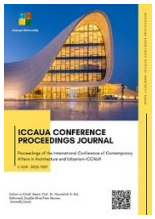

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Rethinking Educational Spaces: How Technology and Architecture Reshape Control and Social Dynamics in Schools

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A b s t r a c t

As technology reshapes our lives, school buildings, too, are undergoing a dramatic shift in terms of their curriculum, modus operandi and building typologies. New tools and technologies, such as artificial intelligence, cloud-based systems, remote education, in addition to an ever increasingly networked society affects the way students learn and teachers teach. In this paper, we explore a new school typology that converges digital and physical spaces, and offers novel teaching and learning environments for the future generation of students and teachers. We survey new design approaches in education, compare existing transformations of other relevant building typologies, and illustrate the application of our findings on a real-world case study. First, we map out the program of physical and/or digital spaces of future school buildings, second, we develop new design approaches to converge the two, and finally, illustrate a replicable framework for a new school typology in Türkiye.

K e y w o r d s : Educational Building Typology; Technological Advancements in School Design; Pedagogical Vision In Architecture.

1. Introduction

Educational buildings increasingly need new architectural program data and changes in line with the needs of our age. As observed during the pandemic process, the education form is evolving towards a new form with the digitalizing world day by day. This article is about investigating what new architectural requirements or suggestions may be aimed at increasing the comfort and convenience of use of buildings as today's accepted education trends develop together with artificial intelligence.

In this article, it is aimed to provide an output that can create a design guide on the architectural building program according to these methods by discussing the selected good examples of the currently used education methods in primary and secondary schools for ages between 6 and 14 in Türkiye. While this issue is being discussed, inferences about what new functions may be possible will be discussed while examining what old functions are less used in the structures of distance education with artificial intelligence in schools affiliated to the Ministry of National Education. In addition, it will be discussed what new benefits the developed education infrastructures in the world can provide in the formal education structures affiliated with the Ministry of National Education.

2.Background

2.1.Current Educational Infrastructure in Türkiye

Education is one of the cornerstones of the development of societies, and the physical structure of educational buildings directly affects the learning process. Educational buildings in Türkiye are largely constructed through general type projects, and according to a report prepared by the ministry in 2015, it is observed that these structures are insufficient to adapt to modern education approaches and technological transformations (Ministry of National Education [MEB], 2015). The implementation of innovative applications, especially artificial intelligence-supported education systems, within old-style education structures brings with it various difficulties.

The findings regarding resistance to innovation and the effective use of digital technologies in education provide a meaningful perspective in terms of the current education system and school management practices in Türkiye. According to TALIS 2018 data, school leaders being more open to innovation can provide a significant advantage in schools' adoption of digital teaching and teaching methods. The fact that teachers in Türkiye have a significant level of education in using digital technology shows that Türkiye is one step ahead in the digitalization process. According to OECD data, the majority of teachers in Türkiye have received training on the use of information and communication technologies (ICT) in education, and this rate puts Türkiye in a position that puts it ahead of many countries (OECD, 2019). This situation is directly related to the modernization of teacher training programs in Türkiye and the strengthening of teaching skills for digital technologies. Türkiye's high rate in this field offers an important opportunity for digital transformation in education.

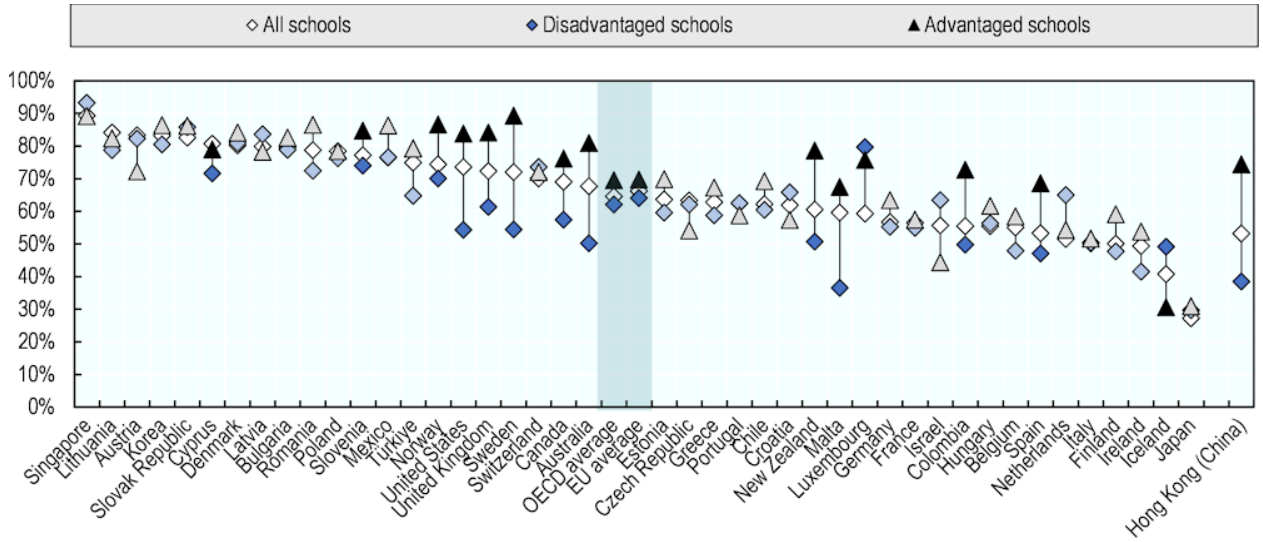

Table1. The socio-economic profile is measured by the PISA index of economic, social and cultural status (ESCS). A socio-economically disadvantaged (advantaged) school is a school in the bottom (top) quarter of the index of ESCS in the relevant country/economy; Statistically significant differences between advantaged and disadvantaged schools are marked in a darker tone; Countries and economies are ranked in descending order of the percentage of students in schools where teachers have the necessary technical and pedagogical skills to integrate digital devices in instruction.
Source: OECD (2020[9]), *PISA 2018 Results (Volume V): Effective Policies, Successful Schools*, https://doi.org/10.1787/ca768d40-en, Tables V.B1.5.15 an.

