, a video camera and recording system is required.

- Nursing Faculty
- Basic Skills/Education Lab
- A lab that allows group practices
- Basic Skills and Nursing Essentials Lab
- Patient unit (e.g., nursing desk, medicine preparation, patient bed etc.)
- At least low fidelity dummy models/skills trainers for fundamental nursing practices.
- Simulation Center/Lab
- A room having audiovisual recording system

- Patient bed and human care simulator which is electronically responsive and has scenario creating properties for case management.

3. METHODOLOGY

3.1. STUDY DESIGN AND SETTING

This thesis is designed as a descriptive study for clinical education, biomedical engineer and education administration members in certain medicine and nursing schools to create an architectural and efficient usability vision of minimum requirements for a simulation lab or a simulation center to be virtually built based on governmental standards. Furthermore, when any facility is in architectural design phase, an effective communication and clarification of requirements declared by the future simulation personnel for the designers plays crucial role in building an efficient and enough space. Thus, detailed descriptions of what is needed in minimum has an effect of lowering future challenges given in section 5.1.

After pinpointing the general needs of a nursing and medicine faculty simulation facilities which can be used jointly or separately given in section 4.2. As if these facilities are planned to turn into scenario-based simulation centers, they should be planned as together for space/location saving for the future additions where ICU, emergency, delivery room and other types of scenario rooms can be added. However, as it can be seen from official document, governmental bodies are not making these additions obligatory where no up-to-date notice is declared over basic requirements based on student capacities. Furthermore, before starting the design phase, Ernst Neufert's publication is referred for if there were any design considerations for simulation centers or hospital settings. When referred to the publication, there was no specific design considerations for simulation-based environment or educational units more than corridor widths (min. 1.50m), door dimensions (min. 2.10m), floor heights (min. 2.40m) and outpatient room area (min. 40m^2) [23]. On this level Neufert's standards could only be applicable for developed simulation center facilities where hospital-like environments could be added for scenario-based education which is again not obliged for minimally executable simulation facilities in Turkiye according to the official standards document. Therefore, only corridor width and outpatient/doctor's room dimensions (doctor's resting bed and shelf system excluded which decreases min. 16-20 m^2 area need approximately to 10 m^2) are taken into account when designing the facility.

3.2. DESIGNING PHASE

AutoCAD software which is generally used by architects is used for this design. At the first stage of the designing, flow character of the facility is decided as half rectangular and half circular flow. Because of the low general requirements, an affective and space saving rectangular flow would not be possible. Additionally, a fully satisfied circular flow would need more rooms of application or simulation where it would also conflict with the goal of designing a compact simulation and application area which can be upscaled with student capacity increment. That is why, minimally required areas are planned as two main blocks as one medicine faculty labs block and one nursing faculty labs block.

First design was based on 0-59 student capacity medicine and nursing faculties. The base design consisted of:

- Skills Lab and OSCE (60 student capacity)
    - OSCE labs are designed in conjunction with skills lab where medicine students could both study their practical skills like suturing, injection and have their practical exams.
    - 6 OSCE units with 10 student per table areas are designed as well as a small corridor type waiting room.
- Anatomy Models Lab (60 Student Capacity)
    - As it is not mentioned in governmental document, the lab is designed for the same capacity need for anatomy dissection lab where 4 student tables are needed for 0-59 student capacity. Therefore, model lab has 4 tables which can handle 10 students per table.
    - Table numbers are increased as +1 for every 60x capacity increment.
- Anatomy Dissection Lab (1 master and 4 student tables, 30 student capacity)
    - Each student table has a capacity of 8 where it can be increased to 10 if additional chairs are placed at the end of the tables.

  - Labs general entrance door is preferred as sliding system to decrease area without interrupting student comfort.

- Cadaver Preparation Room (1 FA Tank, 1 Morgue unit and cadaver preparation equipments)

  - Based on the search of commercial products supplied by companies on the internet it is seen that FA storage tanks are manufactured with 2 or 4 cadaver capacities. Therefore, as it was enough to use 2 cadaver storage units for 0-59 capacity faculty, 2 cadaver capacity FA tanks are preferred and as there was no meaningful difference between the dimensions of 2 cadaver and 4 cadaver tanks, double cadaver storage tanks are used in all upscaled versions.

- Changing rooms (1 for men, 1 for women)

  - There were no significant and standardized data for changing room dimensions. Thus, changing room dimensions are kept the same in every upscaled design and they are separated with a corridor to reach the end point of anatomy dissection lab.

- Debriefing and meeting rooms for administrative staff, students and lecturers.

  - Two of debriefing/meeting rooms are added to every design and the length of these rooms are made equal to the length of the director's room not to interrupt wall continuity. Two rooms are added because the area was too big for one room and it is decided that separate debriefing or meeting sessions would be lead for administrative meetings and after exams or simulation practices.

- Standardized patient/outpatient room with control unit (2 for 0-59 student capacity with +1 increment for every 60-student capacity addition)

  - Standardized patient scenario rooms are particularly defined as outpatient rooms which aims to teach medical students both fundamentals of physical examination and patient communications. Therefore, these rooms serve as multipurpose rooms for learning outcomes. Thus, they are planned as outpatient rooms which are not smaller than 10m^2. Normally at page 545 of Neufert's guidelines, service doctor rooms should be between 16-20m^2 [23]. Yet, in the figure demonstrating service doctor room it is seen that there is two doctor units. Therefore, more compact version not lower than 10m^2 of net application area is designed.

  - The SP room is designed as 12,5 m^2 and 14,51 m^2 in total with control unit.

- Standardized patient education, rest and makeup room
  - Standardized patient education room consisted of meeting table which can accommodate both actor briefing and debriefing as well as a makeup unit for the actors to prepare for the scenario to be held.
  - The room is designed to its most compact form and sampled to converge to 10 m^2 area.
- Facility director's office
  - The office is designed for two personnel accommodation (facility director and its assistant) and guest chairs.
- Biomedical and technical staff office
  - Biomedical and technicians' office is designed to house two technicians and one biomedical responsible.
- Nursing skills lab (60 student capacity)
  - Nursing skills lab is kept at the same dimensions for all upscaled drawings and set to accommodate 60 students, 10 students per table which allows group practices. This lab is separated from medicine skills lab and OSCE to reduce any conflicting rotation flows between medicine and nursing students.
- Nursing essentials lab (2 beds for 60 students, 3 beds for continuing 60x student capacities)

    - Nursing essentials lab is a place where nursing students can practice both their skills and scenario-based applications. It is planned as hybrid patient scenario and skills. An essentials lab containing lo-fi dummy full or partial body patient manikins with two beds may be enough for up to 60 students yet for sufficiency, nursing essentials lab is designed with 3 beds to handle higher numbers of students. Also, the room capacity is kept the same for over 60 students where there is no obligations from governmental standards.

- Nursing simulation/patient room with a single bed system and control unit
    - This room is designed to satisfy the needs of nursing simulation scenarios.
    - Simulation room consists of one bed equipped with electronically responsive manikin designed for nursing educations and audiovisual solutions for session recordings in the control unit.
- Nursing debriefing room
    - Room is designed as the same length of essentials lab not to interrupt wall continuity.
    - Debriefing room is designed to accommodate nursing students to have their feedbacks from lecturer and discuss over their simulation sessions.
- Storage room
    - Storage room dimensions are not specifically defined by any entity. Thus, it is placed into the drawing to fulfill empty areas.
    - Yet as it is advised by literature to place appropriate size of storage to maintain simulation room requirements and store spare parts of equipment, a room capable of containing 9 storage shelves is placed in the design.
    - Storage area is kept the same for every student capacity increment.
    - Following the end of the first design, every step is repeated for 60-119, 120-179, 180-239 student capacity facilities.

3.3. DATA ENTRY, CALCULATIONS USING THE STEP FUNCTION AND ERROR ANALYSIS

After the design phase is completed, area dimensions data in unit of centimeter squares are added to MS Excel software and converted to meters square with two significant figures after decimal for data processing. Furthermore, these data are categorized with room names and listed. Afterwards, by these data graphs of alterations of room areas versus the student capacities are created. Additionally, after creation of graphs, greatest integer function equations of these graphs are derived and coefficients of increments are calculated.

A function on the real numbers is referred to as a step function in mathematics if it can be expressed as a finite linear combination of interval indicator functions. A step function is a piecewise constant function with a finite number of pieces, to put it simply.

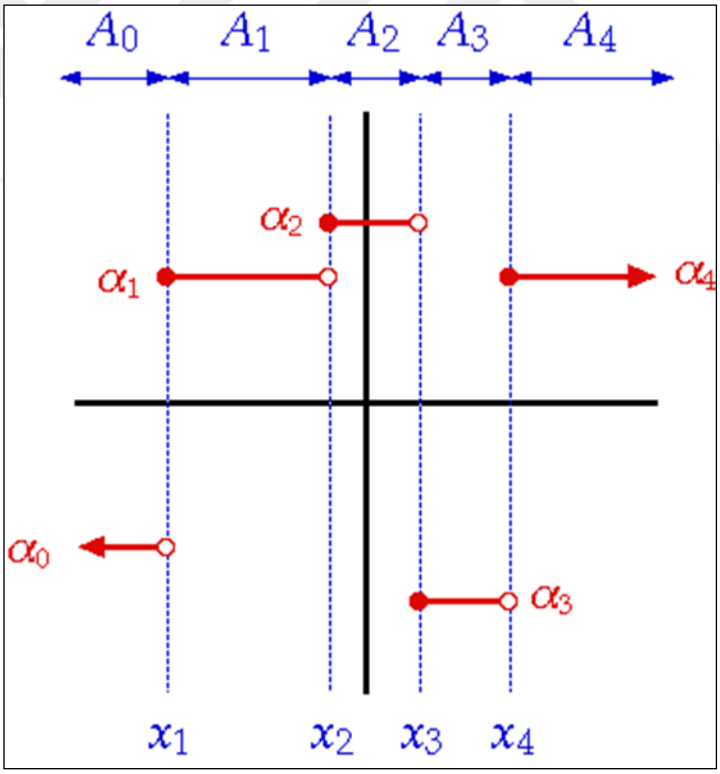

Figure 3.1. A representation of a step function taken from public domain.

So, step functions have constant values in y-axis where variables in x-axis change in a specific domain. These functions divide into two semi-continuous categories as right or left continuous. For example, if a semi-continuous step function is right-continuous, left end point of the function is represented with filled dots and right end points are represented in empty dots. Some step function graphs may not indicate filled or empty end points, but they can be also notated by domain notations given below. Furthermore, step functions have another two properties as floor functions and ceiling functions where graphical characteristics of a floor function is incremental and ceiling function is decremental.

For these reasons step-functions are constant at a domain of variables and uniformly increase, to quantize area problem and upscaling in this study, step functions and specifically floor functions (greatest integer functions) are used.

Below, an example of floor function and calculation to be used in this study is given:

$$\mathrm{f(x)} = \mathrm{floor(x)} = \lfloor x \rfloor \tag{3.1}$$

for a given x value such as x = 2.35 → $\lfloor x \rfloor$ = 2. For the greatest integer functions, a value of x is equal to the nearest integer value smaller than given x value.

$$f(x) = a\lfloor b(x-h) \rfloor + k \tag{3.2}$$

$$D: [g,t), (g,t]$$

$$x, a, b, k \in \mathbb{R}$$

$$g, t \; and \; h \; \in \mathbb{Z}$$

Where **(h,k)** is coordinate pair and **D: [g,t), (g,t]** is the domain range notation of **f(x)**

- Left continuous
  - D: (g,t]; Left end point of the step = **open**
  - D: (g,t]; Right end point of the step = **closed**
- Right continuous
  - D: [g,t); Left end point of the step = **closed**

  - D: [g,t); Right end point of the step = **open**

- **a** = variance
- **b** = 1/step length
- **h** = coordinate of x-axis
- **k** = coordinate of y-axis
- $\mathbb{R}$ = domain of real numbers
- $\mathbb{Z}$ = domain of integers

By this equation, area values and step function representations are to be given and extrapolation will be calculated in this study.

Later, an extrapolation of these minimum area necessities for facilities to serve for 240-299, 300-359 and 360-419 student capacities are calculated room by room and the minimum of general total area dimensions are calculated. Concluding calculations, a data table is made and a final general graph of area increments are plotted.

3.4. ERROR ANALYSIS

After data collection and calculations, standard deviation standard error and confidence interval with %95 probability analysis is made to test the significance of the study.

As the study focuses on the changing values between area parameters, standard deviation and standard error analysis are applied on the areas between measured (real) area values (RV), rectified values (EV1) indicating the area values after calculating and applying arithmetic average of increment rates in areas step by step on to area value for 0-60 student capacity and rounded up values (EV2) which are rounded up values of EV1 to the nearest greater integer.

Standard deviation formula used in the calculation is as follows:

$$\sigma = \sqrt{\frac{\sum(x_i - \mu)^2}{N}} \tag{3.3}$$

Where;

- σ: standard deviation
- N: size of the sample
- x_i: measured values
- μ: the mean of the sample

Standard error formula used in the calculation is as follows:

$$SE = \frac{\sigma}{\sqrt{N}} \tag{3.4}$$

Where;

- SE: standard error
- σ: standard deviation
- N: size of the sample

Confidence interval formula used in the calculation is as follows:

$$CI = \mu \mp 1.96\frac{\sigma}{\sqrt{N}} \tag{3.5}$$

Where;

- σ: standard deviation
- N: size of the sample
- CI: confidence interval

- μ: the mean of the sample

After calculations and tables were made, a general table with confidence intervals is produced.

4. RESULTS AND DISCUSSIONS

4.1. RESULTS

As mentioned in both context of this study and methodology, there can not be any template design for all institutions or organizations for simulation education other than fulfilling the fundamental requirements for a simulation center/lab declared by officials to begin their operative life. Therefore, this study concentrated on the general standards for a faculty to begin its education by responsible governmental body in Turkiye called Y.Ö.K (Yüksek Öğretim Kurulu: Higher Education Organization). As summarized in methodology, standards for simulation and practical education part of the Y.Ö.K's regulations are taken into account.

As a brief summary again, Y.Ö.K's regulations for up to 60 student capacity faculties involved; anatomy dissection room (1 master, 4 student tables, +1 student table for every 60 student increment and sufficient cadaver storage units), anatomical models lab (at most 10 students per table), medical education labs consisting of skills lab and SP labs (2 SP rooms for 60 students and +1 room increment for every 60 students) for medical faculties and basic skills lab, nursing essential lab and simulation lab given in detail in official document.

Simulation centers and laboratories around the world differ in function and size. Therefore, it could not be possible to approximate any space needs before starting the design. When scenario-based simulation centers containing emergency, operation room, delivery room type simulation areas observed, it is seen that approximately at least 1000 m2 of space is needed. Yet, this study's main concern is not to design a scenario-based clinical simulation environment and as there were no standard metrics published for required areas, Ernst Neufert's construction and ergonomic design standards are taken into account.

4.2. DESIGN PHASE

Some labs and rooms are static in areas where their dimensions don’t change by student capacity increment. These rooms are biomedical office, technicians’ office, changing rooms and debriefing rooms. All of the rooms are kept rectangular in shape to keep net area parameters basic and approximate. Additionally, all of the rooms are designed for 0-59 student capacity and upscaled for every 60 students added. Upscaling parameters are explained together under the same item for the readers’ better understanding. Other details of the design phase are explained room by room below.

4.2.1. Operational/Administrative Rooms

- *Biomedical office:* Capable of placing 3 biomedical technicians to help student rotations to flow uninterrupted and troubleshoot any hardware wise problem that can occur.
- *Management/assistant and director’s office:* This room is for facility director and its assistant to manage their administrative work.
- *Changing rooms:* Two rooms in total, one for men and one for women for their donning and doffing processes.

4.2.2. Medicine Faculty

Simulation areas of medicine faculty consisted of Skills Lab, Anatomic Models Lab, Anatomy Dissection Lab, Cadaver Preparation Room and SP Rooms Area. Each design considerations of these rooms are explained below separately.

4.2.3. Skills and Objective Clinical Skills Examination (OSCE) Lab

Skills and OSCE Lab is a lab where students can both train their skills and have their objective clinical skills examinations (OSCE). Lab is designed to have 6 tables and 10 students per table to allow 60 students to work along. As like as it allows 60 students simultaneously, 6 categories of hardware which are a declared in Y.Ö.K's regulations as suturing models, injection models, airway models, CPR models, nasogastric tube models and male/female urinary catheterization models can be placed into these 6 tables for OSCEs[10,11]. Each table were separated from each other by 3 meters and each table locations are planned as one OSCE station. These stations contain their storage areas themselves with cabinets besides the outer walls. Additionally, as students in other stations should not see others in OSCEs, these stations are enclosed by extensile curtains/covers. Also, a student waiting area is added to the entrance of the lab where facilitators can easily navigate students in and out of lab and also manage OSCE times effectively. Waiting area is also planned as students may cause trafficking in corridor. Skills/OSCE Lab does not change in area when student capacities increase that students can be divided into sections and rotation is possible.

4.2.4. Anatomic Models Lab

Anatomic models lab is designed alike with anatomy and dissection lab. As the regulations declared 1 master and 4 tables for students, models lab is also designed as 1 master and 4 tables (10 students per table). As the student capacity increases, table count increases per 120 students not to interrupt the rectangular shape of the room and formation of the lab. This lab contains teacher desk, barcovision, master table, student table and storage cabinets of anatomical models. Each table is separated from each other 130 cm horizontally and 240 cm vertically.

4.2.5. Anatomy Dissection Lab

Anatomy and dissections lab is a place where students should work on cadaveric materials. Therefore, special considerations should be taken into account. This lab contained 1 master and 4 student tables. Each student table have its own screen that lecturer can show students anatomical landmarks and lecture materials. The lab contains one hand washing unit as well as chemicals/emergency cleaning eye shower. Tables are located crosswise to reduce width of the lab and allow cadavers to be placed on them easier. Student tables increased one by one in every 60 student capacity addition. Therefore, area increment is linear.

4.2.6. Cadaver Preparation Room

This room is explained as to be sufficient to supply anatomy lab where 0-59 student capacity facilities should 2 cadaver storing units (FA tanks) and cadaver should increase as one for every 60 students. FA tanks are found to be two or four cadaver capacity in the market. Thus 2 cadaver capacity FA tanks are used in the study. FA tank count increases in every 120-student capacity increment and has the main role in enlarging of the preparation room. Other materials in the cadaver room can be listed as:

- Morgue unit
- Cadaver preparation unit
- Anatomy lab student materials unit
- Cadaver transport cart
- Hand washing unit and chemical/emergency cleaning eye shower

4.2.7. SP Rooms and Actor Education/Preparation Area

For SP rooms, as these rooms are specifically for communication skills and patient management, they are behaved as a unit. A single unit of standardized patient room is designed as a outpatient room with 12.5m^2 area consisting of doctor desk, patient seat, cleaning unit and examination bed and a control unit of 2m^2 with one sided glass for the facilitator to see the inside of the room. Thus, one unit appeared to be 14.5m^2 in total. 0-59 student capacity design had 2 units of SP Rooms and one more unit is added at the upscaling designs. Therefore, the increment of SP Room area requirements are linear.