However, in order to effectively integrate digital technology in schools, school leaders must also play an active role in this process. This will allow “creative thinking and shared design issues” (Nafa & Husain, 2021). among students. In Türkiye, evaluations of school leaders' digital teaching skills and pedagogical training show that how prepared school principals and teachers are to integrate digital devices pedagogically varies greatly depending on the socio-economic status of the school. These differences are especially evident in schools located in socio-economically disadvantaged regions. It is possible to observe similar inequalities in Türkiye, because there are resource and capacity differences between schools in big cities and rural areas (OECD, 2020).

PISA 2018 data also reveals the challenges school leaders face in improving digital teaching skills. Türkiye lags behind some other European countries in the proportion of teachers who have the skills to integrate digital devices in education, but it is still a developing country. In this context, in order to effectively use digital education technologies in schools in Türkiye, school leaders and teachers need to better manage the adaptation processes to these technologies (OECD, 2020).

As a result, the education system in Türkiye has serious potential to accelerate digital transformation and adopt innovative pedagogical approaches. However, in order for this transformation to be successful, school leaders must improve their leadership skills, teachers must increase their competency in providing education with digital technologies, and steps must be taken to eliminate socio-economic inequalities. In this process, it is important to direct education policies to eliminate digital infrastructure deficiencies in schools (OECD, 2019).

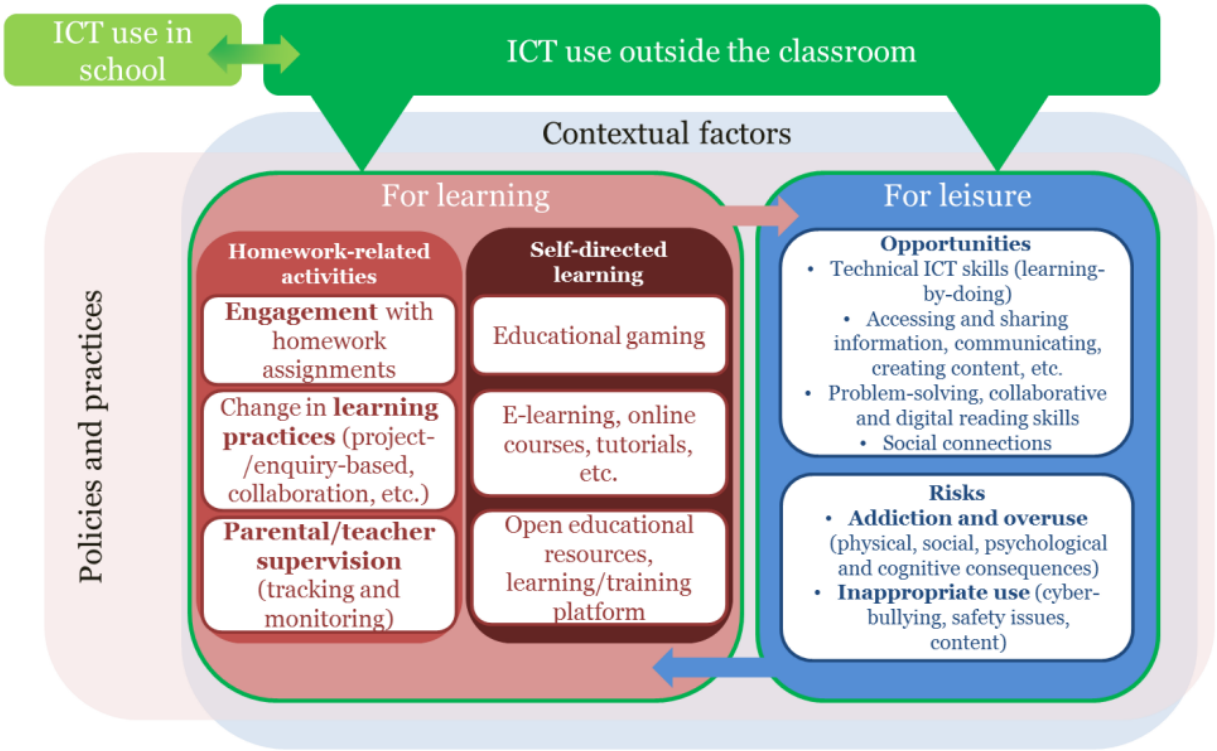

Table 2. Detailing ICT use outside the classroom, OECD (2023), PISA 2022 Assessment and Analytical Framework.

2.2.ICT Integration in Education

Information and communication technologies (ICT) are used in different ways in educational processes both inside and outside of school. These areas of use can be examined under two main headings: learning activities and entertainment use.

The use of ICT for learning involves students using technology in various ways to support their educational process. By using information technologies while doing their homework, students can be more involved in their lessons and improve their learning processes. The use of ICT makes methods such as project-based learning, collaboration and inquiry-based learning more effective. Additionally, thanks to digital tracking systems, parents and teachers can monitor and guide students' progress. In addition, students can have the opportunity to learn at their own pace by using tools such as educational games, online courses, educational videos and open educational resources.

Students use ICT not only for academic purposes but also for entertainment and leisure activities. This use has some opportunities and risks. While ICT helps students improve their technical skills, access information, share and increase their productivity skills, it also offers the opportunity to collaborate and strengthen social connections. However, overuse and the risk of addiction can create physical, social, psychological and cognitive effects. Additionally, security risks such as inappropriate content and cyberbullying are among the negative aspects of ICT use.

Effective use of information technologies can support both the academic and social development of students. However, conscious and controlled use should be encouraged by being aware of possible risks.

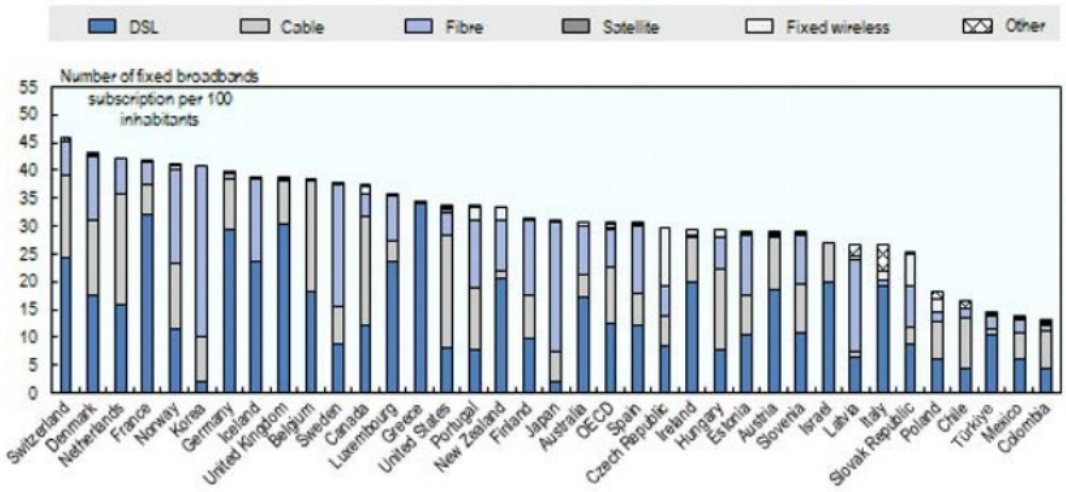

Table 3 . Türkiye's ICT Use and Comparison with OECD Countries, OECD (2023), PISA 2022 Assessment and Analytical Framework.

While the fixed broadband subscription rate in Türkiye was below 15 per 100 people in 2017, this rate is over 40 in some OECD countries. While the share of fiber internet connections in total broadband is over 75% in Japan and Korea, it remains below 10% in Türkiye.

While 95% of 15-year-old students across the OECD have internet access at home, this rate is below 50% in Türkiye. The digital divide is large for disadvantaged students; While the majority of disadvantaged students in OECD countries have access to a computer, in Türkiye less than 50% of disadvantaged students have access to a computer at home. In schools in Türkiye, ICT use is restricted due to lack of bandwidth, and 20% of students cannot fully benefit from ICT due to low bandwidth. While 64% of employees in Norway regularly use ICT in their work, this rate remains below 33% in Türkiye. While the need for digital skills in the labor market in Türkiye is increasing, the rate of employees possessing these skills is well behind the OECD average.

There is a large digital divide between rural and urban areas in Türkiye. While the rate of internet access in rural areas is below 40%, it is close to 80% in cities. Although Türkiye has developed ICT policies, the impact of these policies is not yet at the level of many developed OECD countries.

Although Türkiye is making progress in the use of ICT, it needs to increase infrastructure investments, digital education programs and skill development policies for the workforce to reach the average of OECD countries. In particular, increasing fiber internet investments, improving ICT integration in education and closing the digital divide stand out as priority issues.

2.3.Obstacles of General Type Educational Buildings

Educational buildings in Türkiye are generally designed based on standard projects (OECD, 2023a). One of the biggest problems of these structures is that they are modular and uniform. Since educational buildings are built on a specific type of project, they are far from flexible and have difficulty adapting to different learning models. This situation makes it difficult for teachers and students to adapt to innovative education methods.

Another major obstacle is the lack of digital infrastructure. Most old buildings do not have the infrastructure suitable for modern technologies. Requirements such as fiber internet infrastructure, smart board systems and technology-supported learning areas have been ignored (OECD, 2023b). For this reason, it is not possible to fully implement digital education. In addition, narrow and limited learning areas cannot meet the need for flexibility in education. Today, education takes place not only in classrooms, but also in libraries, workshops and open spaces. However, typical projects are not designed to support this diversity (MEB, 2015).

Another important element in educational environments is acoustics and lighting. Correct acoustic arrangements and the use of natural light support the learning process by increasing students' attention. However, these elements have been ignored in most of the existing buildings. Finally, there are serious deficiencies in old-style education structures regarding energy efficiency and environmental sustainability. While energy efficiency is prioritized in modern educational buildings, sufficient studies on this issue have not been carried out in old projects (OECD, 2023c).

2.4.Applicability Problems of New Technologies

The modern understanding of education requires the integration of innovative technologies such as artificial intelligence, virtual reality (VR), augmented reality (AR) and the internet of things (IoT) (OECD, 2023). However, the applicability of these systems is limited in old-style educational buildings. Artificial intelligence-supported learning environments provide opportunities such as presenting content according to students' individual learning speeds, performing analysis and increasing student success (TÜBİTAK, 2024). However, for these systems to work properly, a strong internet infrastructure, data centers and smart classroom technologies are required. There is no sufficient technical infrastructure for these systems in old-style education buildings.

Digital classrooms and smart technologies have become an important part of modern education. Smart boards, tablets and distance education systems are widely used in today's education approach (OECD, 2023). However, in old-style educational

buildings, electrical installations and internet connections are not capable of supporting such technologies. For this reason, the efficient use of technological developments in education remains limited.
The importance of flexible learning spaces is increasing. Today, education takes place not only in classrooms, but also in group studies, workshops and open spaces (OECD, 2023). However, such areas are not considered in typical projects. In many schools in Türkiye, libraries are inadequate, laboratories are old and environments suitable for group work are limited. In addition, virtual and augmented reality applications are becoming increasingly common in education (OECD, 2023). However, for these systems to work properly, wide range of motion, strong network connections and appropriate hardware are required. Many of these requirements cannot be met in old-style educational buildings.

3.Surveying Analysis

Traditional physical classroom environments, digital learning platforms and hybrid phygital education models that blend these two have emerged as structures that deepen students' learning processes, increase accessibility and offer personalized educational experiences. While the architectural layout of physical environments affects students' learning success with parameters such as natural light, acoustics, color and spatial flexibility (Barrett et al., 2016), digital environments increase student interaction and access through virtual classrooms, e-learning systems and mobile applications (Ivanović et al., 2019). Education in a phygital environment blends the best of these two worlds, allowing students to benefit from both the tactile and social experience provided by the physical classroom and the flexibility offered by the digital world.