Actor education/preparation room is an additional room for SP Room area where standardized patients are to be briefed and educated for the scenario to be realized. The room also involves makeup unit. Increment in such room is based on the 180-student capacity increment where 0-59 capacity design has 4 seated briefing table and the formation is not interrupted until additional actors are needed. In the addition phase, another 4 seated table is added.

4.2.8. Debriefing Rooms

In the design, to fulfill the remaining area, two debriefing rooms are added where administrative, lecturer, student meetings or debriefing sessions for OSCEs can be held.

4.2.9. Nursing Faculty

Simulation areas of medicine faculty consisted of Skills Lab, Essentials Lab, Simulation Lab and Debriefing Room. Each design considerations of these rooms are explained below separately.

4.2.10. Nursing Skills Lab

A lab that can operate with 60 students simultaneously. 6 tables of 10 students per table are placed into this lab as well as storage cabinets for the skills lab materials. The lab also contains teacher desk, demonstration stage and barcovision. This lab doesn’t change in are with student capacity increment.

4.2.11. Nursing Essentials Lab

As there are no declared any increment or decrement per student capacity in the regulations, first design of essentials lab consisted of two nursing essentials practice beds but when the student capacity exceeds 120 students, one more bed area is added for the ease of student flows and practice quality. Therefore, in this section of the study, addition is made on top of general requirements.

At 0-59 student capacity, lab consisted of 2 essentials bed, nursing desk, drug preparation unit and storage room for necessary equipment.

4.2.12. Nursing Simulation Lab

Nursing simulation lab area is one of the static rooms that is not affected by the student capacity. Need of extra labs or beds are discussable yet, one simulation room consisting of electronically responsive simulator and scenario-based area is satisfactory for regulations. That is why, nursing simulation area is kept static not to increase the minimum area and keep the design budget friendly.

4.2.13. Nursing Debriefing Room

After simulation practice, there is a need of debriefing for nursing students. Therefore, a room which is also static and dependent on the number of simulation labs that a nursing schools contains, is placed into design to satisfy the debriefing needs of students. Debriefing room is designed separately from medicine faculty and nursing classrooms because it is thought that immediate debriefing sessions could be more manageable and a separate room suited for debriefing/meeting sessions could be beneficial.

4.2.14. The Design

As mentioned above, first design was 0-59 student capacity facility.

To design the blueprints of the study, AutoCAD software and scale of centimeter is used. Due to the nature of the study, where the most important and useful parameters would be area, area parameters are measured by the software rather than calculating areas depending on the width and length of the design components. An example of scenario-based simulation center with a circular flow design is created that contained two blocks for medicine and nursing faculty. As scenario-based simulation is the most recommended simulation type worldwide, Figure 4.1. aimed to show how a basic scenario-based simulation center would look like.

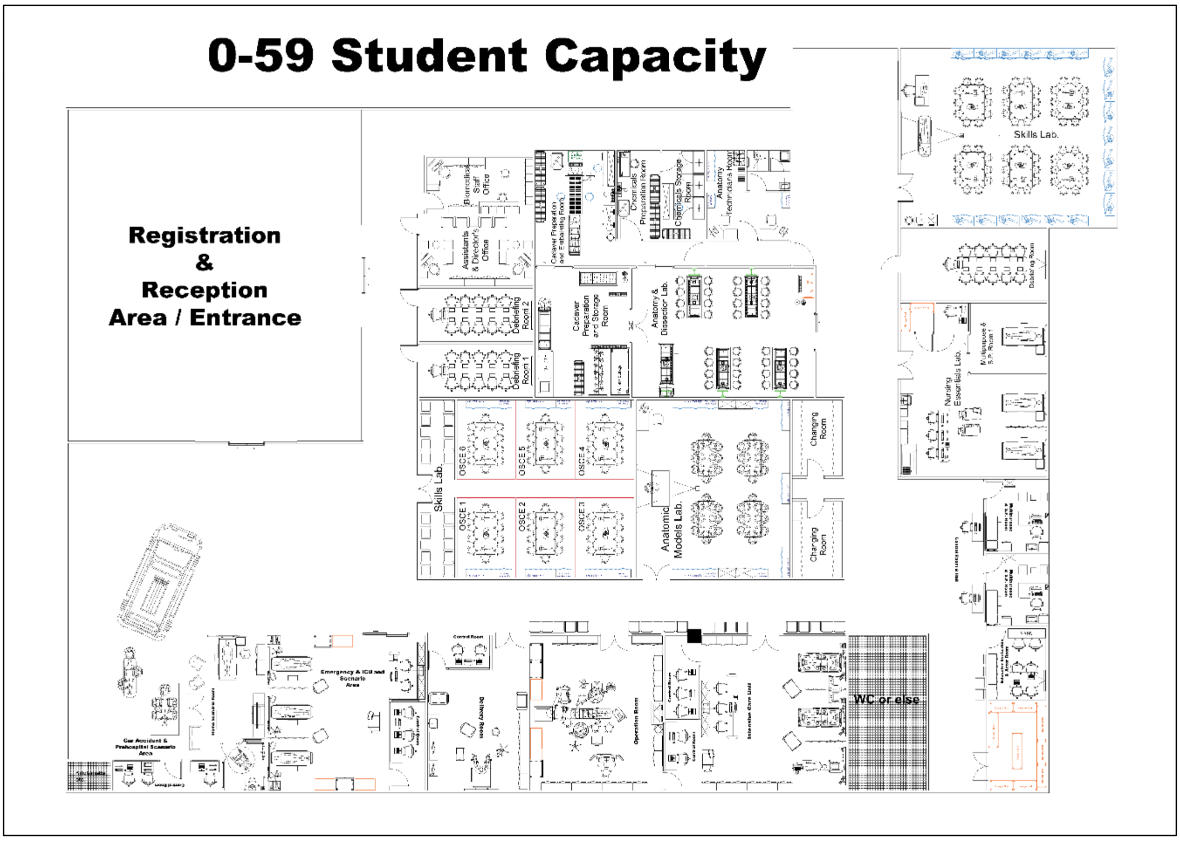

Figure 4.1. Example scenario-based simulation center

At the designing phase of the example scenario-based simulation center, standards given by Y.Ö.K regulations are applied to the required laboratories. After the first design, only labs in medicine faculty and nursing faculty area is upscaled.

4.3. MEDICINE FACULTY DESIGNS

The design is kept rectangular as possible to approximate net area requirements easier. As it was thoughtfully designed as a scenario-based simulation center, main medicine faculty block also contained 2 debriefing/meeting rooms and director’s office in joint to decrease net area necessity in the general design. A different architectural approach is also preferrable. Moreover, every manipulation over the design depending on the student capacity is made over the main block. Additionally, SP and Actor rooms are evaluated separately from main medicine faculty block that they are behaved as single units and they contributed to the area requirements numerically.

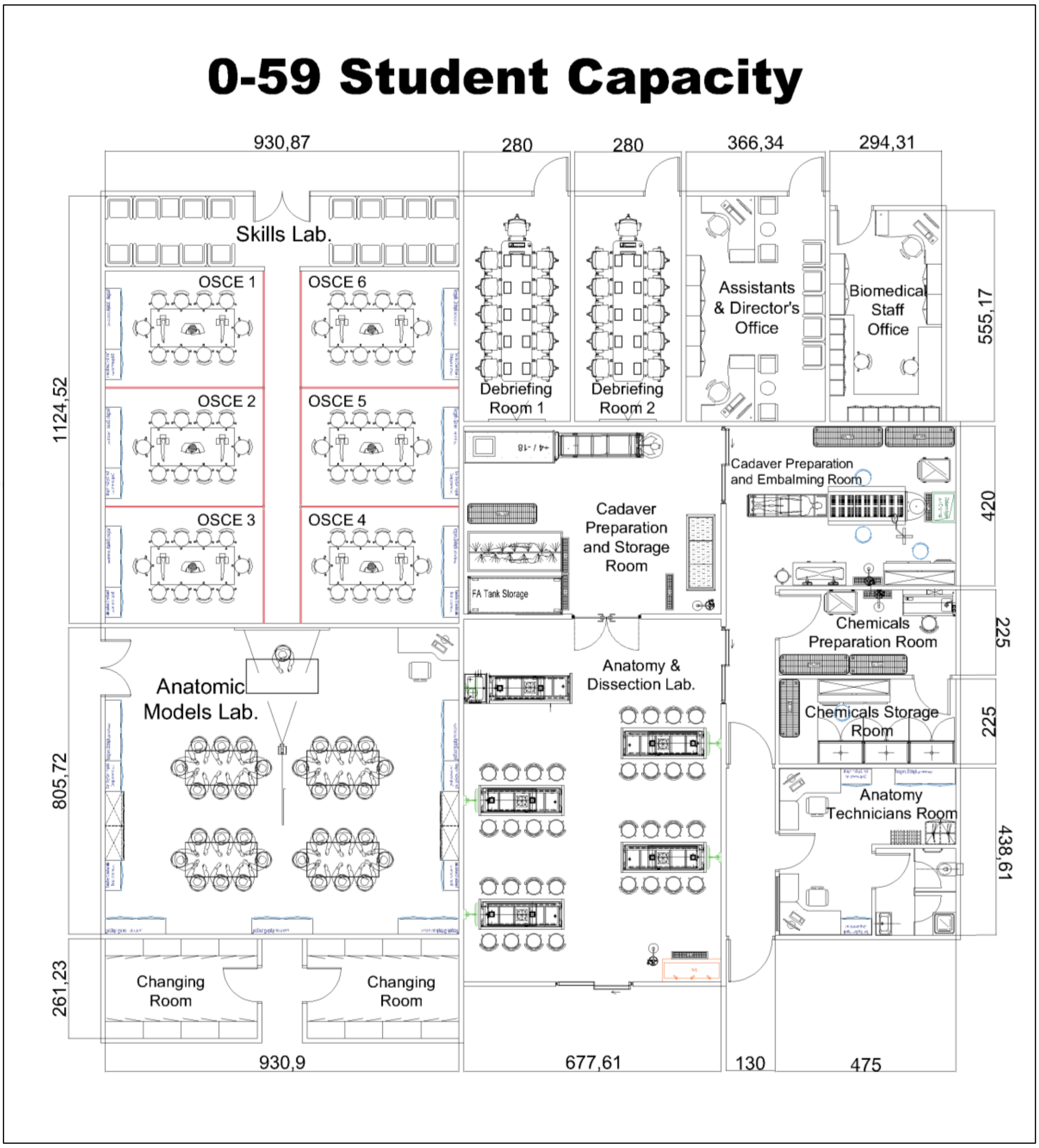

Figure 4.2. 0-59 student capacity design containing Skills & OSCE Lab, Anatomy Models Lab, Cadaver Preparation Room and Anatomy Dissection Lab for medicine faculty (SP rooms and actor room excluded). Dimensions are given in 1:1 cm scale.

The main block for the medicine faculty where anatomy dissection lab, anatomical models lab and OSCEs were put together to ease navigation ease. After finishing the first design for the 0-59 students block, only anatomical models lab, anatomy dissection lab and cadaver preparation rooms have changed in size depending on the increasing student capacities.

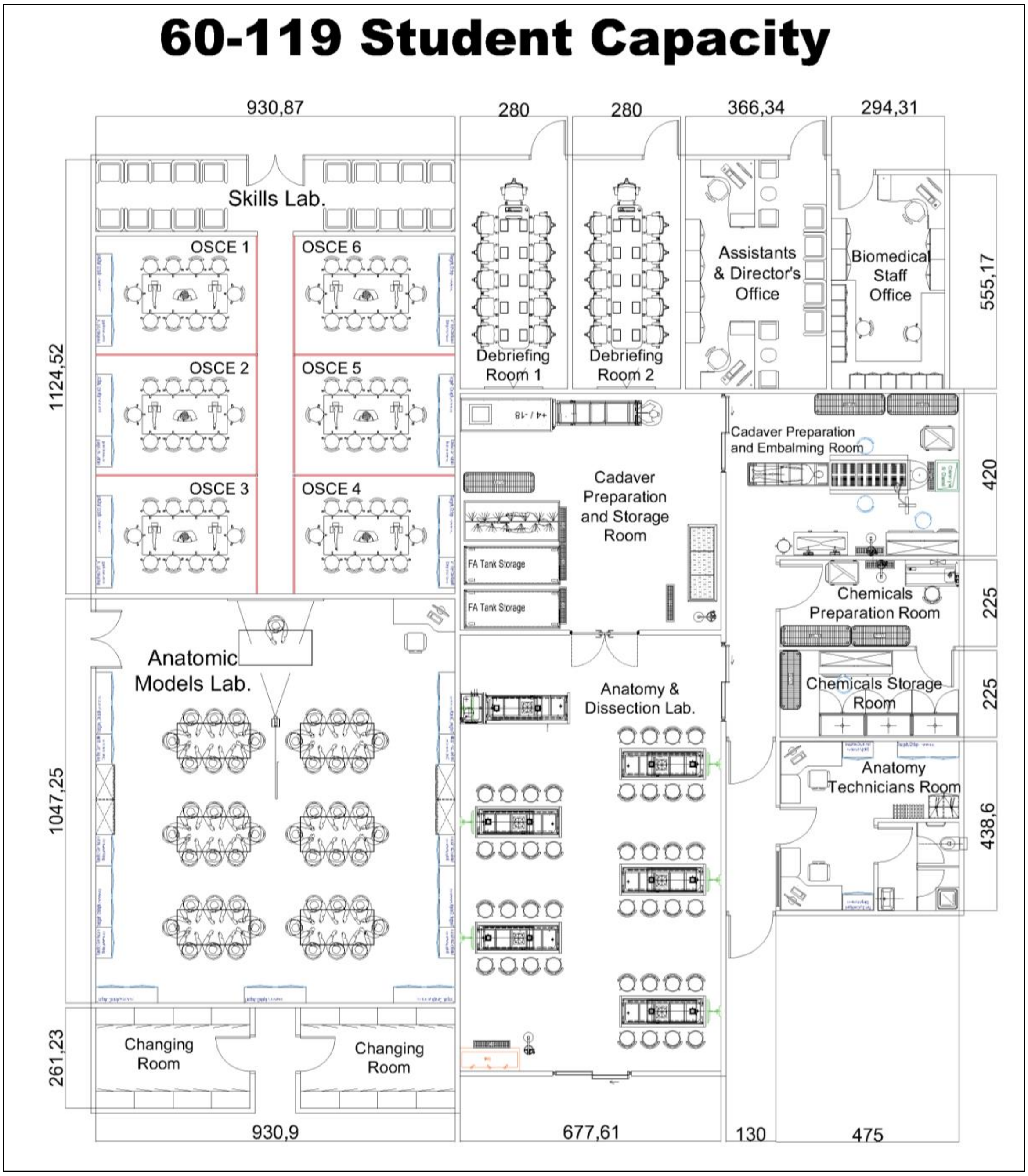

Figure 4.3. Main block of medicine faculty for first step of student increment. Dimensions are given in 1:1 cm scale.

In every step, only the length of the current design has changed where width of the rooms are kept static.

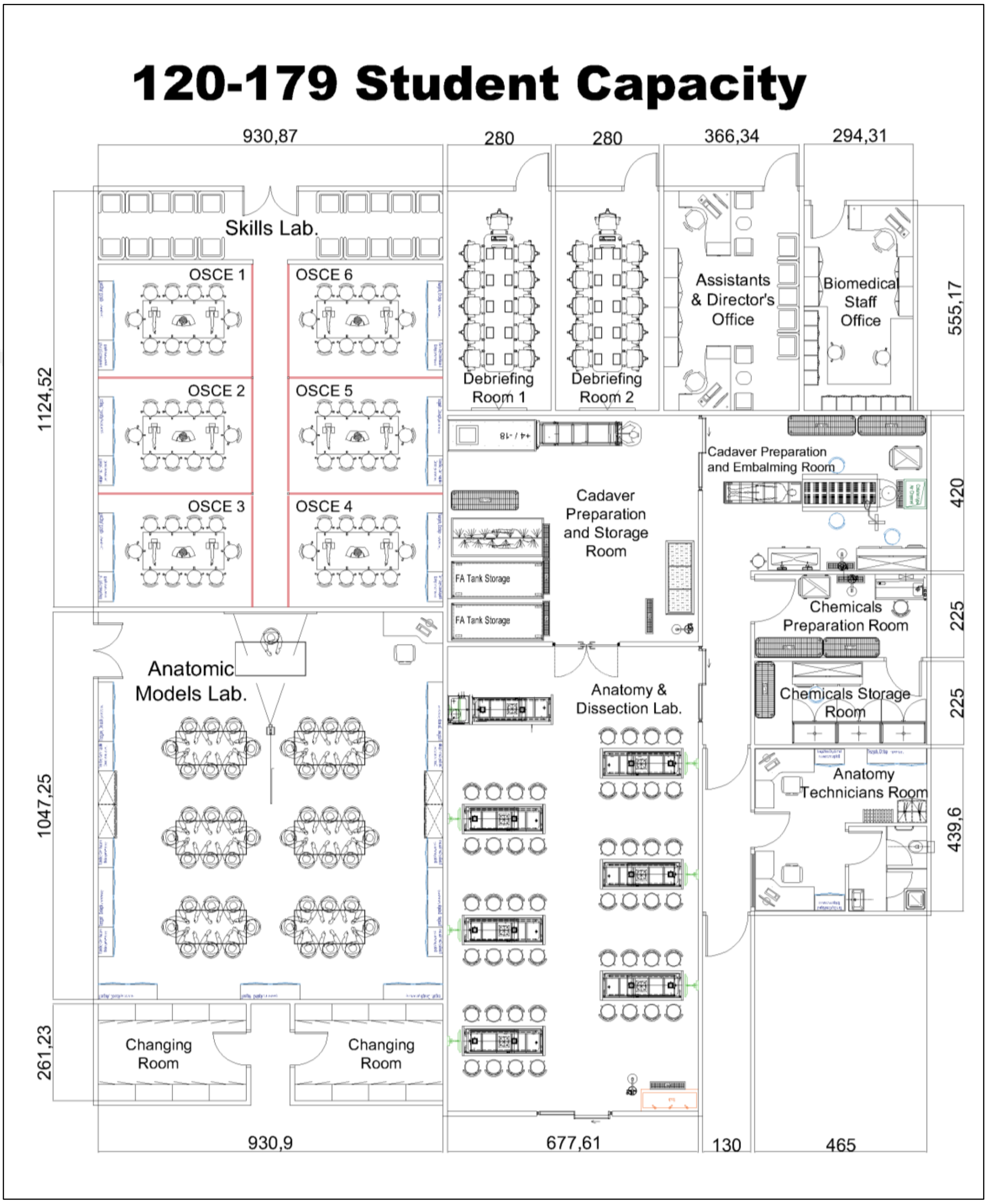

Figure 4.4. Main block of medicine faculty for second step of student increment. Dimensions are given in 1:1 cm scale.