3.1.1.Traditional Classroom Environments

Traditional classroom environments are structures where students interact face to face, the teacher provides direct guidance, and the effects of spatial arrangements on learning are observed. It is known that factors such as natural light, acoustic comfort, use of color, spatial order and flexibility in the design of physical classrooms directly affect students' attention, motivation and learning efficiency. Barrett et al. The HEAD (Holistic Evidence and Design) study conducted by (2016) reveals the effects of classroom physical features on learning progress in basic courses such as reading, writing and mathematics. In the study, it was emphasized that factors such as lighting, natural environment connection, space individualization and visual complexity are effective at different degrees on students' academic success (Barrett et al., 2016). Improvements made in the design of physical education environments not only increase the interaction of students in the classroom, but also positively affect the efficiency of the learning process. For example; While in-class flexibility creates more suitable environments for students' group work and individual activities, individualized learning areas allow students to learn at their own pace. In addition, modern architectural approaches increase students' comfort and therefore their learning motivation by ergonomically designing classroom arrangements and furniture (Barrett et al., 2016).

3.1.2.Digital Education Environments

Digital education makes it possible to access information via internet-based platforms, virtual classrooms, mobile applications and e-learning systems. The main advantages of these environments include space and time independence, customizable learning paths, and increased student interaction. For example; Learning management systems such as Moodle allow teachers to prepare interactive course content, while students can access materials suitable for different learning styles (Ivanović et al., 2019). In addition, virtual laboratories and simulation applications allow students to learn concepts by experimenting, especially in STEM (Science, Technology, Engineering and Mathematics) disciplines (Terracina et al., 2016).
The flexibility offered by digital environments is a great advantage, especially for students with special needs. Speech-to-text and text-to-speech technologies enable hearing or visually impaired students to access educational materials more easily; Additionally, online education platforms improve the traceability of the learning process by increasing student-teacher interaction (Ivanović et al., 2019). However, for digital education environments to be successful, it is important for teachers to use technology effectively, provide appropriate infrastructure and develop digital literacy skills (Savin-Baden, 2015).

3.1.3.Phygital Educational Environments

Education in a phygital environment is an innovative education model that expresses the integration of digital and physical environments. In this model, a hybrid learning experience is offered by integrating digital technologies into the physical classroom environment. Phygital environments simultaneously provide students with the opportunity for face-to-face interaction and the advantages offered by digital tools, such as extensive information access, simulation, interactive content and data analysis.
This hybrid approach has become even more important, especially as distance education has become mandatory during the pandemic period. Students can receive flexible and personalized education through digital platforms without compromising the social and tactile experience of the physical classroom. For example; Thanks to interactive whiteboards, augmented reality (AR) applications and mobile devices, students can experience course content in a more interactive way (Lage, Platt & Treglia, 2000).
Phygital education also plays an important role in increasing inclusivity in education. While the social interaction offered by physical classrooms has an important place in the emotional and social development of students, digital technologies facilitate access to learning materials and personalize the learning processes. In this way, students with different learning styles can have an educational experience that suits their needs; both individual and group learning processes are supported (Ivanović et al., 2019 ; Savin-Baden, 2015).
However, the design and implementation of phygital educational environments brings with it some challenges. Infrastructure deficiencies, adaptation problems experienced in the technological integration process, teachers' inability to use digital tools effectively and digital literacy differences between students are among the important factors that may affect the success of

the phygital model. Therefore, educational institutions need to invest in both the modernization of physical spaces and digital education technologies. In addition, supporting teachers to use digital technologies effectively through continuous professional development programs is of critical importance for the sustainability of the phygital education model.

Table 4. Educational Components in Section Physical, Phygital & Digital, created by Author.

Digital, physical and phygital educational environments are educational approaches that complement each other but offer different advantages. While the tactile and social interaction provided by physical classrooms contributes to the emotional and cognitive development of students; Digital environments accelerate access to information and personalize learning processes. The Phygital approach blends the best aspects of these two models and offers students a richer and more flexible learning experience. It is suggested in the literature that there is a positive relationship between the spatial arrangements of physical classroom environments and students' academic success (Barrett et al., 2016). On the other hand, it is stated that digital educational tools increase learning success, especially in students with special needs, and that interactive and visual materials reflect positively on the learning process (Ivanović et al., 2019). These findings reveal the necessity of adopting flexible and hybrid approaches according to the individual needs of students, instead of a uniform model in education.

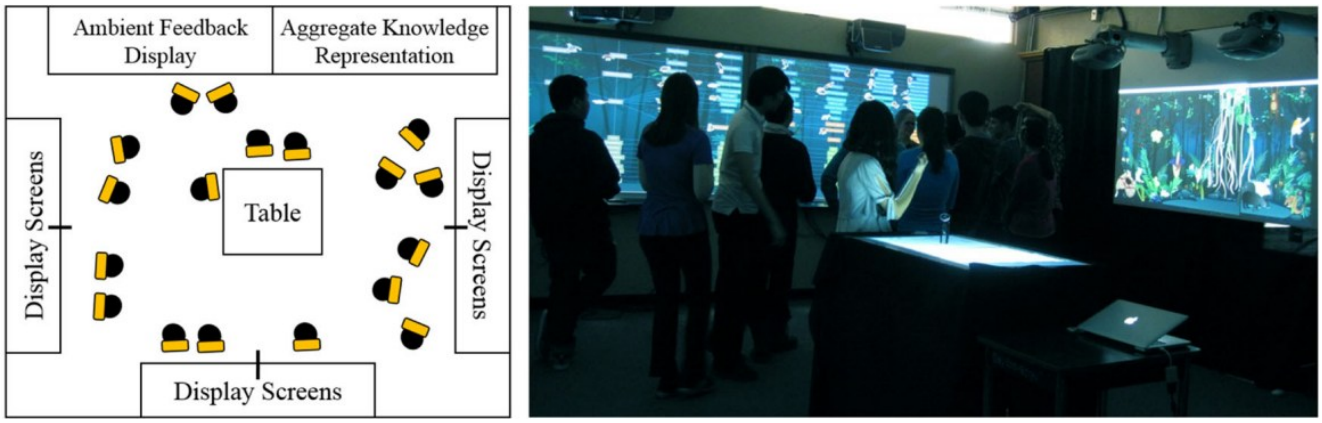

Figure 1. Scripting collaborative knowledge construction, large immersive screens simulate rainforests which students must investigate to study natural selection. (Hod, 2017).

Phygital education has emerged as an effective strategy, especially in the post-pandemic period, to complement the deficiencies of face-to-face education with digital tools and to alleviate the social isolation problem experienced in digital education. While students maintain the social interaction and instant feedback provided by the physical classroom environment, they can also access broader information thanks to digital resources. Thus, the learning process becomes both more inclusive and more effective (Lage, Platt & Treglia, 2000).

3.2. The Two Views of Education

Education has long been divided into two primary approaches: teacher-centered learning and student-centered learning. These paradigms shape not only the instructional strategies used within classrooms but also the architectural and technological structures that support learning environments.

3.2.1. Teacher-Centered Learning

Teacher-centered learning remains a dominant model in education, where the instructor serves as the primary source of knowledge and directs the learning process. Historically, this model has been influenced by industrial-era efficiency models, emphasizing standardized curriculum and direct instruction (Hod, 2017, p. 6).

Teacher-centered classrooms are typically designed with a focus on the instructor. The traditional classroom layout includes rows of desks facing a centralized teaching podium or blackboard, reinforcing the hierarchical structure of knowledge transmission (Hod, 2017, p. 6).

The integration of new technologies in teacher-centered learning often faces challenges, as it is primarily designed for lecture-based instruction rather than interactive, student-led learning experiences. Many technologies fail to be fully utilized due to their misalignment with rigid curricula and assessment structures (Hod, 2017, p. 100). Didactic strategies in teacher-centered learning rely on structured lesson plans, direct lectures, and standardized testing to measure knowledge acquisition. This model is efficient for delivering large amounts of information but often lacks opportunities for critical thinking and creativity (Hod, 2017, p. 7).

3.2.2. Student-Centered Learning

Student-centered learning represents a shift from traditional methodologies by placing learners at the core of the educational process. It emphasizes personalized, experiential, and collaborative learning experiences.Flexible learning environments support student-centered education by offering modular furniture, open spaces, and collaborative areas. Schools designed under this model often feature learning commons, makerspaces, and multipurpose classrooms that encourage autonomy and creativity (Hod, 2017, p. 8). Pedagogically, student-centered learning employs strategies such as problem-based learning (PBL), flipped classrooms, and inquiry-based learning. These methods encourage students to take ownership of their education, fostering engagement and deeper understanding (Hod, 2017, p. 9).With advances in technology, online autonomous models have become integral to student-centered learning. Digital platforms facilitate self-directed learning, allowing students to engage with content at their own pace while interacting with instructors and peers through virtual discussions and collaborative projects (Hod, 2017l, p. 145).

Figure 2. Active learning Classroom. (Yotam Hod, Future Learning Spaces in Schools: Concepts and Designs from the Learning Sciences, 2017).

3.2.3. Blended Learning (Phygital) Pedagogical Model

Blended learning integrates elements of both traditional face-to-face instruction and online education, creating a flexible and effective learning environment (Blended Learning Pedagogical Model, p. 143). In blended learning, face-to-face interactions remain essential for fostering social connections and providing direct instructional support. This component allows for in-depth discussions, hands-on activities, and real-time feedback from instructors (Blended Learning Pedagogical Model, p. 147).

Table 5. Timeline of an Typical Face to Face Model (Blended Learning Pedagogical Model, 2020 p. 150).

Blended learning models strategically integrate online and in-person activities, ensuring coherence in curriculum delivery. Teachers serve as facilitators, guiding students through digital resources while incorporating collaborative projects that bridge online and offline learning experiences (Blended Learning Pedagogical Model, p. 149).
Virtual learning environments provide interactive components such as discussion forums, multimedia content, and adaptive learning systems. These technologies allow for personalized learning pathways, enhancing student engagement and self-regulation (Blended Learning Pedagogical Model, p. 151).
Addressing two different approaches in education (teacher-centered and student-centered) covers not only pedagogical approaches but also the design of physical and digital environments in which these approaches are applied. Although the teacher-centered model provides an orderly and structured learning environment, it cannot fully respond to the flexibility and individualization needs of the age. On the other hand, the student-centered approach ensures the active participation of the learner and the addition of personal touches to the learning process, while creating more dynamic and adaptable learning environments with the opportunities offered by technology.
The blended learning model combines the best features of these two approaches and supports both pedagogical and technological transformation in modern education. Thanks to this model, teachers not only transfer knowledge but also allow students to develop 21st century skills such as digital literacy, problem solving and critical thinking.
In addition, the impact of architectural arrangements and technological integration on education profoundly affects not only learning processes but also students' motivation and social interactions. Flexible, innovative and versatile design of learning environments in student-centered and blended models creates infrastructures that will better meet the educational needs of the future.

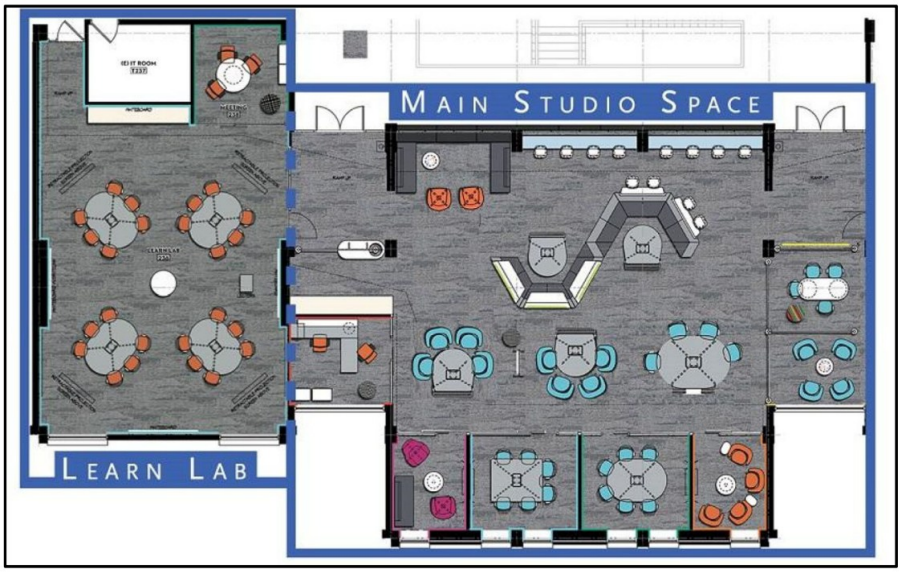

Figure 3. Two main spaces of Typical Phygital Class. (Yotam Hod, Future Learning Spaces in Schools: Concepts and Designs from the Learning Sciences, 2017).