After one more +60 student increment, changing rooms' locations were changed to fill the gap between anatomical models lab and anatomy dissection lab. Also, it was advantageous to place director's office near the main block to save space from the general design.

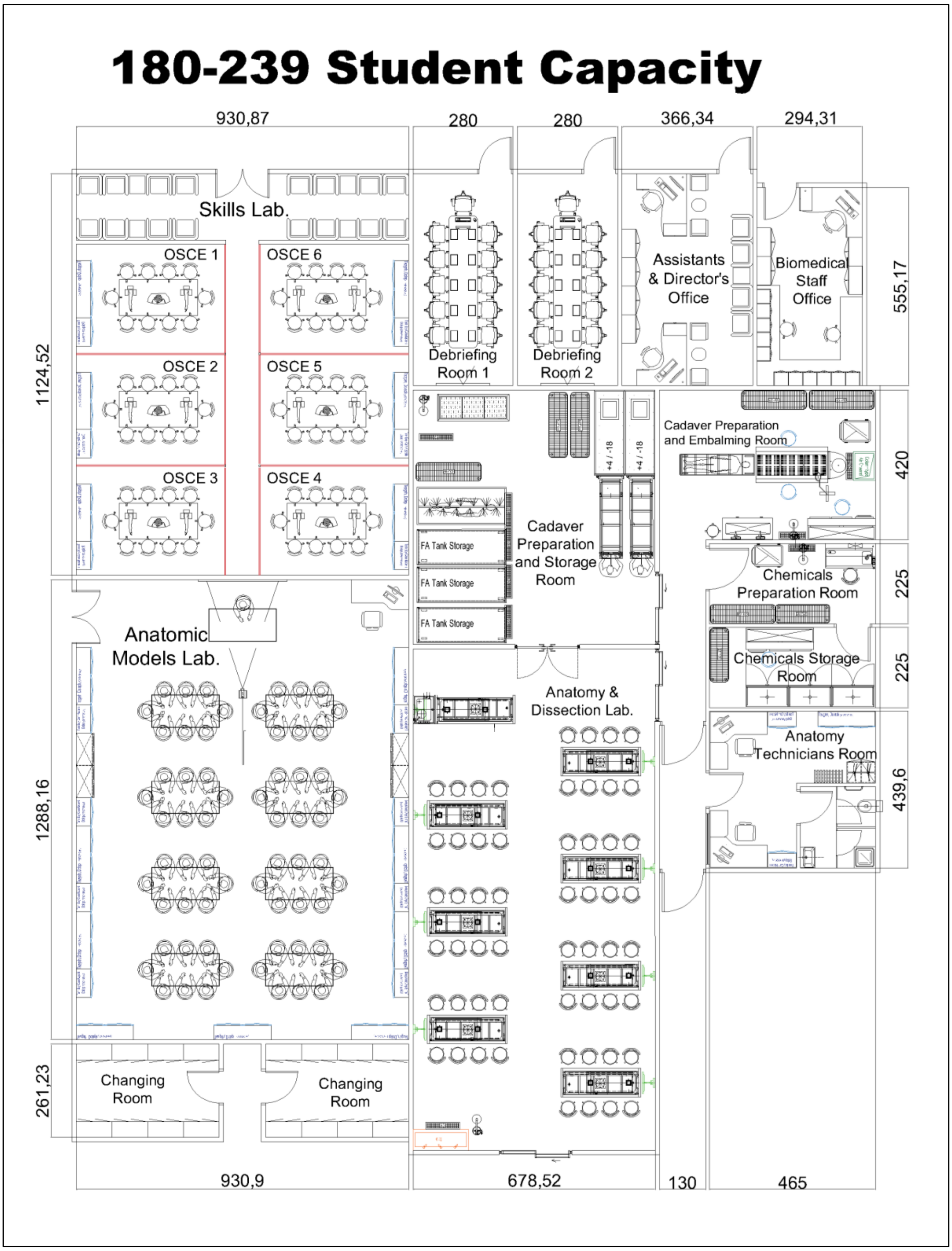

Figure 4.5. Medicine block for 180-239 student capacity. Dimensions are given in 1:1 cm scale.

180-239 student capacity was the last design for the design phase of the main block of medicine faculty. Afterwards, extrapolation of data extracted from the design is made.

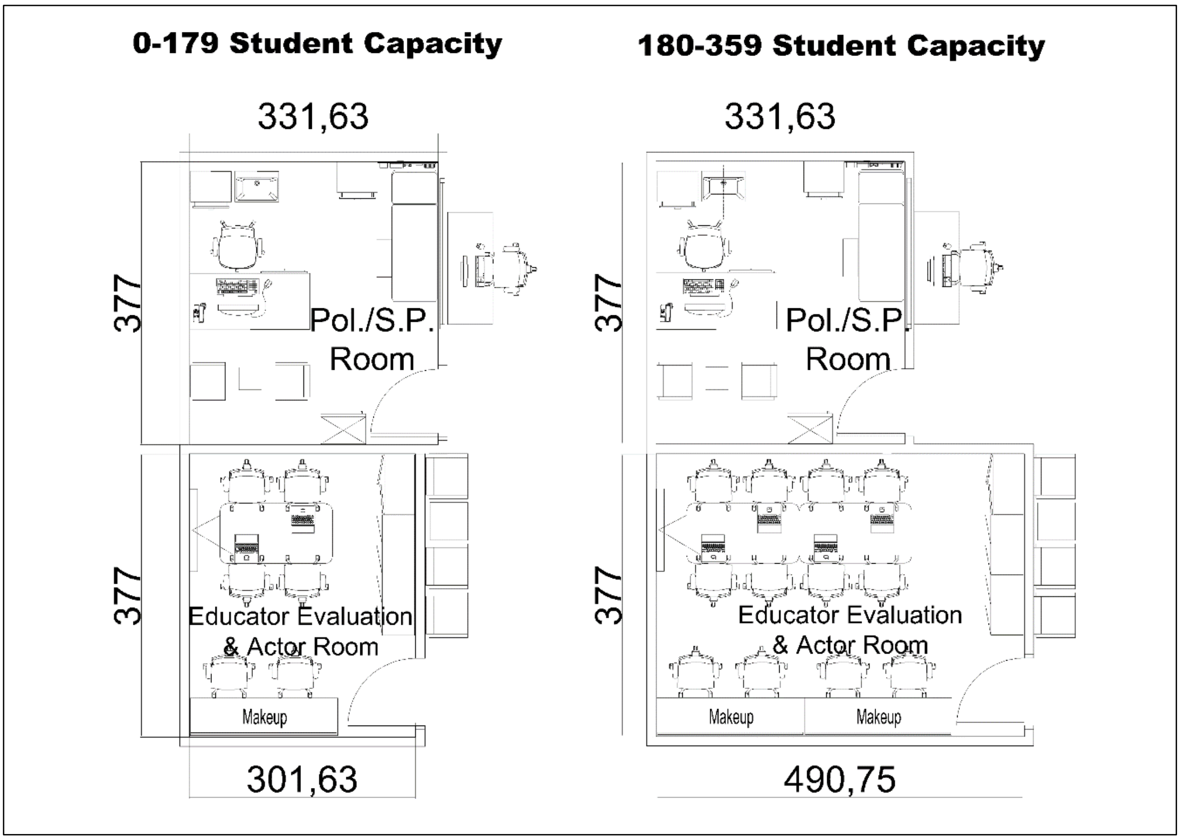

Figure 4.6. SP and actor room designs where the only size of the actor rooms change in 180 student increment steps and SP rooms are treated as units. Dimensions are given in 1:1 cm scale.

The last component of required area for main block of medicine faculty was standardized patient application rooms and actor's rooms. As it can be seen from Figure 4.6, SP room dimensions stayed the same at all increments where they were treated as single units and increased in count as one more for every 60 students added for the capacity of the faculty (e.g.: 3 units for 60-119 student capacity, 5 units for 180-239 student capacity). The real reason of separating/putting in different location the SP units and actor rooms from the main block of the medicine faculty was all about design considerations. Students having their lecture in anatomical models could be interrupted by the scenario applications. Also, as the

SP units increased linearly in numbers, it is thought to be better in different location rather than jointing these units to the main block. Yet SP units and actor rooms are counted as the component of main medicine block.

4.4. NURSING FACULTY DESIGNS

Finishing the main medicine block has finished, nursing block is designed in the same simulation center on a different location. Skills lab of medicine faculty and nursing faculty could be jointly used but they are separated because it could interrupt general student flow. Therefore, nursing faculty block had its own skills lab. Furthermore, as it was mentioned above, there were no metric regulations for the nursing schools in governmental standards. That is because, nursing block could be maintained static for all student capacities, but this study preferred to slightly increase the inner content of the rooms against the student capacities to help increase the comfort of student flow.

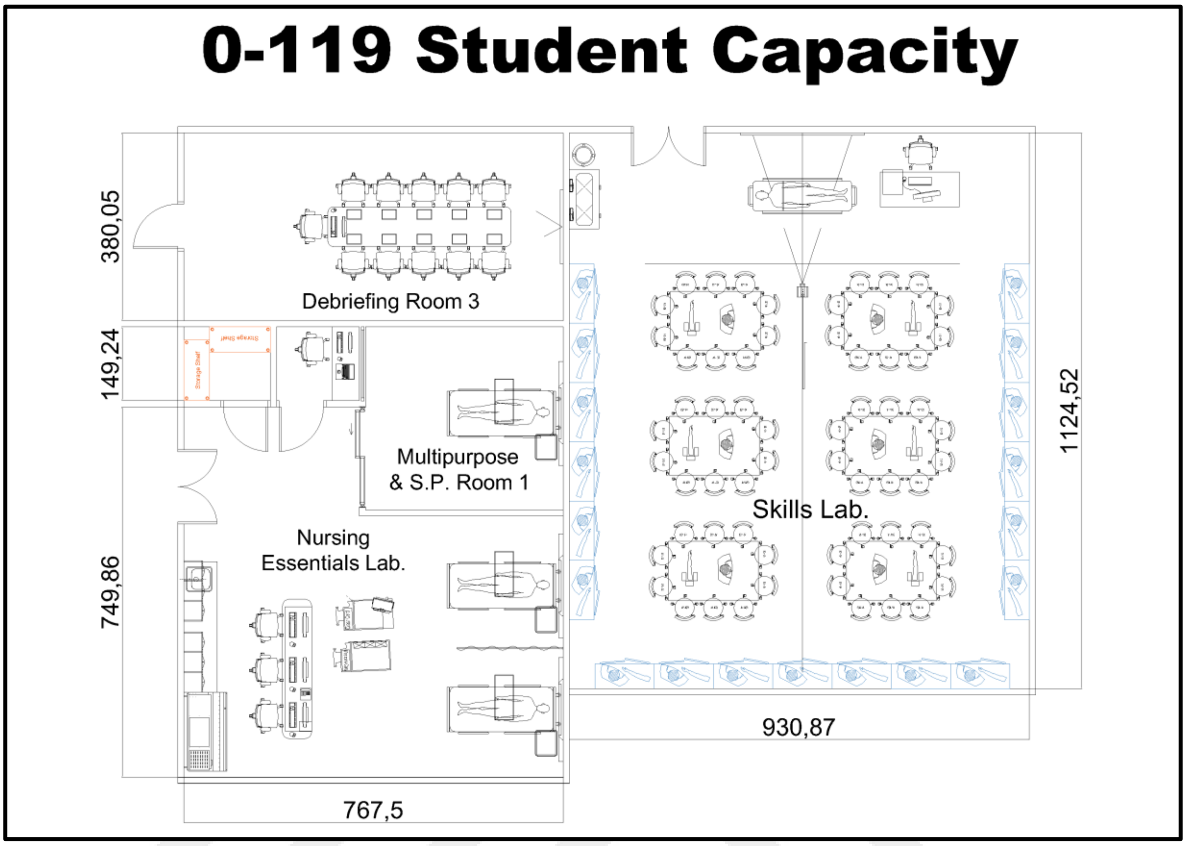

Figure 4.7. Nursing faculty main block for 0-119 student capacity containing simulation room, essentials lab, its own debriefing room and skills lab. Dimensions are given in 1:1 cm scale.

Nursing skills lab was designed to hold up to 60 students at the same time same as the medicine faculty's skills lab/OSCE as well as 10 students per table. Additionally, nursing essentials and simulation rooms was planned to hold 30 students where they could be divided into two groups of 30 students. So, this planning suggests that 10 students at most can study in every practical unit as simulation bed, essentials bed and skills lab tables.

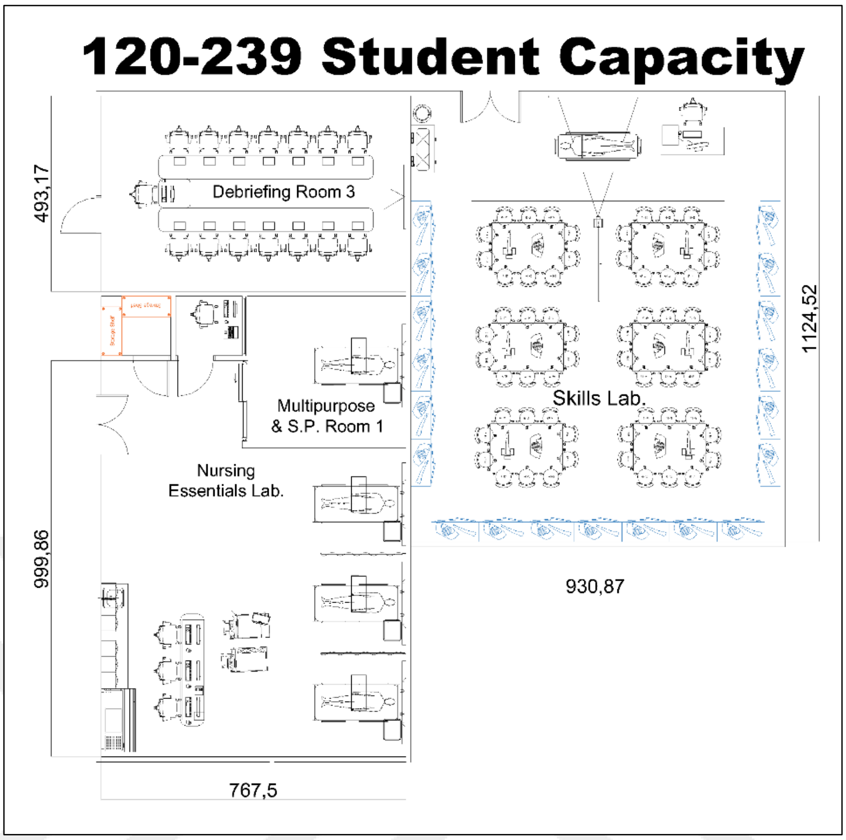

Figure 4.8. Nursing Faculty block for 120-239 students. Dimensions are given in 1:1 cm scale.

The increment in this design was only adding one more bed to nursing essentials room for better student handling. Aside from increasing bed numbers, lab hours of students could also be engineered to satisfy educational goals and also it would be more budget friendly yet as the student capacity increases, quality of group works and lab hours would decrease. That is why, incremental pattern is also preferred in this section of the study.

4.5. DATA PROCESSING

After finishing designs, areas are calculated and transferred to MS Excel software to see parameters together and for further calculations. Raw data showed that room by room area increment were very close to each other but not optimally uniform in cadaver preparation room, anatomy dissection lab and anatomical models lab. As the SP rooms were treated as units/stations, changes in area were perfectly uniform and linear. Table 4.1 shows the raw data and the total net area for active simulation/education sessions acquired from the designs and unrectified changes by the notation Δx. All data outputs were converted to m2 from cm2 and the final value is reduced to two significant figures after decimal. Thus, all of the values are rounded by the software.

Table 4.1. Raw data of areas after design phase

Student Capacity	**0-59**			**60-119**			**120-179**			**180-239**		
	Qty.	**Δx**	**Area (m^2)**	**Qty.**	**Δx**	**Area (m^2)**	**Qty.**	**Δx**	**Area (m^2)**	**Qty.**	**Δx**	**Area (m^2)**
Skills Lab / OSCE	1	0,00	104,68	1	0,00	104,68	1	0,00	104,68	1	0,00	104,68
Anatomic Models Lab	1	0,00	**75,00**	1	**22,48**	**97,49**	1	0,00	97,49	1	**22,48**	**119,97**
Debrief 1	1	0,00	16,61	1	0,00	16,61	1	0,00	16,61	1	0,00	16,61
Debrief 2	1	0,00	16,61	1	0,00	16,61	1	0,00	16,61	1	0,00	16,61
Directors Office	1	0,00	21,73	1	0,00	21,73	1	0,00	21,73	1	0,00	21,73
Cadaver Prep Room	1	0,00	33,56	1	**7,98**	**41,54**	1	0,00	41,54	1	**6,77**	**48,31**
Anatomy & Dissection Lab.	1	0,00	64,68	1	**11,90**	**76,58**	1	**8,49**	**85,07**	1	**10,20**	**95,27**
Cadaver Embalming Room	1	0,00	25,41	1	0,00	25,41	1	0,00	25,41	1	0,00	25,41
Chemicals Preperation Room	1	0,00	10,46	1	0,00	10,46	1	0,00	10,46	1	0,00	10,46
Chemicals Storage Room	1	0,00	10,46	1	0,00	10,46	1	0,00	10,46	1	0,00	10,46
Anatomy Technicians Room	1	0,00	20,44	1	0,00	20,44	1	0,00	20,44	1	0,00	20,44
Changing Room 1	1	0,00	10,45	1	0,00	10,45	1	0,00	10,45	1	0,00	10,45
Changing Room 2	1	0,00	10,45	1	0,00	10,45	1	0,00	10,45	1	0,00	10,45
Pol./Std Patient Room	2	0,00	29,01	3	**14,51**	**43,52**	4	**14,51**	**58,02**	5	**14,51**	**72,53**
Actor's Room	1	0,00	11,37	1	0,00	11,37	1	0,00	11,37	1	**7,13**	**18,50**
Nursing Ess & Sim Room	1	0,00	69,97	1	0,00	69,97	1	**19,19**	**89,15**	1	0,00	89,15
Nursing Skills Lab	1	0,00	104,68	1	0,00	104,68	1	0,00	104,68	1	0,00	104,68
Debriefing Room 3 (Nursing)	1	0,00	29,17	1	0,00	29,17	1	0,00	29,17	1	0,00	29,17
Biomedical Office	1	0,00	16,34	1	0,00	16,34	1	0,00	16,34	1	0,00	16,34
Total net Area of Pracitce	1	**0,00**	**681,07**	1	**56,87**	**737,94**	1	**42,19**	**780,13**	1	**61,09**	**841,22**

To make increase rates uniform, arithmetic average of the change in areas are calculated specific to the design component. Afterwards new values based on 0-59 capacity design is calculated. Table 4.2 shows that differences in areas after this rectification was neglectable considering the specific area needs for a simulation center components yet it affected the overall area needs of the simulation center.