3.3.Comperative Analysis

The transformation in the field of education in Türkiye and around the world affects many different dimensions, from the architectural structures of schools to classroom practices. While the traditional formal education model has been one of the basic building blocks of education systems for many years, alternative education approaches have also attracted attention in recent years. These alternative models include Waldorf, Montessori, new AltSchool and online education methods, each of which provides different contributions to the learning process with its own pedagogical and architectural features.

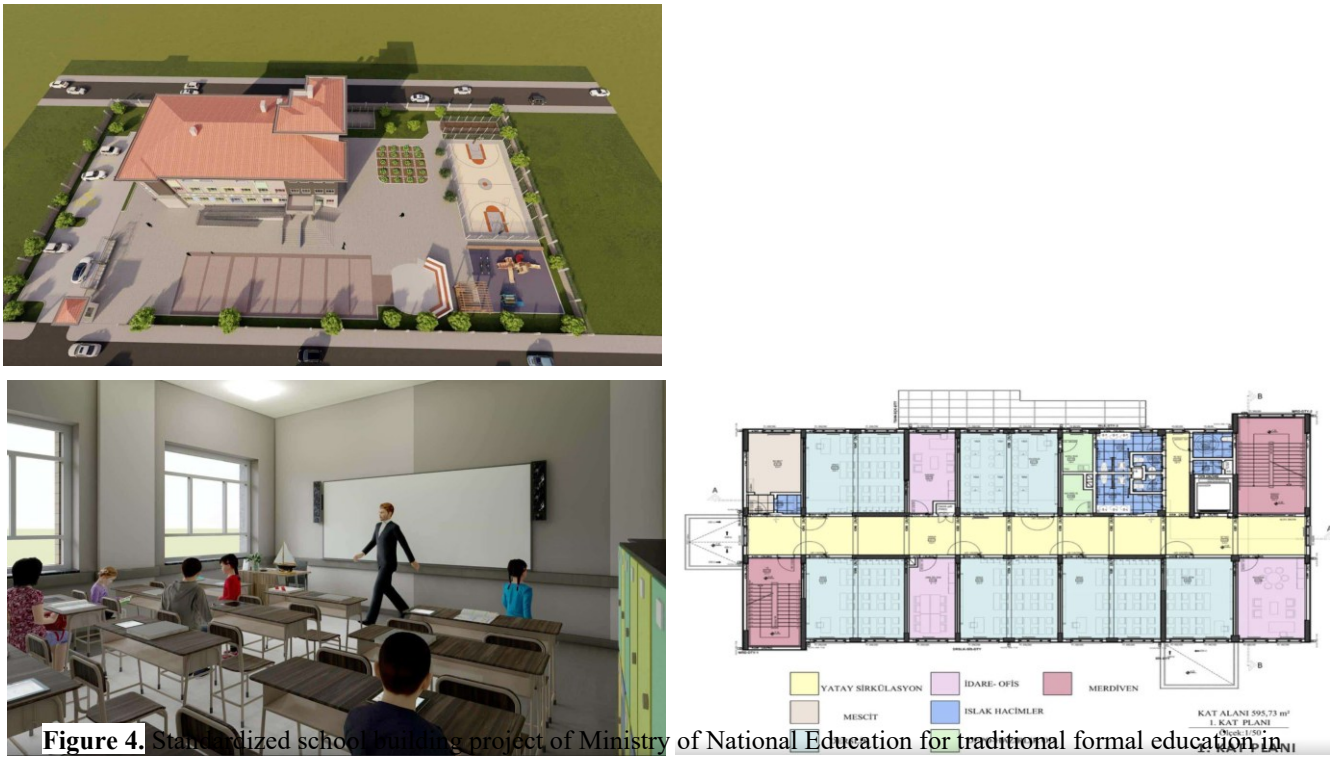

Figure 4. Standardized school building project of Ministry of National Education for traditional formal education in Türkiye, (Project Code MEB.İO.8.BZ2.21*39.Bt.2022,2022.).

3.3.1.In Traditional Formal Education

The layout of classrooms is generally based on a row-based table and chair arrangement. In this model, a teacher-centered approach is adopted; The teacher is the main figure who directly transfers information, lectures and focuses on students' performance measured by exams. Classrooms are designed as rectangular and closed areas, with fixed seating arrangements allowing students to sit in certain rows. This layout allows the transfer of knowledge to be carried out systematically, especially in large-scale classes. However, critics of this model argue that it fails to develop students' critical thinking, problem-solving and creative skills. OECD's 2018 "Education at a Glance" report states that classroom dynamics in the traditional education model have begun to change with the digital transformation process, but emphasizes that the flexibility of this model is limited (OECD, 2018). Recent studies conducted by the Ministry of National Education (MEB) in Turkey have revealed that steps have been taken towards flexible seating arrangements in modern school buildings, but they are still not widely implemented (MEB, 2021).

Figure 5..An example for Waldorf Primary school, Nairobi Waldorf School (Urko Sanchez Architects, 2024). Photographs by Javier Callejas.

3.3.2.Waldorf Education

which is among the alternative models, adopts a completely different approach. The classroom layout in Waldorf schools is equipped with areas that support students' individual work, with the use of wooden tables and chairs, natural materials and warm colors. In this model, classes are organized in smaller groups, usually with 15-25 students, creating large, bright classroom environments. In the Waldorf approach, the use of technology is minimal; Teachers emphasize storytelling, artistic activities, and learning methods in touch with nature. Students receive guidance through one-on-one interaction with the teacher. Additionally, regarding the use of open space, Waldorf schools have large green areas, agricultural gardens and outdoor classrooms to enable students to actively interact with nature. Students take nature walks in these gardens, take care of plants and attend outdoor classes. This contributes to students' social, emotional and cognitive development through physical activity and interaction with nature. This aspect of Waldorf education ensures that emphasis is placed not only on students' academic achievement, but also on life skills and love of nature.

Figure 6. An example for Montessori Primary school, Secondary school, Children's house, The Montessori Place East Sussex, United Kingdom (Paul Pillai, Rob Gueterbock, 2017).

3.3.3.The Montessori Approach

is a student-centered learning model and the classroom environment is designed entirely according to the needs of children. In Montessori classrooms, the open plan concept is applied; The classroom is divided into different learning areas, allowing children to work individually and in groups. Child-sized furniture, freely accessible learning materials, and organized workspaces are essential elements of the Montessori approach. Although the use of technology varies in Montessori schools, material-based learning primarily comes to the fore. Unlike traditional teaching methods, teachers play a guiding role that allows students to determine their own learning pace. Additionally, the use of open space is very important in Montessori school environments; Medium-sized natural gardens encourage children to explore plants by touching, smelling and observing. Garden areas are designed as spaces where students can move around freely, where outdoor lessons are held and individual discovery activities are organized. These features of Montessori education provide an environment that supports students to become individuals who are self-directed, develop original thinking skills, and are compatible with the environment.

3.3.4.The New AltSchool

model stands out as an innovative approach that responds to modern education needs. In this model, classes are organized in smaller groups with 10-20 students and feature flexible, modular design. AltSchool aims to use technology effectively in education, highlighting personalized learning platforms, VR/AR supported contents and STEM-based applications. While students manage their own learning processes thanks to modern technologies, teachers play the role of mentor and coach. In this model, the furniture in the classroom is mobile and flexible and can be rearranged according to the needs of the students. Additionally, noise and movement freedom within the classroom is higher, allowing students to move freely between classes. This flexibility offered by the new AltSchool model supports students' active learning experiences and development of problem-solving skills. Research conducted on a global scale reveals that hybrid and personalized learning environments increase students' motivation and academic success (UNESCO, 2020).

Figure 7. An example for Phygital School, AltSchool, AI Supported Teaching and Learning System (2013-2019).

3.3.5.The Online Education

model represents an approach that takes place in a completely digital environment, where the physical classroom is replaced by a virtual classroom. In online education, students attend classes through virtual classrooms from different geographical locations. In this model, video conferencing, interactive platforms, digital resources and virtual laboratories are used extensively. Interaction between student and teacher is provided through virtual guidance and individual coaching systems. In online education, students are encouraged to progress at their own learning pace, while the learning process is supported thanks to the various interaction tools offered by technology. Studies conducted in the post-pandemic period indicate that the advantages of online education, especially flexible time management, individual learning control and wide resource access, positively affect the overall success of students (UNESCO, 2020). However, limited physical interaction in online education may create some difficulties in terms of the development of social skills.

The architectural structures of schools are also evolving in parallel with educational models. Traditional formal educational institutions are characterized by concrete, multi-storey buildings and large classrooms, while centralized administrative structures dominate. Although these structures have supported standard educational practices for many years, they cannot fully respond to today's rapidly changing educational needs. OECD reports state that modern education approaches require flexible and technologically equipped buildings, so that students can have more efficient and interactive learning experiences (OECD, 2018). In Turkey, the Ministry of Education announced that it has taken steps towards the implementation of flexible classroom arrangements, digital infrastructure investments and sustainable architectural solutions within the scope of the modernization of schools (MEB, 2021).

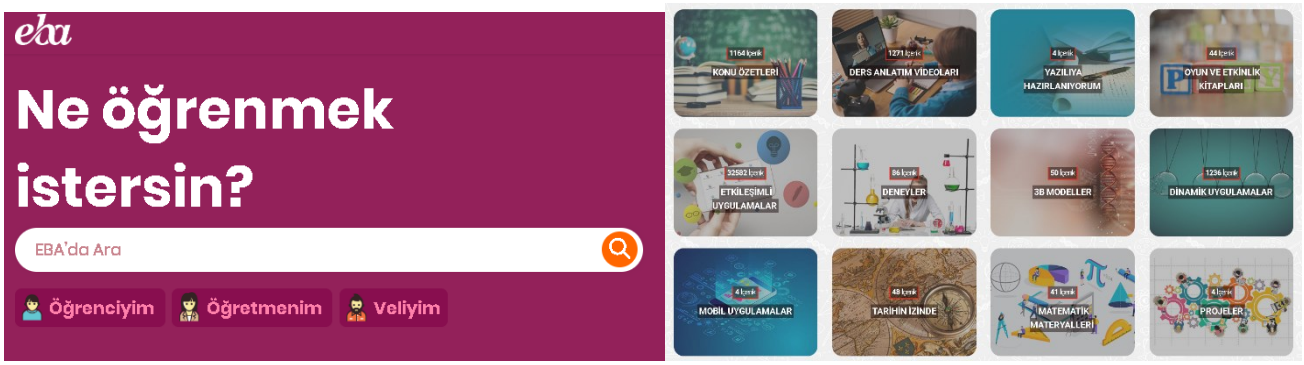

Figure 8.An example for Online Education System, EBA (Education Informatics Network) by Ministry of National Education of Türkiye.

In Waldorf schools, the architectural approach is characterized by designs integrated with nature, where natural materials and aesthetic elements are prioritized, illuminated by large windows. These structures help students relax and focus on learning, both physically and emotionally. In Montessori schools, spaces where students can move freely are created with open-plan classrooms, maximum use of natural light, child-friendly furniture and individual study areas. The new AltSchool models feature modern technological infrastructure and flexible, personalized learning spaces; These schools are equipped with innovative and student-centered designs and offer dynamic structures to meet the educational needs of the future. Although a physical comparison cannot be made in terms of architecture since online education is structured entirely in a digital environment without the need for a physical building, the platforms used in the virtual environment and the functionality of digital resources play an important role.

open space Its use is also an important component of educational models. In traditional formal education, open spaces are generally designed for decorative purposes or as playgrounds, and are areas where students can have limited interaction with nature. In contrast, in Waldorf schools, open spaces are designed as areas where students actively interact with nature, tend to plants and grow their own vegetables and fruits. In Montessori schools, open spaces are used as a learning area where students can make individual explorations and get to know nature by touching, smelling and observing. Although garden areas may be limited in the new AltSchool models, especially in urban areas, virtual nature experiences are offered with

augmented reality applications thanks to the integration of technology. Since there is no physical garden in online education, students benefit from their own environment and efforts are made to develop environmental awareness through virtual applications. In a study conducted by Demir and Yılmaz (2021), it was determined that only 30% of schools in Turkey were arranged to provide active nature interaction for students, and it was emphasized that this rate should be increased.