Table 4.2. Data after rectified increase rates

Student Capacity	0-59			60-119			120-179			180-239		
	Qty.	Δx	Area (m^2)	Qty.	Δx	Area (m^2)	Qty.	Δx	Area (m^2)	Qty.	Δx	Area (m^2)
Skills Lab / OSCE	1	0,00	104,68	1	0,00	104,68	1	0,00	104,68	1	0,00	104,68
Anatomic Models Lab	1	0,00	**75,00**	1	**22,48**	**97,49**	1	0,00	97,49	1	**22,48**	**119,97**
Debrief 1	1	0,00	16,61	1	0,00	16,61	1	0,00	16,61	1	0,00	16,61
Debrief 2	1	0,00	16,61	1	0,00	16,61	1	0,00	16,61	1	0,00	16,61
Directors Office	1	0,00	21,73	1	0,00	21,73	1	0,00	21,73	1	0,00	21,73
Cadaver Prep Room	1	0,00	33,56	1	**7,38**	**40,93**	1	0,00	40,93	1	**7,38**	**48,31**
Anatomy & Dissection Lab.	1	0,00	64,68	1	**10,20**	**74,88**	1	**10,20**	**85,07**	1	**10,20**	**95,27**
Cadaver Embalming Room	1	0,00	25,41	1	0,00	25,41	1	0,00	25,41	1	0,00	25,41
Chemicals Preperation Room	1	0,00	10,46	1	0,00	10,46	1	0,00	10,46	1	0,00	10,46
Chemicals Storage Room	1	0,00	10,46	1	0,00	10,46	1	0,00	10,46	1	0,00	10,46
Anatomy Technicians Room	1	0,00	20,44	1	0,00	20,44	1	0,00	20,44	1	0,00	20,44
Changing Room 1	1	0,00	10,45	1	0,00	10,45	1	0,00	10,45	1	0,00	10,45
Changing Room 2	1	0,00	10,45	1	0,00	10,45	1	0,00	10,45	1	0,00	10,45
Pol./Std Patient Room	2	0,00	29,01	3	**14,51**	**43,52**	4	**14,51**	**58,02**	5	**14,51**	**72,53**
Actor's Room	1	0,00	11,37	1	0,00	11,37	1	0,00	11,37	1	**7,13**	**18,50**
Nursing Ess & Sim Room	1	0,00	69,97	1	0,00	69,97	1	**19,19**	**89,15**	1	0,00	89,15
Nursing Skills Lab	1	0,00	104,68	1	0,00	104,68	1	0,00	104,68	1	0,00	104,68
Debriefing Room 3 (Nursing)	1	0,00	29,17	1	0,00	29,17	1	0,00	29,17	1	0,00	29,17
Biomedical Office	1	0,00	16,34	1	0,00	16,34	1	0,00	16,34	1	0,00	16,34
Total net Area of Pracitce	1	**0,00**	**681,07**	1	**54,56**	**735,63**	1	**43,89**	**779,52**	1	**61,69**	**841,22**

After data collection and data rectification, step function graphs are plotted and functions of the rooms are calculated. As stated in the introduction, step functions are type of functions that a set of given variables are equal to same results depending on the domain range of the variables. Graphs of these functions resemble to steps and these functions are finite. Accordingly, as these functions have a jump in a specific value, domain ranges are notated as closed and open boundaries. Closed boundaries indicate that the value given to the equation belongs to the set of values to that specific step where open sided boundaries indicate that the value at the open end of the step belongs to the nearest step. Step functions may have decremental, incremental or hybrid structures. As part of the step functions, there are sub-categories of step functions depending on the data set being processed. The most common type of step functions used for the type of data like this study are *Greatest Integer Functions* and *Least Integer Function*. The difference between these two functions is where a real number is rolled down to the nearest lesser integer or rolled up to the greater integer. Thus, they have their own notation type as explained in the introduction part. By the knowledge so far, greatest integer functions belonging to step functions are to be used for data calculations and extrapolation of student capacity versus area iterations. Data are input to MS Excel manually to plot the graphs, yet this function can be executed and plotted with different software such as MATLAB. MATLAB has its own math library where these functions can be run by as it is generally noted as and also noted in MATLAB with "*floor(x)*" function. There are several other notations in mathematics as well but not to interrupt clearance, functions are to be tagged as "*f(x) = floor(x)*".

Below, general representation of the greatest integer/floor function and the details of the *f(x) = floor(x)* function is given as:

$$f(x) = a\lfloor b(x-h)\rfloor + k \tag{3.2}$$

$$D: [g, t)$$

$$x, a, b, k \in \mathbb{R}$$

$$g, t \text{ and } h \in \mathbb{Z}$$

Where **(h,k)** is coordinate pair and **D: [g,t)** is the domain range of **f(x)**, left end point of the step is **closed**, right end point of the step is **open**, f(x) is right-continuous function

In this study, all of the step functions and step function graphs have incremental structures and range boundaries are closed at the left side of the step and open in the right side as well as ranges or so-called step length is 60 integers (e.g.: noted as [60,180).). Boundaries are decided to be closed and open in this style because governmental regulations declared that all of the minimum requirements are designed "up to" 60 students which implied that standards are given for student capacity <60 and indicated that SP rooms should be 3 for 60 and 60-120 students. Therefore, Table 4.1 and Table 4.2 threads in the row of *Student Capacity* like *0-59*, *120-179* are written accordingly rather than 0-60 as well as mathematical equations and notations are not given yet.

Firstly, step graphs of all laboratories and rooms changing in size are plotted. After the plot, general graph is separated into specific graphs for labs and rooms.

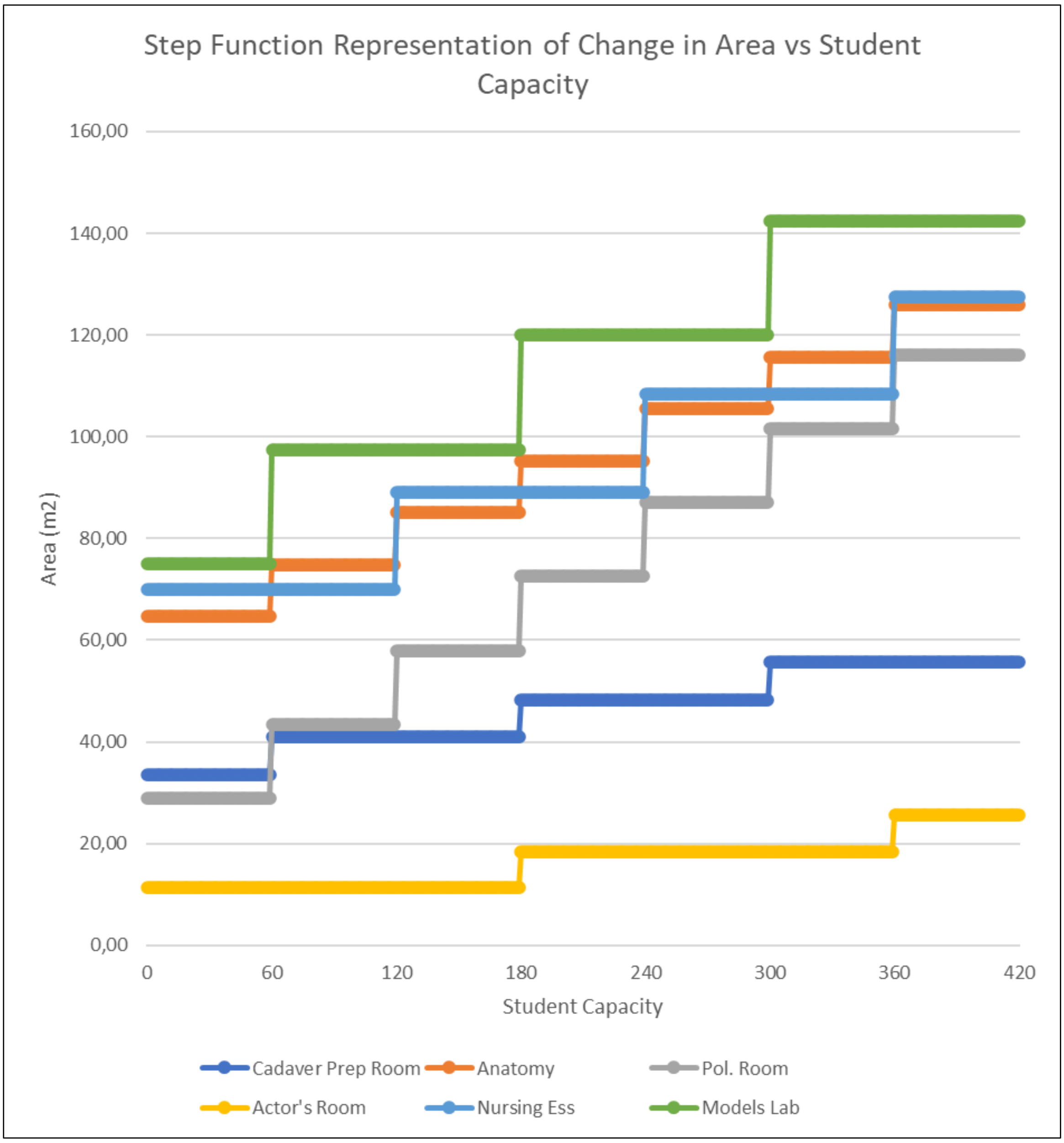

Figure 4.9. Step function graphs of all rooms vs the change in student capacity

As it can be seen from the graph, every room and lab had its unique step function and increment. Thus, they are to be investigated separately below.

4.5.1. Anatomical Models Lab

Specific graph of anatomical models lab is separated from the general graph.

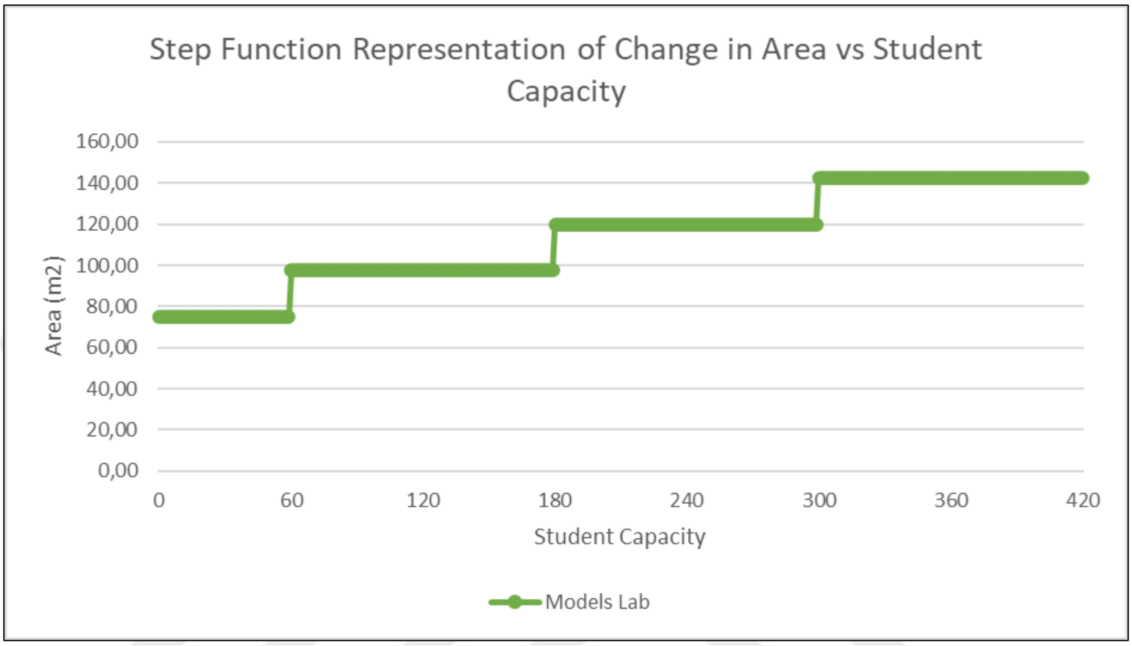

Figure 4.10. Step function graph of Anatomical Models Lab.

It is found that the step length of the anatomical model lab was 120.

Furthermore, the graph equation is as follows;

Where a = 22.48, b = 1/120, k = 75, h = -60

$$f(x) = 22.48\lfloor\frac{1}{120}(x+60)\rfloor + 75 \quad (4.1)$$

4.5.2. Cadaver Preparation Room

Specific graph of cadaver preparation room is separated from the general graph.

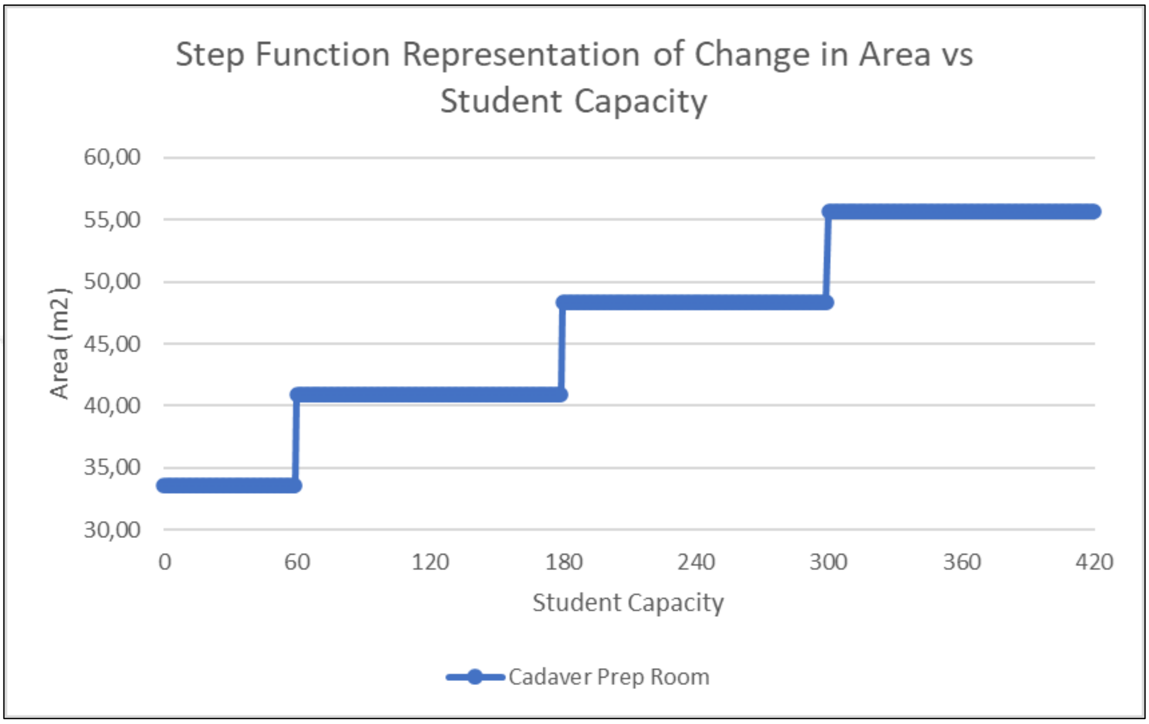

Figure 4.11. Step function graph of cadaver preparation room

It is found that the step length of the cadaver preparation room was 120.

Furthermore, the graph equation is as follows;

Where a = 7.38, b = 1/120, k = 33.56, h = -60

$$f(x) = 7.38\lfloor\frac{1}{120}(x+60)\rfloor + 33.56 \quad (4.2)$$

4.5.3. Anatomy & Dissection Lab

Specific graph of anatomy and dissection lab is separated from the general graph.

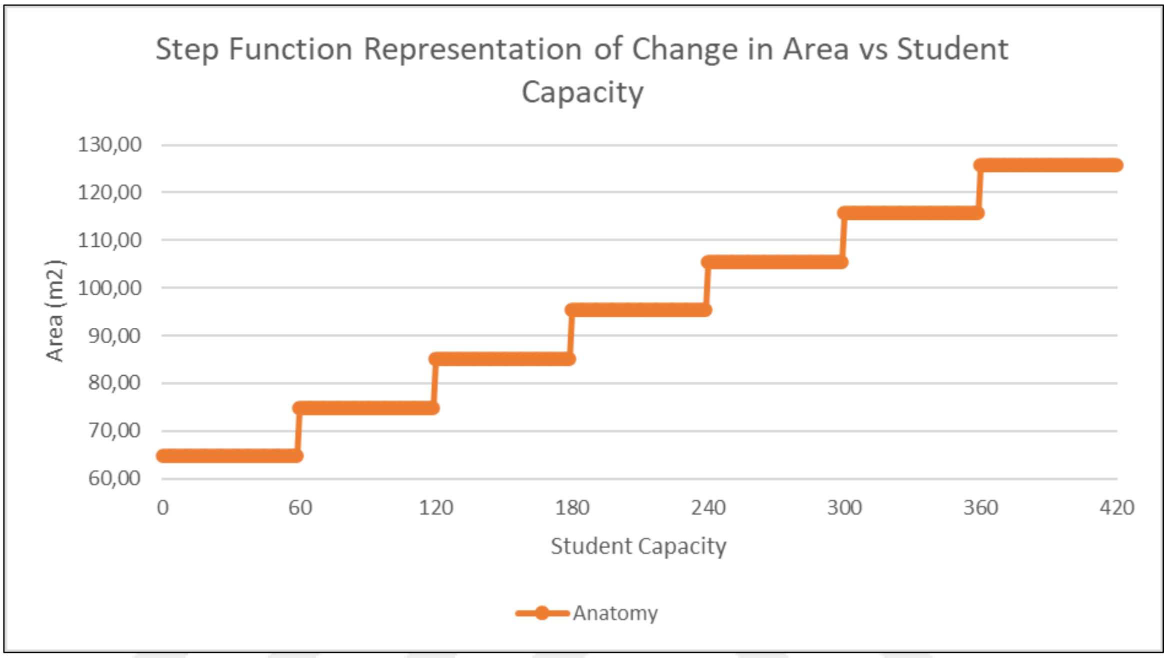

Figure 4.12. Step function graph of anatomy and dissection lab

It is found that the step length of the anatomical model lab was 60.

Furthermore, the graph equation is as follows;

Where a = 10.20, b = 1/60, k = 64.68, h = 0

$$f(x) = 10.20\lfloor\frac{1}{60}(x)\rfloor + 64.68 \tag{4.3}$$

4.5.4. Standardized Patient/Outpatient Scenario Rooms

Specific graph of standardized patient/outpatient scenario rooms is separated from the general graph.

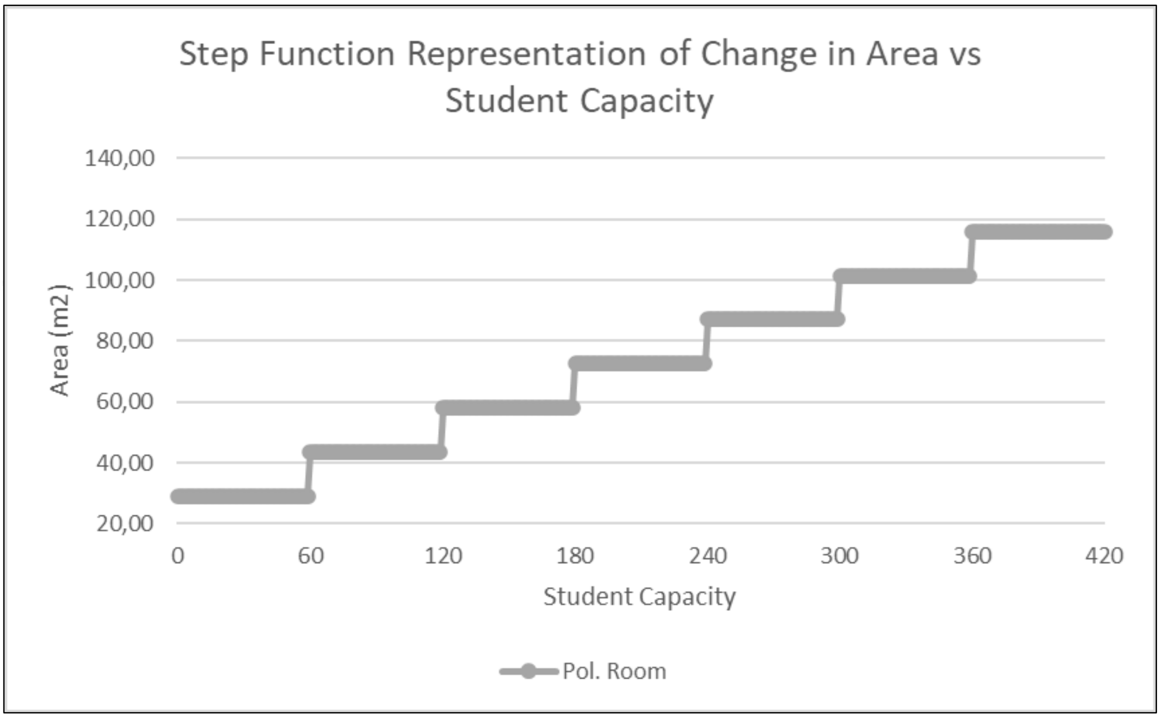

Figure 4.13. Step function graph of standardized patient/outpatient scenario rooms

It is found that the step length of the standardized patient/outpatient scenario rooms was 60.

Furthermore, the graph equation is as follows;

Where a = 14.51, b = 1/60, k = 29.01, h = 0

$$f(x) = 14.51\lfloor\frac{1}{60}(x)\rfloor + 29.01 \tag{4.4}$$

4.5.5. Actors, Makeup & Educators Room

Specific graph of actors, makeup & educators room is separated from the general graph.

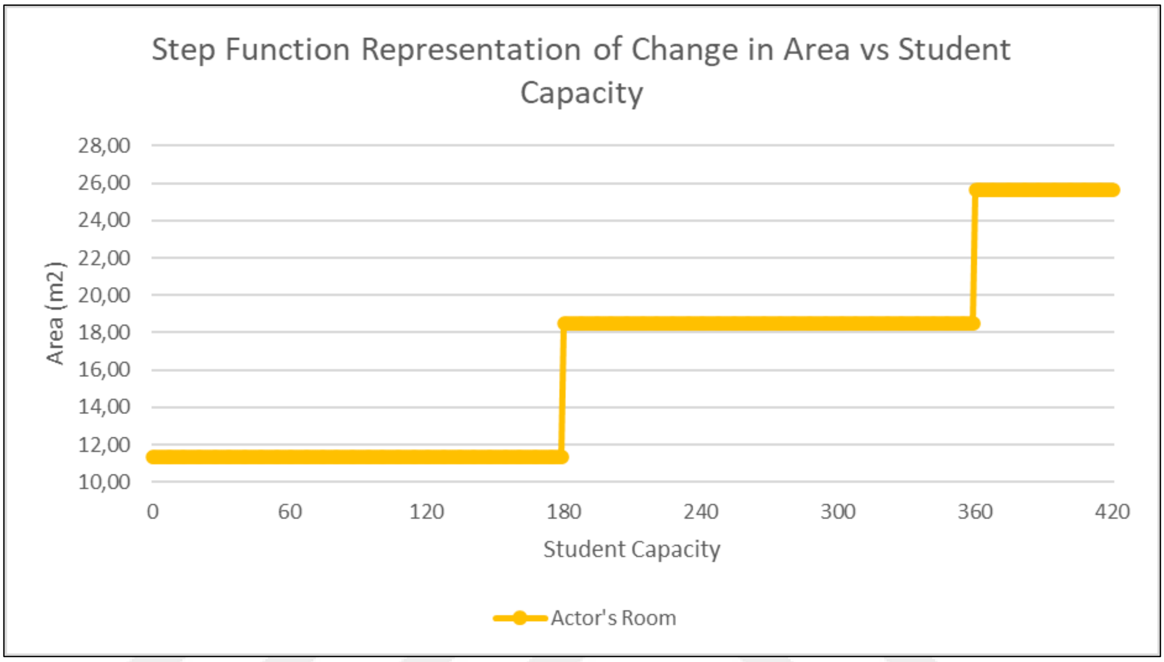

Figure 4.14. Step function graph of actors, makeup and educators room

It is found that the step length of the actors, makeup & educators room was 180.

Furthermore, the graph equation is as follows;

Where a = 7.13, b = 1/180, k = 11.37, h = 0

$$f(x) = 7.13\left\lfloor \frac{1}{180}(x) \right\rfloor + 11.37 \tag{4.5}$$

4.5.6. Nursing Essentials Lab

Specific graph of nursing essentials lab is separated from the general graph.

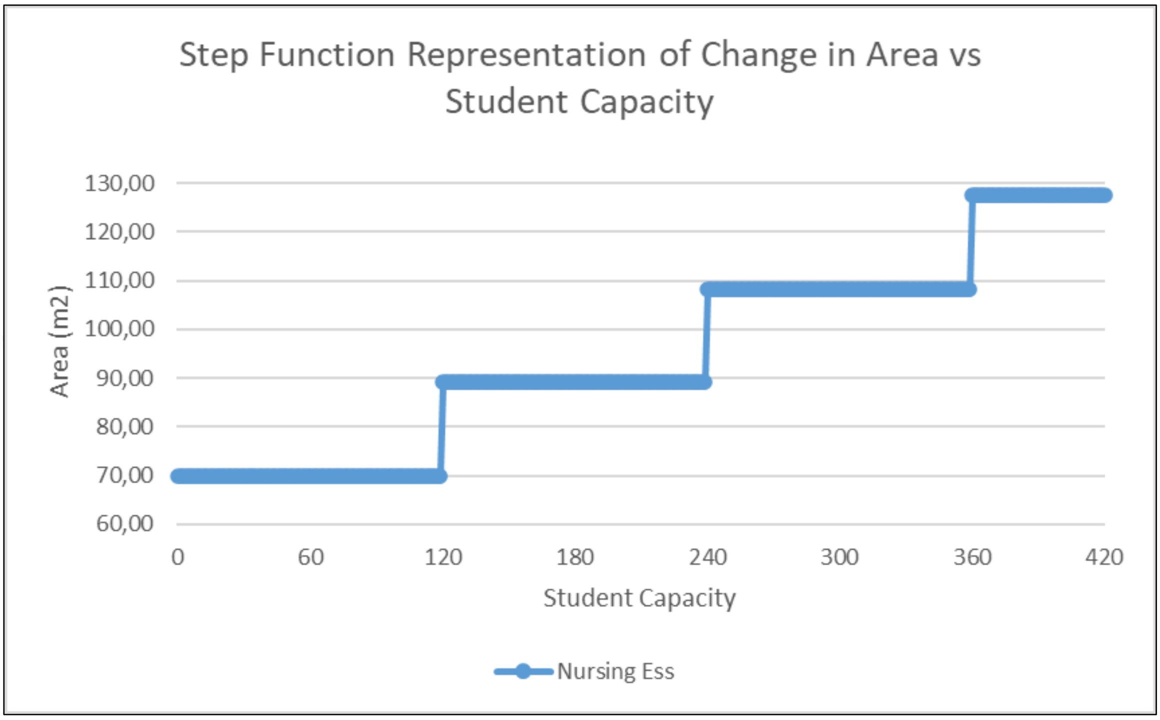

Figure 4.15. Step function graph of nursing essentials lab

It is found that the step length of the nursing essentials lab was 120.

Furthermore, the graph equation is as follows;

Where a = 19.19, b = 1/120, k = 69.97, h = 0

$$f(x) = 19.19\lfloor\frac{1}{120}(x)\rfloor + 69.97 \quad (4.6)$$

4.5.7. Main Block of Medicine & Nursing Faculty

After the graph plots and calculations of the greatest integer functions which also included extrapolation values after 240 student capacities. Data are put together and total net areas required for the main blocks are calculated.

Table 4.3. Table of net areas in meter square for both medicine school and nursing school, extrapolated values and total areas.

	Table of Med. School & Nursing Sim. Net Areas (m2)						
D: [g,t)	**[0,60)**	**[60,120)**	**[120,180)**	**[180,240)**	**[240,300)**	**[300,360)**	**[360,420)**
Range	**0-59**	**60-119**	**120-179**	**180-239**	**240-299**	**300-359**	**360-419**
Skills Lab / OSCE	104,68	104,68	104,68	104,68	104,68	104,68	104,68
Anatomic Models Lab	75,00	97,49	97,49	119,97	119,97	142,45	142,45
Debrief 1	16,61	16,61	16,61	16,61	16,61	16,61	16,61
Debrief 2	16,61	16,61	16,61	16,61	16,61	16,61	16,61
Directors Office	21,73	21,73	21,73	21,73	21,73	21,73	21,73
Cadaver Prep Room	33,56	40,93	40,93	48,31	48,31	55,68	55,68
Anatomy & Dissection Lab.	64,68	74,88	85,07	95,27	105,47	115,67	125,86
Cadaver Embalming Room	25,41	25,41	25,41	25,41	25,41	25,41	25,41
Chemicals Preperation Room	10,46	10,46	10,46	10,46	10,46	10,46	10,46
Chemicals Storage Room	10,46	10,46	10,46	10,46	10,46	10,46	10,46
Anatomy Technicians Room	20,44	20,44	20,44	20,44	20,44	20,44	20,44
Changing Room 1	10,45	10,45	10,45	10,45	10,45	10,45	10,45
Changing Room 2	10,45	10,45	10,45	10,45	10,45	10,45	10,45
Pol./Std Patient Room	29,01	43,52	58,02	72,53	87,03	101,54	116,04
Actor's Room	11,37	11,37	11,37	18,50	18,50	18,50	25,63
Nursing Ess & Sim Room	69,97	69,97	89,15	89,15	108,34	108,34	127,53
Nursing Skills Lab	104,68	104,68	104,68	104,68	104,68	104,68	104,68
Debriefing Room 3 (Nursing)	29,17	29,17	29,17	29,17	29,17	29,17	29,17
Biomedical Office	16,34	16,34	16,34	16,34	16,34	16,34	16,34
Main Block Total Area	**681,07**	**735,63**	**779,52**	**841,22**	**885,11**	**939,67**	**990,69**

Values of the graph were rounded up to two significant figures after decimal and one further step of rectification is made on the Table 4.3. values to save data from decimal values and have more general values without decimal values. For the rounding up process, all of the values at Table 4.3 are put into built-in equation of MS Excel “=ROUNDUP(XX;0)” where the function at for any given cell rounds the values up to the nearest greater value with zero decimal point and these values are shown in Table 4.4.

Table 4.4. Values of Table 4.3 rounded up to the nearest greater integer values with the built-in 'ROUNDUP' function of MS Excel

	Rounded Up Table of Med. School & Nursing Sim. Net Areas (m2)						
D: [g,t)	**[0,60)**	**[60,120)**	**[120,180)**	**[180,240)**	**[240,300)**	**[300,360)**	**[360,420)**
Range	**0-59**	**60-119**	**120-179**	**180-239**	**240-299**	**300-359**	**360-419**
Skills Lab / OSCE	105	105	105	105	105	105	105
Anatomic Models Lab	76	98	98	120	120	143	143
Debrief 1	17	17	17	17	17	17	17
Debrief 2	17	17	17	17	17	17	17
Directors Office	22	22	22	22	22	22	22
Cadaver Prep Room	34	41	41	49	49	56	56
Anatomy & Dissection Lab.	65	75	86	96	106	116	126
Cadaver Embalming Room	26	26	26	26	26	26	26
Chemicals Storage Room	11	11	11	11	11	11	11
Chemicals Preparation Room	11	11	11	11	11	11	11
Anatomy Technicians Room	21	21	21	21	21	21	21
Changing Room 1	11	11	11	11	11	11	11
Changing Room 2	11	11	11	11	11	11	11
Pol./Std Patient Room	30	44	59	73	88	102	117
Actor's Room	12	12	12	19	19	19	26
Nursing Ess & Sim Room	70	70	90	90	109	109	128
Nursing Skills Lab	105	105	105	105	105	105	105
Debriefing Room 3 (Nursing)	30	30	30	30	30	30	30
Biomedical Office	17	17	17	17	17	17	17
Main Block Total Area	**691**	**744**	**790**	**851**	**895**	**949**	**1000**

To see the area differentiation between the real values and the rounded-up values Table 4.5 is created.

Table 4.5. Differentiation of the values of main block totals between Table 4.3 and Table

	D: [g,t)	Range	Main Block Total Area	Main Block Total Area After ROUNDUP Function	Δx (Difference)
Table of Med. School & Nursing Sim. Net Areas (m2)	[0,60)	0-59	681,07	691	**9,93**
	[60,120)	60-119	735,63	744	**8,37**
	[120,180)	120-179	779,52	790	**10,48**
	[180,240)	180-239	841,22	851	**9,78**
	[240,300)	240-299	818,33	895	**76,67**
	[300,360)	300-359	939,67	949	**9,33**
	[360,420)	360-419	990,69	1000	**9,31**
				Arithmetic av.:	**19,12**

Values between main block total net areas and rounded-up version of the main block total net areas differ less than 10 m^2 where it specifically differentiates 7,36 m^2 on average where this value corresponds to a half of an area of standardized patient room.

Although the components of the simulation center for medicine and nursing faculty are assessed, one last step function calculation is realized for the main block net area.

Specific graph of main block of medicine and nursing faculty is created from the Table 5.

At first, as above graphs were rectified to an average and equal increment structure. Same application is done to Table 4.5. values and Table 4.6. is created. Afterwards, step-graph of the last column is plotted.

Table 4.6. Rectification of the differences in Table 4.5 for uniform step-function graph

	D: [g,t)	Range	Main Block Total Area After ROUNDUP Function	Δx Between Ranges	Main Block Area with average Δx increment
Table of Med. School & Nursing Sim. Net Areas (m2)	[0,60)	0-59	691	0	**691,00**
	[60,120)	60-119	744	53	**742,50**
	[120,180)	120-179	790	46	**794,00**
	[180,240)	180-239	851	61	**845,50**
	[240,300)	240-299	895	44	**897,00**
	[300,360)	300-359	949	54	**948,50**
	[360,420)	360-419	1000	51	**1000,00**
			Arithmetic av.:	**51,50**	

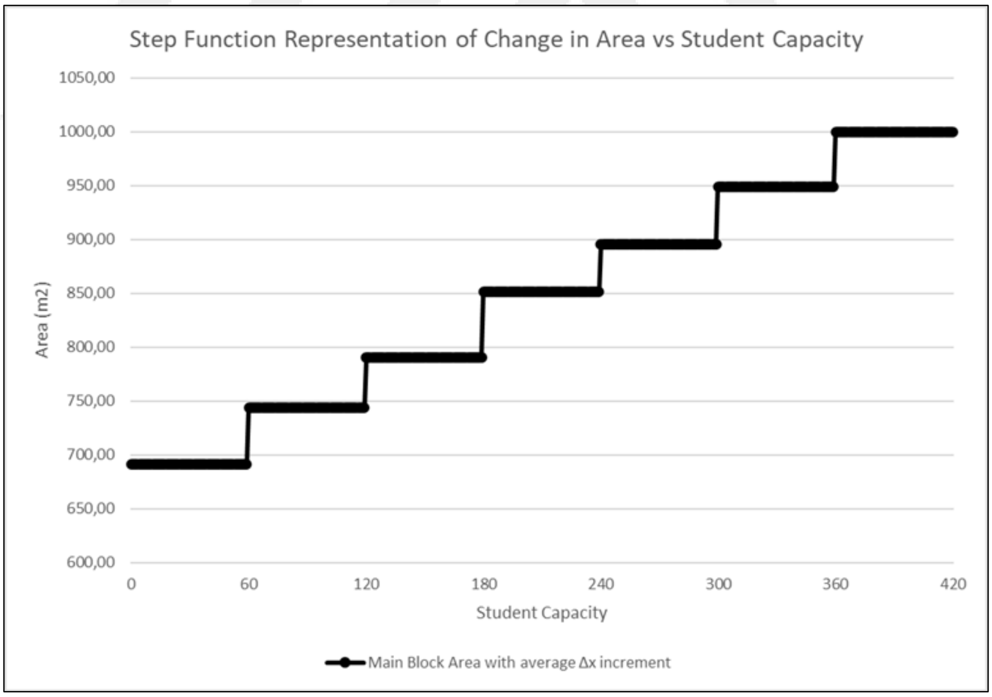

Figure 4.16. Step function graph of main block of medicine and nursing faculty

It is found that the step length of the main block of medicine and nursing faculty was 691.

Furthermore, the graph equation is as follows;

Where a = 51.50, b = 1/60, k = 691, h = 0

$$f(x) = 51.50\lfloor\frac{1}{60}\ (x)\rfloor + 691 \qquad (4.7)$$

4.6. ERROR ANALYSIS

Before error analysis, from the tables, the real (measured) values, rectified values (EV1) and rounded up values (EV2) are placed into a table and the differences of values between these values with respect to RV are calculated. Afterwards the table is revised to only show the differences. Furthermore, standard error, standard deviation and confidence interval calculations are made with respect to these difference values.

According to the Table 4.7. maximum standard deviation for the total area is 5.35. Additionally, maximum standard error for the total area is 1.89. These values mean that, total area differences differentiates in the range of ±5.35 m^2 and total area differentiation error is ±1.89 m^2.

Table 4.7. Table of standard deviation (STDEV) and standard error (Std.Err) values with respect to area differences of real values, rectified values (EV1) and rounded up values (EV2) between student capacities.

Student Capacity	[0,60)		[60,120)		[120,180)		[180,240)			
	Δx (EV1-RV) (m²)	Δx (EV2-RV) (m²)	Δx (EV1-RV) (m²)	Δx (EV2-RV) (m²)	Δx (EV1-RV) (m²)	Δx (EV2-RV) (m²)	Δx (EV1-RV) (m²)	Δx (EV2-RV) (m²)	STDEV (m²)	Std.Err (±...m²)
Skills Lab / OSCE	0,00	0,32	0,00	0,32	0,00	0,32	0,00	0,32	**0,17**	**0,06**
Anatomic Models Lab	0,00	1,00	0,00	0,51	0,00	0,51	0,00	0,03	**0,38**	**0,13**
Debrief 1	0,00	0,39	0,00	0,39	0,00	0,39	0,00	0,39	**0,21**	**0,07**
Debrief 2	0,00	0,39	0,00	0,39	0,00	0,39	0,00	0,39	**0,21**	**0,07**
Directors Office	0,00	0,27	0,00	0,27	0,00	0,27	0,00	0,27	**0,14**	**0,05**
Cadaver Prep Room	0,00	0,44	-0,61	-0,54	-0,61	-0,54	0,00	0,69	**0,51**	**0,18**
Anatomy & Dissection Lab.	0,00	0,32	-1,70	-1,58	-0,03	0,90	0,00	0,73	**0,97**	**0,34**
Cadaver Embalming Room	0,00	0,59	0,00	0,59	0,00	0,59	0,00	0,59	**0,32**	**0,11**
Chemicals Preperation Room	0,00	0,54	0,00	0,54	0,00	0,54	0,00	0,54	**0,29**	**0,10**
Chemicals Storage Room	0,00	0,54	0,00	0,54	0,00	0,54	0,00	0,54	**0,29**	**0,10**
Anatomy Technicians Room	0,00	0,56	0,00	0,56	0,00	0,56	0,00	0,56	**0,30**	**0,11**
Changing Room 1	0,00	0,55	0,00	0,55	0,00	0,55	0,00	0,55	**0,29**	**0,10**
Changing Room 2	0,00	0,55	0,00	0,55	0,00	0,55	0,00	0,55	**0,29**	**0,10**
Pol./Std Patient Room	0,00	0,99	0,00	0,48	0,00	0,98	0,00	0,47	**0,44**	**0,15**
Actor's Room	0,00	0,63	0,00	0,63	0,00	0,63	0,00	0,50	**0,32**	**0,11**
Nursing Ess & Sim Room	0,00	0,03	0,00	0,03	0,00	0,85	0,00	0,85	**0,39**	**0,14**
Nursing Skills Lab	0,00	0,32	0,00	0,32	0,00	0,32	0,00	0,32	**0,17**	**0,06**
Debriefing Room 3 (Nursing)	0,00	0,83	0,00	0,83	0,00	0,83	0,00	0,83	**0,44**	**0,16**
Biomedical Office	0,00	0,66	0,00	0,66	0,00	0,66	0,00	0,66	**0,35**	**0,12**
Total net Area of Pracitce	0,00	9,93	-2,31	6,06	-0,64	9,84	0,00	9,78	**5,35**	**1,89**

In table 4.8, means and confidence interval of the area differentiation are given. Looking at the values of confidence interval in %95 probability, area differentiations are limited in a smaller range which is expected. Confidence interval gives a result of how near is the true mean of observations or values experimented in a chosen probability which is %95 in this case with the Z value of 1.96.

Table 4.8. Table of room by room mean, standard deviation, standard error and confidence intervals of %95 probability in area differences with respect to real values, rectified values (EV1) and rounded up values (EV2)

				Confidence Interval (CI=%95)		
	Mean of Δx (m²)	STDEV (m²)	Std.Err (±...m²)	Lower Limit (m²)	Upper Limit (m²)	CI (±...m²)
Skills Lab / OSCE	0,16	0,17	0,06	0,04	0,28	0,24
Anatomic Models Lab	0,26	0,38	0,13	0,00	0,52	0,52
Debrief 1	0,20	0,21	0,07	0,05	0,34	0,29
Debrief 2	0,20	0,21	0,07	0,05	0,34	0,29
Directors Office	0,13	0,14	0,05	0,03	0,23	0,20
Cadaver Prep Room	-0,15	0,51	0,18	-0,50	0,21	0,71
Anatomy & Dissection Lab.	-0,17	0,97	0,34	-0,84	0,50	1,35
Cadaver Embalming Room	0,29	0,32	0,11	0,08	0,51	0,44
Chemicals Preperation Room	0,27	0,29	0,10	0,07	0,47	0,40
Chemicals Storage Room	0,27	0,29	0,10	0,07	0,47	0,40
Anatomy Technicians Room	0,28	0,30	0,11	0,07	0,49	0,41
Changing Room 1	0,28	0,29	0,10	0,07	0,48	0,41
Changing Room 2	0,28	0,29	0,10	0,07	0,48	0,41
Pol./Std Patient Room	0,37	0,44	0,15	0,06	0,67	0,60
Actor's Room	0,30	0,32	0,11	0,08	0,52	0,45
Nursing Ess & Sim Room	0,22	0,39	0,14	-0,05	0,49	0,54
Nursing Skills Lab	0,16	0,17	0,06	0,04	0,28	0,24
Debriefing Room 3 (Nursing)	0,42	0,44	0,16	0,11	0,72	0,62
Biomedical Office	0,33	0,35	0,12	0,09	0,58	0,49
Total net Area of Pracitce	4,08	5,35	1,89	0,38	7,79	7,41

These calculations showing the standard errors and standard deviations were all made for the actual designs that were drawn and area parameters were collected. Pushing the calculations further, another table (Table 4.9.) of error analysis is made over the total area calculations with extrapolations for the ranges [240,300), [300,360) and [360,420). The values used as a real value (RV) have become the values given to these areas after rectifying the differences between steps on average increment. Further iterations were named as EV1 and EV2 where rounded up values were gathered (EV1) and the differences between EV1 steps were rectified as an average increment (EV2).

Table 4.9. Error analysis table of extrapolated values for total areas and differences of med. school & nursing sim. measured (RV), roundedup (EV1) and rectified after roundup (EV2) values (m2)

D: [g,t)	Main Block Total Net Area (RV) (m²)	Main Block Total Area After ROUNDUP Function (EV1) (m²)	Main Block Area with average Δx increment (EV2) (m²)	Δx Between Ranges of RV (m²)	Δx Between Ranges of EV1 (m²)	Δx Between Ranges of EV2 (m²)	Δx (Area Difference) (EV1-RV) (m²)	Δx (Area Difference) (EV2-RV) (m²)
[0,60)	681,07	691,00	691,00	0,00	0,00	0,00	9,93	9,93
[60,120)	735,63	744,00	742,50	54,56	53,00	51,50	8,37	6,87
[120,180)	779,52	790,00	794,00	43,89	46,00	51,50	10,48	14,48
[180,240)	841,22	851,00	845,50	61,69	61,00	51,50	9,78	4,28
[240,300)	885,11	895,00	897,00	43,89	44,00	51,50	9,89	11,89
[300,360)	939,67	949,00	948,50	54,56	54,00	51,50	9,33	8,83
[360,420)	990,69	1000,00	1000,00	51,02	51,00	51,50	9,31	9,31
			Standard Deviation (m²):	**6,91**	**6,09**	**0,00**	**0,67**	**3,30**
			Standard Error (±...m²):	**2,82**	**2,49**	**0,00**	**0,25**	**1,25**
			Confidence Interval (%95) Lower Limit (m²):	**29,56**	**31,06**	**42,92**	**8,32**	**2,92**
			Confidence Interval (%95) Upper Limit (m²):	**57,13**	**56,37**	**51,50**	**10,08**	**11,81**
			Confidence Interval (%95) (±...m²):	**27,57**	**25,31**	**8,58**	**1,76**	**8,89**

Table shows that for the last iteration of extrapolation, standard error becomes even less than ±1.89 m² that the value becomes ±1.25 m². Yet it is also seen that standard error is also less before the last rectification process for EV1-RV with a value of ±0.25 m².

4.7. DISCUSSION

This study has outlined the general design process and sampled minimally required space management of a simulation center/lab that could be constructed with the minimum requirements that Turkish governmental organization of higher education – Y.Ö.K published regulations about (10,11). Nonetheless, after creation of such structure, study has shown that a mathematical approach and equation wise enlargement is possible. Keeping simulation centers/labs capable of mobility could be beneficial especially for institutions aiming for enlargement and capacity increment yet other considerations like employment and budgeting are severe issues to be paid attention especially in countries with economic instability and the countries that are not manufacturers in simulation-based education market. Therefore, space management and student flow management at the most possible minimality plays a crucial role for the organizations, institutions, universities etc. especially in above-mentioned countries that sufficient management approach could be beneficial also for budgeting and effectiveness of the practical education. At the first stage, architectural know-how plays an important role in space management and increasing layout to flow efficacy could be more forgiving for the institutions. Especially implementing different types of flow layouts such as circular, star-shaped flow layouts may decrease the space necessity, yet it is an architectural research and development problem. Although different types of flow layouts could benefit, in simulation centers/labs that are aiming to satisfy the minimum requirements of the Turkish governmental regulations, creating such flow layouts become more challenging where room and lab numbers or areas are minimal. Therefore, it is both observed and seen that minimality in such studies/design-works forces the design process to circular or linear flow layouts. Architecturally these layouts may be promising and optimal for simulation facilities. Thus, especially in design phases of such facilities, cooperative work between administratives, actual educators, biomedical engineers and architects is the key for optimally efficient planning where different know-hows are to be integrated together.

According to the results, the spaces differentiating in size and units were the labs/rooms that were the most used in practical educations. Two of the labs that are to be active the most, skills labs for both professions, did not change the size where they had 60 student capacity on their own. Increasing those labs, rooms' capacity would only decrease the efficiency of the practical education held in where an educator would have to deal with more students. That is why it can be suggested that, adding more units of these labs could ease the effort yet could increase the time spent by the educator on the field which could also affect efficiency. Nevertheless, Y.Ö.K regulations ensure that faculties have sufficient number of academic staff employment to handle the crowdedness. Therefore, space management must have approved to be more crucial.

In addition, even if calculated net area values project minimal values for a simulation center/lab they are optimized for a such design, these calculations are not optimal where effective architectural approaches may reduce the space necessities. Although, this is a fact, values calculated forecast that an area of a practical education facility of a medicine or nursing faculty with a capacity of 0 to 60 students cannot be smaller than 600 m^2 and effective as it should be. In addition, corridor areas, wall thicknesses, reception areas, breakout areas, restrooms and other type of components needed for a facility to run properly are neglected where this study focused on the net area needed for practical education and helper rooms for these components (e.g.: debriefing rooms). Therefore, by the addition of these neglected components, general area requirement for a facility naturally increases yet as mentioned above, this problem needs an architectural supervision. Additionally, there with the architectural supervision, spaces designed in this study tried to converge to the ergonomic principals of Neufert's guidelines (23). Therefore, parameters like wall-table distances, table-table distances can be revised and revised to more optimal parameters which also can affect the areas room by room. Yet already, it is approximated that these minimal changes would not cause dramatic alterations in main block area requirements. Furthermore, referencing to error analysis in Table 4.9. the standard deviation and standard error for the spaces needed to run a simulation facility seems minimally affecting the general calculations where the area scale of the designs is on hundreds and area scale of the errors are on units' digit. Also, it is seen that, leaving the last rounded up values without rectification of area increments gave more precise results. This shows that, calculation with non-homogenous differentiations that can be either a step function or else can give more accurate and precise results. However, looking at the confidence intervals it can be said that up to $10m^2$ standard error can be tolerated for the designs if there are no other considerations in designing.

5. CONCLUSIONS

Putting results together, it became clear that every room and main block itself can be formulated as a greatest integer step function and extrapolation depending on the student capacity is possible. Although, quantitative approach is preferred and roughly without any formulation, a simulation center/lab that are only satisfying general requirements of Y.Ö.K regulations without scenario-based areas like crash site, emergency, delivery room and etc. can be extrapolated as minimum of 50 m^2 of an extra area is needed for every 60-student addition to quota.

By general acceptance, the design in this study is not preferred in the healthcare education where scenario-based, learning from errors are suggested in literature [1,3,7,24–27]. Therefore, institutions in design phases should consider building simulation centers comprising an environment suitable for scenario-based education and life-like applications. Also, it seems clear to claim that a step function approach suits very well for such study with minimal error output. Although this approach seems to produce minimal error, it should be kept in mind that every further iteration of extrapolation may increase the standard error. That is why, a better and a complex mathematical approach can increase the accuracy and precision for such designs. All in all, this study does not satisfy the needs of scenario-based simulation center designs as well as space needs would dramatically increase and layout plan would have to be revised, yet, it is clear that with a homogenously increasing step function approach, design works can be more efficient.

5.1. FUTURE WORKS

Although, simulation in healthcare has wide literature to reference, in Turkiye, research is limited. Additionally, at a design perspective of a healthcare simulation facility, references and research are very limited within the realms of increasing efficiency and compactness correlation. More research and work are expected for further development.

Secondarily, Turkish governmental body YÖK's sincere approach to simulation in healthcare should be motivated more by responsible officials and key opinion leaders in the area. It is seen that, considering budgeting limitations of Turkish schools, regulations only ensuring that a healthcare education schools to have such defined accommodations forces the educational approach to more theoretical structure where the new generations' learning behavior has shifted from reading to practically applying, learning from errors and peer discussions [1,3,4,8,24]. That is why, it is seen that more comprehensive and a regulation jointing to ÇEP systems would be best fitting solution to motivate education market to build their facilities more active-learning friendly and multi-modal. All in all, it is expected that governmental entities in Turkiye will kindly re-consider revising and detailing the regulations in addition to being more descriptive about building minimally required space to multi-modal learning systems.

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APPENDIX A: LIST OF LEARNING OUTCOMES OF UÇEP/HUÇEP AND THE YÖK'S REGULATIONS OF MINIMUM REQUIREMENTS FOR SIMULATION AREAS IN NURSING AND MEDICINE SCHOOLS

Every school in Türkiye are allowed to create their additional curriculum material if they are as long as they adhere to the core education program requirements. Therefore, there are fundamental learning outcomes that a student graduating from a school has to satisfy. After graduation, former doctors are accepted that they have learnt these learning objectives with the specified degree.

Table A.1 and A.2 shows the learning outcomes of the UÇEP and HUÇEP. Table A.3 shows the YÖK's regulations for minimum requirements for simulation areas in nursing and medicine schools.

Table A.1. Learning outcomes defined in UÇEP

TEMEL HEKİMLİK UYGULAMALARI

Temel Hekimlik Uygulamaları Öğrenme Düzeyleri:

Tıp fakültesinden mezun olan hekimin, temel hekimlik uygulamaları sırasında sergilemesi gereken performansın, dolayısıyla öğrenmenin asgari düzeyini belirtir (Tablo 2.4.1.). Asgari düzey listesindeki her bir beceri / uygulama için ayrı ayrı belirlenir. Fakülteler uyguladıkları eğitim süresi içinde, her bir öğrencinin söz konusu hekimlik uygulamasını belirlenen asgari düzeyde yapabilir duruma gelmesini sağlarlar.

Tablo 2.4.1. Temel Hekimlik Uygulamaları Öğrenme Düzeyi

Öğrenme Düzeyi	Açıklama
1	Uygulamanın nasıl yapıldığını bilir ve sonuçlarını hasta ve/veya yakınlarına açıklar
2	Acil bir durumda kılavuz/yönergeye uygun biçimde uygulamayı yapar
3	Karmaşık olmayan, sık görülen, durumlarda/olgularda uygulamayı* yapar
4	Karmaşık durumlar/olgular da dahil uygulamayı* yapar

* Ön değerlendirmeyi/değerlendirmeyi yapar, gerekli planları oluşturur, uygular ve süreç ve sonuçlarıyla ilgili hasta ve yakınlarını/toplumu bilgilendirir

Tablo 2.4. Temel Hekimlik Uygulamaları	Düzeyler
A. Öykü alma	
1. Genel ve soruna yönelik öykü alabilme	4
2. Mental durumu değerlendirebilme	3
3. Psikiyatrik öykü alabilme	3
B. Genel ve soruna yönelik fizik muayene	
1. Adli olgu muayenesi	3
2. Antropometrik ölçümler	3
3. Batın muayenesi	4
4. Bilinç değerlendirme	4
5. Çocuk ve yenidoğan muayenesi	4
6. Deri muayenesi	4
7. Digital rektal muayene	3
8. Gebe muayenesi	3
9. Genel durum ve vital bulguların değerlendirilmesi	4
10. Göz dibi muayenesi	2
11. Göz muayenesi	3
12. Jinekolojik muayene	3
13. Kardiyovasküler sistem muayenesi	4
14. Kas-İskelet sistem muayenesi	3
15. Kulak-burun-boğaz ve baş boyun muayenesi	3
16. Meme ve aksiller bölge muayenesi	3
17. Nörolojik muayene	3
18. Olay yeri incelemesi	2
19. Ölü muayenesi	3
20. Ruhsal durum muayenesi	3
21. Solunum sistemi muayenesi	4
22. Ürolojik muayene	3
C. Kayıt tutma, raporlama ve bildirim	
1. Adli rapor hazırlayabilme	3
2. Adli vaka bildirimi düzenleyebilme	4
3. Aydınlatma ve onam alabilme	4
4. Engellilik raporu konusunda danışmanlık yapabilme	3
5. Epikriz hazırlayabilme	4
6. Güncel mevzuata uygun sağlık raporlarını hazırlayabilme	3

Tablo 2.4. Devamı	Düzeyler
C. Kayıt tutma, raporlama ve bildirim	
7. Hasta dosyası hazırlayabilme	4
8. Ölüm belgesi düzenleyebilme	3
9. Reçete düzenleyebilme	4
10. Tedaviyi red belgesi hazırlayabilme	4
11. Yasal olarak bildirimi zorunlu hastalıkları ve durumları bildirme ve raporlama	4
D. Laboratuvar testleri ve ilgili diğer işlemler	
1. Biyolojik materyalle çalışma ilkelerini uygulayabilme	4
2. Dekontaminasyon, dezenfeksiyon, sterilizasyon, antisepsi sağlayabilme	4
3. Dışkı yayması hazırlayabilme ve mikroskopik inceleme yapabilme	3
4. Direkt radyografileri değerlendirebilme	3
5. EKG çekebilme ve değerlendirebilme	3
6. Gaitada gizli kan incelemesi yapabilme	4
7. Glukometre ile kan şekeri ölçümü yapabilme ve değerlendirebilme	4
8. Kanama zamanı ölçümü yapabilme ve değerlendirebilme	2
9. Laboratuvar inceleme için istek formunu doldurabilme	4
10. Laboratuvar örneğini uygun koşullarda alabilme ve laboratuvara ulaştırabilme	4
11. Mikroskop kullanabilme	4
12. Peak-flow metre kullanabilme ve değerlendirebilme	3
13. Periferik yayma yapabilme ve değerlendirebilme	3
14. Su dezenfeksiyonu yapabilme	3
15. Su numunesi alabilme	3
16. Sularda klor düzeyini belirleyebilme ve değerlendirebilme	3
17. Tam idrar analizi (mikroskopik inceleme dahil) yapabilme ve değerlendirebilme	3
18. Tarama ve tanısal amaçlı inceleme sonuçlarını yorumlayabilme	3
19. Vaginal akıntı örneği hazırlayabilme	3

Tablo 2.4. Devamı	Düzeyler
E. Girişimsel ve girişimsel olmayan uygulamalar	
1. Acil psikiyatrik hastanın stabilizasyonunu yapabilme	3
2. Adli olguların yönetilebilmesi	3
3. Airway uygulama	3
4. Akılcı ilaç kullanımı ilkelerini uygulayabilme	4
5. Akılcı laboratuvar ve görüntüleme inceleme istemi yapabilme	4
6. Arteryal kan gazı alma	3
7. Atel hazırlayabilme ve uygulayabilme	3
8. Balon maske (ambu) kullanımı	4
9. Bandaj, turnike uygulayabilme	4
10. Burun kanamasına müdahale edebilme	2
11. Çocuklarda büyüme ve gelişmeyi izleyebilme (persentil eğrileri, tanner derecelendirmesi)	3
12. Çoklu travma hastasının değerlendirilmesi	3
13. Damar yolu açabilme	3
14. Defibrilasyon uygulayabilme	4
15. Delil tanıyabilme/koruma/nakil	2
16. Deri-yumuşak doku apsesi açabilme	3
17. Dış kanamayı durduracak/sınırlayacak önlemleri alabilme	3
18. Dix Hallpike testi ve Epley manevrası uygulayabilme	3
19. Doğum sonrası anne bakımını yapabilme	3
20. Doğum sonrası bebek bakımı yapabilme	3
21. El yıkama	4
22. Endoskopik işlem	1
23. Entübasyon yapabilme	3
24. Epizyotomi açılabilme ve dikebilme	2
25. Gebe ve loğusa izlemi yapabilme	3
26. Genogram çıkarabilme (soy ağacı çıkarabilme)	1
27. Glasgow/AVPU koma skalasının değerlendirilebilme	4
28. Gözden yçabancı cisim çıkarılması	2
29. Hastadan biyolojik örnek alabilme	3
30. Hastanın uygun olarak taşınmasını sağlayabilme	4
31. Hastaya koma pozisyonu verebilme	4

Tablo 2.4. Devamı	Düzeyler
E. Girişimsel ve girişimsel olmayan uygulamalar	
32. Hastayı uygun biçimde sevk edebilme	4
33. Hava yolundaki yabancı cismi çıkarmaya yönelik ilk yardım yapabilme	3
34. Hukuki ehliyeti belirleyebilme	2
35. IM, IV, SC, ID enjeksiyon yapabilme	4
36. İdrar sondası takabilme	3
37. İleri yaşam desteği sağlayabilme	3
38. İntihara müdahele	2
39. İntraosseos uygulama yapabilmesi	2
40. Kan basıncı ölçümü yapabilme	4
41. Kan transfüzyonu yapabilme	3
42. Kapiller kan örneği alabilme	4
43. Kene çıkartabilme	3
44. Kültür için örnek alabilme	3
45. Lavman yapabilme	3
46. Lomber Ponksiyonyapabilme	1
47. Minimental durum muayenesi	3
48. Nazogastrik sonda uygulayabilme	3
49. Normal spontan doğum yaptırabilme	2
50. Oksijen ve nebul-inhaler tedavisi uygulayabilme	4
51. Oral, rektal, vajinal ve topikal ilaç uygulamaları yapabilme	3
52. Otopsi yapabilme	2
53. Parasentez yapabilme	1
54. Perikardiyosentez uygulayabilme	1
55. Plevral ponksiyon/torasentez yapabilme	2
56. PPD testi uygulayabilme ve değerlendirme	3
57. Puls oksimetre uygulayabilme ve değerlendirebilme	4
58. Rinne-Weber testleri uygulayabilme	3
59. Servikal collar (boyunluk) uygulayabilme	4
60. Soğuk zincire uygun koruma ve taşıma sağlayabilme	4
61. Solunum fonksiyon testlerini değerlendirebilme	3
62. Suprapubik mesane ponksiyonu yapabilme	2

Tablo 2.4. Devamı	Düzeyler
E. Girişimsel ve girişimsel olmayan uygulamalar	
63. Temel yaşam desteği uygulayabilme	4
64. Topuk kanı alabilme	4
65. Travma sonrası kopan uzvun uygun olarak taşınmasını sağlayabilme	4
66. Uygulanacak ilaçları doğru şekilde hazırlayabilme	3
67. Vajinal ve servikal örnek alabilme	3
68. Yara-yanık bakımıyapabilme	3
69. Yenidoğan canlandırması	2
70. Yüzeyel sütür atabilme ve alabilme	4
71. Zehirlenmelerde akut dekontaminasyon ilkelerini sağlama	2
F. Koruyucu hekimlik ve toplum hekimliği uygulamaları	
1. Acil yardımların organizasyonunu yapabilme	3
2. Aile planlaması danışmanlığı yapabilme	4
3. Bağışıklama danışmanlığı verebilme	4
4. Bağışıklama hizmetlerini yürütebilme	4
5. Doğru emzirme yöntemlerini öğretebilme	4
6. Geriyatrik değerlendirme yapabilme	3
7. Kendi kendine meme muayenesini öğretebilme	4
8. Kontrasepsiyon yöntemlerini doğru uygulayabilme ve kullanıcıları izleyebilme	3
9. Maluliyet değerlendirme	1
10. Olağan dışı durumlarda sağlık hizmeti sunabilme	2
11. Periyodik sağlık muayenesi (görme, işitme, metabolik hastalıklar, riskli grupların aşılanması, kanser taramaları)	4
12. Sağlık çalışanlarının sağlığının korunması ile ilişkili önlemleri alabilme	4
13. Sağlık hizmeti ilişkili enfeksiyonları engelleyici önlemleri alabilme	3
14. Toplu yaşam alanlarında enfeksiyonları engelleyici önlemleri alma	4
15. Topluma sağlık eğitimi verebilme	3
16. Toplumda bulaşıcı hastalıklarla mücadele edebilme	3

Tablo 2.4. Devamı	Düzeyler
F. Koruyucu hekimlik ve toplum hekimliği uygulamaları	
17. Toplumda sağlıkla ilgili sorunları epidemiyolojik yöntemler kullanarak saptayabilme ve çözüm yollarını ortaya koyabilme	3
18. Toplumdaki risk gruplarını belirleyebilme	3
G. Bilimsel araştırma ilke ve uygulamaları	
1. Bilimsel verileri derleyebilme, tablo ve grafiklerle özetleyebilme,	3
2. Bilimsel verileri uygun yöntemlerle analiz edebilme ve sonuçları yorumlayabilme	2
3. Bir araştırmayı bilimsel ilke ve yöntemleri kullanarak planlayabilme	2
4. Güncel literatür bilgisine ulaşabilme ve eleştirel gözle okuyabilme	3
5. Klinik karar verme sürecinde, kanıta dayalı tıp ilkelerini uygulayabilme	3
6. Sağlık düzeyi göstergelerini kullanarak hizmet bölgesinin sağlık düzeyini yorumlayabilme	3
H. Sağlıklılık	
1. Bağışıklama-çocukluk çağı ve erişkinlerde	4
2. Bebek Sağlığı İzlemi	4
3. Egzersiz ve fiziksel aktivite	4
4. Hayatın farklı evrelerinde izlem ve periyodik sağlık muayeneleri (gebelik, doğum, lohusalık, yenidoğan, çocukluk, ergenlik, yetişkinlik, yaşlılık)	4
5. Sağlıklı beslenme	4
I. Taramalar	
1. Evlilik öncesi tarama programı	4
2. Gelişimsel kalça displazisi tarama programı	4
3. Görme tarama programları	4
4. İşitme tarama programları	4
5. Yenidoğan metabolik ve endokrin hastalık tarama programı	4

Table A.2. Learning outcomes defined in HUÇEP

Vücut sıcaklığının düzenlenmesinde yetersizlik
Yalnızlık riski
Yaralanma riski
Yas tutma
Yatakta hareket etme yeteneğinde bozulma
Yenidoğan sarılığı
Yer değiştirme stresi sendromu
Yer değiştirme stresi sendromu riski
Yoğun stress
Yorgunluk
Yutma güçlüğü
Yürümede bozulma
Zehirlenme riski

*Tanılar alfabetik sıralanmıştır.

Planlama: Hemşirelik tanısı belirlendikten sonra hemşire, beklenen sonuçlara ulaşmak için belirlenen girişimleri içeren bir bakım planı geliştirir. Planlama aşamasında; öncelikler, hedefler ve beklenen sonuçlar belirlenir, hemşirelik girişimleri planlanır, kayıt edilir. Plan yazılı hale getirildikten sonra uygulamaya geçilir.

Uygulama: Uygulama aşaması, bakım planında belirlenen hedefe ulaşmak için bakım planının uygulamaya konmasıdır. Planın uygulanmasında temel hemşirelik uygulamaları ve ilgili beceriler esas alınır (bkz. Temel Hemşirelik Uygulamaları ve İlgili Beceriler listesi).

Değerlendirme: Değerlendirmede, planlanan girişimlerin uygulanması sonucunda belirlenen hedeflere ulaşılıp ulaşılmadığı değerlendirilir. Eğer ulaşılmadıysa süreç yeniden başlatılır. Hemşirelik sürecinin her aşamasında kayıt ve rapor edilmesi önemlidir.

Hemşirelik uygulamalarının sistemli ve bilimsel düzeyde gerçekleştirilebilmesi için hemşirelik sürecinin model/kuramlara temellendirilmesi gerekir. Hemşirelik süreci, yeterliklerle birlikte ulusal ve kurumsal düzeydeki hemşirelik eğitimi uygulamalarında esas alınmalıdır.

8.1.4.Temel Hemşirelik Uygulamaları ve İlgili Beceriler Listesi

Temel hemşirelik uygulamaları ve ilgili beceriler listesi diğer ana bileşenlerle birlikte ülkemizde tüm hemşirelik eğitimi uygulamalarının ana dayanaklarından birisidir. Hemşirelik eğitim kurumlarında yürütülen eğitimler, laboratuvarda ve simüle ortamlarda, klinik ortamlarda ve sahada gerçekleşecek uygulamalı eğitimler ve içerikleri bu liste kullanılarak oluşturulur. Bir uygulamayı çekirdek olarak niteleyen ve bu listeye girmesini belirleyen ölçütler şunlardır:

- Hemşirelik uygulamalarında sık karşılaşılması
- Yaşamsal önem arz etmesi
- Birey, aile ve toplumun sağlık bakımının niteliğini etkilemesi
- Birey, aile ve toplumun yaşam kalitesini etkilemesi
- Birey, aile ve toplumun var olan sağlık sorunlarının sonuçlarını etkilemesi

Mezun hemşirenin, belirlenen düzeylerde yapması, yönetmesi gereken temel hemşirelik uygulamalarını ve becerilerini içerir. Aşağıda HUÇEP Temel Hemşirelik Uygulamaları ve İlgili Becerileri sıralanmış ve düzeylendirilmiştir.

Öğrenme Düzeyi: Hemşirelik eğitimi programını tamamlayan bir hemşirenin sağlık bakımı uygulamalarında sergilemesi gereken performans düzeyini belirtir. Hemşirelik eğitimi programlarında eğitim süresi içinde, söz konusu performans için belirlenen düzeydeki kazanım her bir öğrenci için gerçekleştirilmeye çalışılır.

Hemşirelik uygulamaları ve becerileri öğrenme düzeyleri:

1. Uygulamanın nasıl yapıldığını bilir ve hasta ve/veya yakınlarına açıklar.
2. Karmaşık olmayan durumlarda uygulamayı Rehber/Protokol/Talimat vb. doğrultusunda yapar.
3. Karmaşık durumlarda uygulamayı Rehber/Protokol/Talimat vb. doğrultusunda yapar.

Tablo 2.Temel Hemşirelik Uygulamaları ve İlgili Beceriler Listesi ve Öğrenme Düzeyi*

TEMEL HEMŞİRELİK UYGULAMALARI	BECERİLER	ÖĞRENME DÜZEYİ
BESLENME	• Ağızdan beslenmeye yardım etme • Beslenmeyi izleme ve değerlendirme • Biberonla besleme • Emzirmeyi başlatma ve sürdürme • Gastrostomiden besleme • Gavajla besleme • Nazogastrik sonda yerleştirme ve bakımı • Parenteral, enteral besleme • Total parenteral besleme	3 3 3 3 3 3 3 3 3
BOŞALTIM	• Aldığı çıkardığı takibi yapma • Bağırsak eğitimi verme • Boşaltıcı-tedavi edici lavman yapma • İdrar torbasını değiştirme • Kondom kateter uygulama • Mesane eğitimi verme • Mesane irrigasyonu uygulama • Mesane katerizasyonu uygulama ve bakımını yapma • Ördek/sürgü verme • Rektal tüp uygulama • Ürostomi, kolostomi, ileostomi bakımı verme	3 3 3 3 3 3 3 3 3 3 3 3
CERRAHİ GİRİŞİM	• Ameliyata hazırlama • Ameliyat öncesi bakım verme • Ameliyat sırası bakım verme • Ameliyat sonrası bakım verme	3 3 3 3
DOĞUM ÖNCESİ VE SONRASI BAKIMI	• Çocuk Kalp Sesleri (ÇKS)'ni dinleme • Epizyo bakımı yapma • Fundus masajı yapma • Kanama kontrolü yapma • Leopold manevrası yapma • Loşia izleme • Meme bakımı yapma	3 3 3 3 3 3

EĞİTİM	• Eğitim gereksinimlerine ilişkin veri toplama • Eğitime ilişkin hemşirelik tanılarını belirleme • Eğitimi planlama • Eğitimi uygulama • Eğitimi değerlendirme • Eğitim uygulamalarını kaydetme • Eğitim uygulamalarında etkili sunum becerilerini kullanma	3 3 3 3 3 3 3
GÜVENLİ ÇEVRENİN SAĞLANMASI VE SÜRDÜRÜLMESİ	• Basınç yarasını önleme • Cerrahi el yıkama • Düşmeleri önleme • El yıkama • Hasta izolasyonu • Hasta kimliğini doğrulama • Hastayı kliniğe kabul etme • İlaç ve malzemelerin güvenliğini sağlama ya da güvenli ilaç ve malzeme kullanma • İzolasyon önlemlerini uygulama • Kontraktürleri önleme • Solüsyonlarla dezenfeksiyon uygulama • Steril eldiven, gömlek ve maske giyme-giydirme-çıkarma • Steril malzeme kullanma • Tıbbi asepsiye uygun maske takma • Tıbbi asepsiye uygun önlük giyme/giydirme • Yatak yapma(Hasta içinde)	3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
HAREKET	• Alçı-atel-traksiyon bakımı yapma • Basınç yarasını önleyici destek malzemesi yerleştirme • Bireyi yatak içinde hareket ettirme ve pozisyon verme • Dorsal rekümbent pozisyonu verme • Fowlers-yarı fowlers pozisyonu verme • Hastayı mobilize etme • Hastayı yataktan sandalyeye/sedyeye geçirme • İzometrik-izotonik-izokinetik egzersizler yaptırma • Litotomi pozisyonu verme • Ortopne pozisyonu verme • Özel cerrahi girişimlere uygun (mastektomi, vb.) egzersiz yaptırma • Prone/yüzüstü yatış pozisyonu verme	3 3 3 3 3 3 3 3 3 3 3 3 3

	• ROM/ Eklem açıklığı egzersizlerini yaptırma • Sims pozisyonu verme • Supine/sırtüstü yatış pozisyonu • Şok pozisyonu verme • Vücut mekaniklerine uygun hareket etme	3 3 3 3 3
HEMŞİRELİK SÜRECİ	• Bakım gereksinimlerine ilişkin veri toplama • Hemşirelik tanılarını belirleme • Hemşirelik girişimlerini planlama • Hemşirelik girişimlerini uygulama • Hemşirelik girişimlerini değerlendirme • Hemşirelik uygulamalarını kaydetme • Hemşirelik uygulamalarında etkili iletişim becerilerini kullanma	3 3 3 3 3 3 3
HEMŞİRELİK YÖNETİMİ	• Etkili liderlik davranışı gösterme • Hemşirelik hizmetlerini yönetme • Sağlık bakımı ekibinin etkin bir üyesi olarak hareket etme	3 3 3
İLAÇ UYGULAMA	• Aldığı çıkardığı sıvı izlemi yapma • Buruna ilaç uygulama • Deri altı enjeksiyon yapma • Deri içi enjeksiyon yapma • Deriye ilaç uygulama • Göze ilaç uygulama • İlaç dozu hesaplama • İlaçları hazırlama • İlaçları uygun koşullarda saklama • İnhalasyon yoluyla ilaç uygulama • Ven içi/İntra venöz (İV) katater uygulama • İV set hazırlama • İV sıvı akış hızı hesaplama • İV sıvı tedavisini başlatma, akış hızını düzenleme ve izleme • İV solüsyona ilaç ilave etme • Kan ürünleri ve kan transfüzyonunu başlatma, akış hızını düzenleme ve izleme • Kas içi enjeksiyon yapma • Kateter izlemi ve bakımı yapma • Kateterden ilaç verme • Kulağa ilaç uygulama • Nazogastrik (NG) ve perkütan endoskopik	3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3

	gastrostomi (PEG) yoluyla ilaç uygulama • Oral yolla ilaç verme • Rektuma ilaç uygulama • Solüsyonları uygun şekilde hazırlama • Vajinaya ilaç uygulama • Ven içi /intra venöz (İV enjeksiyon yapma	3 3 3 3 3
İLK YARDIM	• Boğulmalarda ilk yardım uygulama • Diğer acil durumlarda ilk yardım uygulama • Göz, burun ve kulağa yabancı cisim kaçmasında ilk yardım uygulama • Hayvan ve insan ısırmalarında ilk yardım uygulama • Kanamalarda ilk yardım uygulama • Kırık, çıkık ve burkulmalarda ilk yardım uygulama • Temel yaşam desteği verme • Yanık, sıcak çarpması ve donmalarda ilk yardım uygulama • Yaralanmalarda ilk yardım uygulama • Zehirlenmelerde ilk yardım uygulama	3 3 3 3 3 3 3 3 3 3 3
KİŞİSEL TEMİZLİK ve RAHATLIĞI SAĞLAMA	• Ağız, yüz, göz, kulak, burun, el, ayak, tırnak, saç bakımı verme • Bit tedavisi uygulama • Deri ve mukoza bütünlüğünü koruma • Diyabetik ayak bakımı verme • Hastanın giyinme ve soyunmasına yardım etme • İçinde hasta bulunan yatağı yapma • Masaj yapma • Perine bakımı verme • Tam vücut banyosu verme	3 3 3 3 3 3 3 3 3
ÖRNEK ALMA	• Balgam örneği alma • Boğaz kültürü alma • Gaita örneği alma • İdrar örneği alma • Kan alma • Kan şekeri ölçme • Kan, idrar ve gaita kültürü alma • Kateter kültürü alma • Yara kültürü alma	3 3 3 3 3 3 3 3 3
SAĞLIĞIN DEĞERLENDİRİLMESİ	• Antropometrik değerlendirme • Deri ve deri eklerini değerlendirme • Kardiyovasküler sistemi değerlendirme • Kas iskelet sistemini değerlendirme	3 3 3 3

	• Kulak burun boğazı değerlendirme • Meme muayenesi yapma • Nörolojik değerlendirme • Ruhsal değerlendirme • Sindirim sistemini değerlendirme • Solunum sistemini değerlendirme • Sosyal değerlendirme • Ürogenital sistemi değerlendirme	3 3 3 3 3 3 3 3
SICAK SOĞUK UYGULAMALAR	• Genel sıcak uygulama • Genel soğuk uygulama • Lokal sıcak uygulama • Lokal soğuk uygulama • Oturma banyosu (sitz) verme	3 3 3 3 3
SOLUNUM	• Derin soluk alma ve öksürme egzersizleri yaptırma • Maske ile oksijen verme • Nazal yolla oksijen verme • Oksijenasyonu değerlendirme • Oral, nazal, trakeal aspirasyonu yapma • Postüral drenaj uygulama • Trakeostomi bakımı yapma	3 3 3 3 3 3 3 3
YARA BAKIMI	• Basınç yarası gelişme riskini değerlendirme • Yara ve basınç yarası bakımı verme • Yarayı değerlendirme	3 3 3
YAŞAMSAL BULGULAR	• Ağrıyı değerlendirme • Kan basıncını ölçme ve değerlendirme • Nabzı (Apikal ve periferik) sayma ve değerlendirme • Santral venöz basıncı ölçme ve değerlendirme • Solunumu sayma ve değerlendirme • Vücut sıcaklığını ölçme ve değerlendirme	3 3 3 3 3 3
YENİ DOĞAN BAKIMI	• Anne bebek etkileşimini sağlama • APGAR'ı değerlendirme • Bebek banyosu yapma • Deri bakımı yapma • Fizik muayene yapma • Fototerapi alan bebeğe bakım yapma • Göbek bakımı yapma • Göz bakımı yapma • Vücut sıcaklığını koruma	3 3 3 3 3 3 3 3 3 3

*Beceriler alfabetik olarak sıralanmıştır.

Table A.3.YÖK's regulations of minimum requirements for simulation in nursing schools

*** Öğretim üyesine ek olarak belirtilen asgari öğretim elemanı ebelik veya Doğum ve Kadın Hastalıkları Hemşireliği alanından olmak üzere araştırma görevlisi, öğretim görevlisi veya öğretim üyesi olabilir.**
**** Yukarıda staj olarak ifade edilen eğitimlerin, uygulama eğitimi veya zorunlu staj eğitimi olup olmadığı ilgili programın zorunlu müfredatın belirlenecektir.**

Program Adı	Eğitim ve Öğretime Başlangıç İçin Asgari Öğretim Üyesi Sayısı	Öğretim Üyesi Alanları	Eğitim ve Öğretimin Üçüncü Yılının Sonuna Kadar Sağlanması Gereken Asgari Öğretim Üyesi + Asgari Öğretim Elemanı* Sayısı	Gerekli Laboratuvar ve Birimler	Laboratuvar Özellikleri	Uygulama/Staj/ İşyeri Eğitimi İmkanları**
Hemşirelik	**SBF/ SBYO, Hemşirelik Bölümü:** 4 + 1 **Hemşirelik Fakültesi** 8 + 2	**SBF/ SBYO, Hemşirelik Bölümü:** Öğretim üyelerinin en az 2 tanesinin hemşirelik esasları, Hemşirelikte yönetim, İç hastalıkları hemşireliği, Çocuk sağlığı ve hastalıkları hemşireliği, Doğum ve kadın hastalıkları hemşireliği veya Cerrahi hastalıklar/ ameliyathane hemşireliği alanlarından olmak üzere, farklı hemşirelik veya tıp alanlarından en az 4 öğretim üyesi ve hemşirelik lisans mezunu 1 öğretim elemanı **Fakültede Hemşirelik Bölümü:** Her bir hemşirelik ABD'da alandan en az bir öğretim üyesi olmak üzere farklı anabilim dallarından toplamda en az 8 öğretim üyesi ve 2 öğretim elemanı	**SBF/ SBYO, Hemşirelik Bölümü:** Tıp Fakültesi bulunan üniversitelerde en az 4 öğretim üyesi ve 2 öğretim elemanı, Tıp fakültesi bulunmayanlarda an az 5 öğretim üyesi ve 3 öğretim elemanı **Fakültede Hemşirelik Bölümü: 8+4**	Temel Eğitim Laboratuvarı Temel Beceri Laboratuvarı Simülasyon Merkezi	Grup çalışmalarına olanak tanıyan ve ayrılmış bölmelerden oluşan salonlar bulunmalıdır. Hasta Ünitesi bölümü olmalıdır Malzemeleri muhafaza etmek için uygun dolaplar ve malzeme hazırlık ünitesi olmalıdır. İnsan Bakım Simülatörü* Yaşam Belirtileri Simülatörü Enjeksiyon Simülatörleri. Kataterizasyon Simülatörü Lavman Uygulama Simülatörü Rutin hemşirelik uygulamalarını göstermek üzere diğer malzemeler. İnsan Bakım Simülatöründe bilgisayar üzerinde senaryo oluşturma programı ile önceden ya da yeni oluşturulan senaryolarla vaka yönetimini uygulama özelliği de bulunmalıdır.	Hemşirelik Temel İlke ve Uygulamaları, İç Hastalıkları Hemşireliği, Cerrahi Hastalıklar Hemşireliği, Doğum ve Kadın Hastalıkları Hemşireliği, Çocuk Sağlığı ve Hastalıkları Hemşireliği, Halk Sağlığı Hemşireliği gibi stajlar, en az 100 yataklı Üniversiteye bağlı Sağlık Uygulama ve Araştırma Merkezleri, Eğitim ve Araştırma Hastaneleri, Afiliye Hastaneler veya Devlet Hastaneleri ve Halk Sağlığı Müdürlüğü'ne bağlı birimlerde yapılacak şekilde protokoller yapılmalıdır.

***Öğretim üyesine ek olarak belirtilen asgari öğretim elemanı hemşirelik veya ebelik alanından olmak üzere araştırma görevlisi, öğretim görevlisi veya öğretim üyesi olabilir.**
**** Yukarıda staj olarak ifade edilen eğitimlerin, uygulama eğitimi veya zorunlu staj eğitimi olup olmadığı ilgili programın zorunlu müfredatında belirlenecektir.**

3000 elektronik kitap ve tıp fakülteleri için güncel bilgi sunan en az 1000 adet e-dergi ve en az 2 adet bibliyografik veri tabanına abone olunmalıdır.

Tıp öğrencilerinin faydalanabilmesi için her bir dersle ilgili "Text-Book" kitaplarının son baskılarının her birinden en az 10 tane olmalıdır.

Fakülte kütüphaneleri, ihtisas ve araştırma kütüphaneleri olduğu için fakülte kütüphanesinde mutlaka kütüphane ve belge yönetimi eğitimi almış en az 2 adet kütüphane elemanı olmalıdır.

4. Diğer Eğitim Ortamları ve Eğitim Araçları

4.1 Anatomi Eğitim Laboratuvarı Diseksiyon Salonu

a) Biri ana diseksiyon masası olmak üzere en az 5 masadan oluşan ve 30 öğrencinin aynı anda çalışabileceği uygun bir oda veya ayrı bir salon bulunmalıdır.

b) Öğrenci ve çalışanların, sağlığı ve güvenliği açısından kadavra uygulama laboratuvarlarının havalandırma sistemleri olmalıdır.

c) En az 2 (60-120 öğrenci arası 3) adet kadavranın muhafazası için uygulama birimi içinde laboratuvarlardan bağımsız kadavra havuzu ya da soğutucu dondurma dolapları önceden hazır olmalıdır.

ç) Kadavra ilaçlama ve koruma için gerekli diseksiyon malzemeleri ve kimyasallar alınmış ve hazır olmalıdır.

4.2 Maket Salonu

Sistematik anatomi eğitimine uygun, tüm vücut bölümlerini topografik, kesitsel ve fonksiyonel açıdan uygulamalı eğitim amacıyla 10 öğrenci/ bir masa olmak üzere gerekli yardımcı eğitim materyali çeşitliliği sağlanmalıdır.

4.3 Multidisipliner Laboratuvarlar

a) Laboratuvar biyogüvenliği sağlanmış, 30 öğrenci için 5 çalışma masasının olduğu, eğitim laboratuarına ek olarak çözelti hazırlama ünitesinin yer aldığı, laboratuvar masalarında en az 2 adet musluk, kaynatma işlemi için tüp sisteminin planlandığı, çalışma ortamının oda ısısı şartlarında (25 °C) olduğu, en az bir adet kimyasal depo, soğuk depo, giyinme ve yıkanma odası şartlarının temin edilmiş olduğu belgelenmelidir.

b) Tıbbi biyoloji için moleküler sistemler (DNA ekstraksiyon santrifüjü, PCR. elektroforez vb. sistemler) olmalıdır.

c) Biyokimya için gerekli araç (spektrofotometre santrifüj, pH metre vd.) ve gereç olmalıdır.

d) Çekirdek eğitim müfredatı kapsamındaki Enfeksiyon Hastalıkları için gereken klinik örneklerde (balgam, idrar, kan vb.) mikrobiyolojik incelemeleri yapmak için gerekli araç-gereç ve hazır preperat setleri (öğrenci sayısına göre yeterli sayıda) olmalıdır.

e) Her 5 öğrenci için bir hücre fizyolojisi seti olmalıdır.

f) Elektrofizyolojik kayıt sistemi (EMG, EEG, EKG, EOG, organ banyosu) bulundurulmalıdır.

g) Öğrenci başına bir adet olmak üzere binoküler mikroskop, mikroskop adedince mikroskop dolabı, eğitim mikroskobu ve görüntüleme sistemi (laboratuvar büyüklüğüne göre LED monitörle desteklenmiş görüntüleme sistemi) bulundurulmalıdır.

h) Biyogüvenlik emniyet kabinleri, atık konteynırı, kimyasal depolama kabini, kimyasal çeker ocağı, inceleme örneği saklama dolabı vb teçhizat bulundurulmalıdır.

4.4 Histoloji ve Patoloji Dersleri İçin Multidisipliner Laboratuvar

a) En az 5 öğrencinin oturabildiği en az 5 çalışma masasıyla düzenlenmiş asgari 60 öğrenci için laboratuvar kurulmalıdır. Laboratuvarlar, Yükseköğretim Genel Kurulu tarafından belirlenen "Asgari Mekan Standartları" ile uyumlu yapılandırılmalıdır.

b) Laboratuvarın havalandırılması, aydınlatılması ve ses akustiği eğitime uygun olmalıdır.

c) En az öğrenci adedince (pratik sayısı grubuna göre) binoküler öğrenci mikroskobu, mikroskop dolabı, eğitim mikroskobu ve görüntüleme sistemi (laboratuvar büyüklüğüne göre LED monitörle desteklenmiş monitör sistemi) eğitim preparatları seti bulunmalıdır.

d) Biyogüvenlik emniyet kabinleri, atık konteynırı, kimyasal depolama kabını, kimyasal çeker ocağı, doku saklama dolabı bulunmalıdır.

4.4 Tıp Eğitimi Laboratuvarı

Mesleksel beceri dersleri için gerekli masa maket ve donanımlar ile tıbbi beceri laboratuvarları olmalıdır.

4.4.1 Maket ve Modellerle Tıbbi Beceri Eğitimi Laboratuvarı

Tıbbi beceri eğitimi laboratuvarında kazandırılmak istenen beceriler ile uyumlu ve öğrenci sayısına göre yeterli sayıda donanım bulundurulması önemlidir. Özellikle temel eğitimin hasta üzerinde yapılanmasının mümkün olmadığı becerilerin kazandırılmasına yönelik olmalıdır. Bu kapsamda aşağıdaki model ve donanımların tıbbi beceri laboratuvarında yer alması gereklidir:

a. Cerrahi dikiş atma ve cerrahi düğüm becerisi için modeller
b. Enjeksiyon eğitimi modelleri

Damar içi enjeksiyon modelleri, erkek, kadın ve çocuk tipi kol maketleri, tercihen içinde dönebilen omuz kası bulunmalı; yüzeysel ve derin damarlara giriş sağlanabilmeli; arter içi girişler içinde kullanılabilmelidir. Kas içi enjeksiyon modelleri, hatalı uygulamada sinyal veren veya alt anatomik yapıları görmek için ayrılabilir parçalar şeklinde üretilmiş olmalıdır. Deri altı enjeksiyon modelleri bulunmalıdır.

c. Havayolu, ambu eğitim maketleri
d. Kalp akciğer canlandırması (CPR) simülasyon modeli (erişkin, çocuk)
e. Nazo Gastrik Tüp (NGT) uygulama modeli
f. Erkek/kadın idrar sondası uygulama modeli

4.4.2 Simüle Hasta Laboratuvarı

Öğrenci sayısı ve eğitim planlamasına göre değişen sayıda en az 2 simüle hasta odasına ihtiyaç vardır. Öğrenci sayısı 60 olan tıp fakülteleri için 3, daha büyük olanlarda 60 ve katları için ilave 1 olmak üzere simüle hasta odası planlanması uygundur.

a) Simüle hasta odasında aşağıda belirtilen cihaz ve donanım bulunmalıdır: Doktor masası ve sandalyesi, hasta sandalyesi, paravan.

b) Masaüstü bilgisayar (hastanede kullanılan otomasyon sistemine uygun bir programın yüklü olması tercih edilmelidir).

c) Muayene masası, etajer, refleks çekici, steteskop ve tansiyon aleti, otoskop, oftalmoskop, EKG cihazı, Negatoskop, Video kamera ve kayıt sistemi.

- Öğrencilerin laboratuvarları, öğrencilerin bağımsız çalışmalarını sağlayacak şekilde ve sayıda donanıma sahip olmalıdır

TIP PROGRAMLARINDA EĞİTİME BAŞLANMASI VE EĞİTİMİN SÜRDÜRÜLMESİ İÇİN GEREKLİ OLAN ASGARİ ÖĞRETİM ÜYESİ SAYISI VE DAĞILIMI				
Anabilim Dalları	İstihdam Şekli	Eğitim ve Öğretime Başlangıç İçin Asgari Öğretim Üyesi Sayısı	Eğitim ve Öğretim Yılının Üçüncü Yılı Sonuna Kadar Sağlanması Gereken Asgari Öğretim Üyesi Sayısı	
			60 Öğrenci Kontenjanına Kadar	120 Öğrenci Kontenjanına Kadar
Anatomi	K	1	1	2
Fizyoloji	K	1	1	2
Histoloji - Embriyoloji	K	1	1	1
Tıbbi Biyokimya	K	1	2	3
Tıbbi Mikrobiyoloji	K	1	2	3
Tıbbi Biyoloji/ Tıbbi Genetik	K	1	1	2
Patoloji	K	1	2	3
Farmakoloji	K	1	1	2
Tıp Tarihi ve Deontoloji	K/G	1	1	1
Biyofizik	K/G	1	1	2
Tıbbi İstatistik	K/G	1	1	2
Tıp Eğitimi	K/G	1	1	1
Adli Tıp	K/G	1	1	1
Acil Tıp	K/G	1	1	2
Aile Hekimliği/ Halk Sağlığı	K/G	1	1	2
İç Hastalıkları	K	1	3	5
Çocuk Hastalıkları	K	1	3	5
Genel Cerrahi	K	1	2	4
Kadın Hastalıkları ve Doğum	K	1	2	4
Göğüs Hastalıkları	K		2	3
Enfeksiyon Hastalıkları ve Klinik Mikrobiyoloji	K		2	3
Kardiyoloji	K		2	3
Nöroloji	K		2	3
Radyoloji	K		2	3
Psikiyatri	K		2	3
Dermatoloji	K		1	2
Fiziksel Tıp ve Rehabilitasyon	K		1	2
Nükleer Tıp	K		1	1
Kalp ve Damar Cerrahisi	K		1	1
Göğüs Cerrahisi	K		1	1
Ortopedi ve Travmatoloji	K		1	2
Beyin ve Sinir Cerrahisi	K		1	2
Anesteziyoloji ve Reanimasyon	K		1	2
Kulak Burun Boğaz	K		1	2
Göz Hastalıkları	K		1	2
Çocuk Cerrahisi	K		1	1
Plastik Rekonstrüktıf Cerrahi	K		1	1
Üroloji	K		1	2
Toplam		19 (12K+7KG)	53 (46K+7KG)	86 (75K+11KG)

K: Kadrolu K, K/G: Kadrolu veya Görevlendirmeli.
Asgari sayı dağılımı ders yükü, laboratuvar uygulamaları ve ÇEP temsiliyeti göz önünde bulundurularak yapılmıştır