As for the comparison of classroom structures, in traditional formal education, classrooms generally consist of rectangular closed spaces that accommodate 25-40 students. The table and chair arrangement is fixed and the use of technology is limited. In this model, the teacher-student relationship is based on authority and students generally remain in fixed positions during the lesson. In Waldorf schools, classrooms are smaller (15-25 students) and have flexible layouts that are large, bright and furnished with natural materials. Technology use is kept to a minimum and teachers provide one-on-one interaction with students, acting as guides. The open plan concept is applied in Montessori classrooms; The classroom is divided into different learning areas, allowing children to progress at their own pace. While teachers adopt the role of guides, students have high freedom of movement and free access to learning materials. In the new AltSchool model, classes are smaller and more flexible, and thanks to the intensive use of technology (VR/AR, personalized learning platforms), more active interaction and mobility are observed among students. In online education, virtual environments replace the physical classroom; In this environment, teacher-student relationships are provided through video conferences, interactive platforms and digital resources, but the rate of face-to-face interaction is lower.

As a result, each of the educational models affects students' learning experiences by offering different architectural, technological and pedagogical features. While traditional formal education supports a structured and systematic transfer of knowledge, alternative models such as Waldorf and Montessori adopt student-centered approaches based on nature and individuality. While the new AltSchool model offers a student-focused and innovative learning environment by highlighting modern technological infrastructure and flexible classroom layouts, online education provides flexibility and personalization opportunities based entirely on digital environments.

In today's world, especially after the COVID-19 pandemic, hybrid education models and digital transformation have led to radical changes in school structures and learning environments. UNESCO (2020) and OECD (2018) reports reveal that the integration of digital technologies increases learning efficiency and makes students' learning processes more interactive. In Turkey, the Ministry of Education aims to increase the quality of education by accelerating the digital transformation process of schools, flexible classroom arrangements and modern infrastructure investments.

4.Results

In the future, artificial intelligence (AI) supported education will be among the basic components of all education models, and the adaptation process of each type of school to this transformation will vary. While traditional formal education is a long-standing model with its well-established curriculum and structured classroom layout, it may face certain challenges in integration into AI-powered education systems. In this model, standardized testing and teacher-centered practices are at the forefront, so curricula will need to be restructured for effective integration of AI-based personalized learning analytics and adaptive learning platforms. On the other hand, limited state-supported infrastructure and resources may affect the speed of this transformation.

The Waldorf education model is more cautious about technological integration due to its emphasis on nature and artistic activities. Although AI-supported education provides advantages, especially in terms of data analysis, identification of students' learning styles and creation of individualized learning paths, it is necessary to develop strategies to slowly and consciously integrate technology into the educational process in order to comply with the Waldorf pedagogical philosophy. In relation to that, AI technologies can be used as tools that facilitate teacher support.

Montessori would be the most suitable for adaptive learning systems using AI since the Montessori system focuses on children's self-learning process. In Montessori schools, learning systems that support learners at their own pace have the ability to customize learning content according to the power of the AI algorithms.Thus, students can access content that suits their interests and abilities, and teachers can play more effective roles in guidance and intervention areas.

The new AltSchool model is an innovative approach based on technology integration from the beginning. This model is in the most advantageous position in the adoption of AI-supported education applications as it is supported by flexible classroom layouts and digital platforms. Using AI technologies, AltSchools can analyze students' performance in real time, create personalized learning paths and optimize feedback mechanisms throughout the educational process.

Since the online education model is carried out on a completely digital platform, it is the structure that is most naturally integrated with AI-supported applications. In this model, AI-based analytics integrates with adaptive learning systems by collecting students' interaction and achievement data in virtual classroom environments. Additionally, thanks to digital guidance, personalized recommendation systems and interactive assistants, online education can maximize a flexible and student-centered learning experience.

Therefore, all school models have the potential to undergo transformation into AI-enabled education based on the respective pedagogical and structural characteristics. Montessori and AltSchool models will adopt the adaptation the most rapidly because these models appreciate the use of technology and differentiated learning methods. Traditional and Waldorf models will make the adaptation take the longer route while maintaining the pedagogical fundamentals.. From a didactic and pedagogical perspective, AI-supported educational applications are redefining the roles of both teacher and student in the teaching process. While the teacher, who is central in traditional teaching methods, now assumes the role of guide and coach, the learning process becomes more student-centered and participatory. This transformation allows learning materials to be personalized according to the individual needs of the student and contributes to the development of skills such as critical thinking, problem solving and creativity. Data analytics provided by AI technologies allows teachers to better observe students' progress and intervene immediately, while also making it possible to enrich didactic planning with more flexible

and innovative methods. In this context, pedagogical strategies are being restructured to support students' learning processes with active participation, in line with the opportunities offered by technology.

5.Discussion

In 2022, 70% of students in Türkiye stated that it was easy to make friends at school, while the OECD average was measured as 76%. While 69% of students state that they feel like they belong to school, this rate is 75% across the OECD. On the other hand, 28% of students in Türkiye stated that they felt lonely at school, and 26% stated that they felt like an outsider or not part of a group. OECD averages on these two issues are 16% and 17% respectively. Compared to 2018, there is a decrease in students' sense of belonging at school in Türkiye.

In general, students' life satisfaction has decreased in many countries in recent years. In 2022, 44% of students in Türkiye stated that they were dissatisfied with their lives and scored their satisfaction between 0 and 4 on a scale between 0 and 10. In 2018, this rate was 34%, meaning there was a significant increase in the number of students with low life satisfaction. While the rate of students with low life satisfaction across the OECD was 11% in 2015, it increased to 16% in 2018 and 18% in 2022.

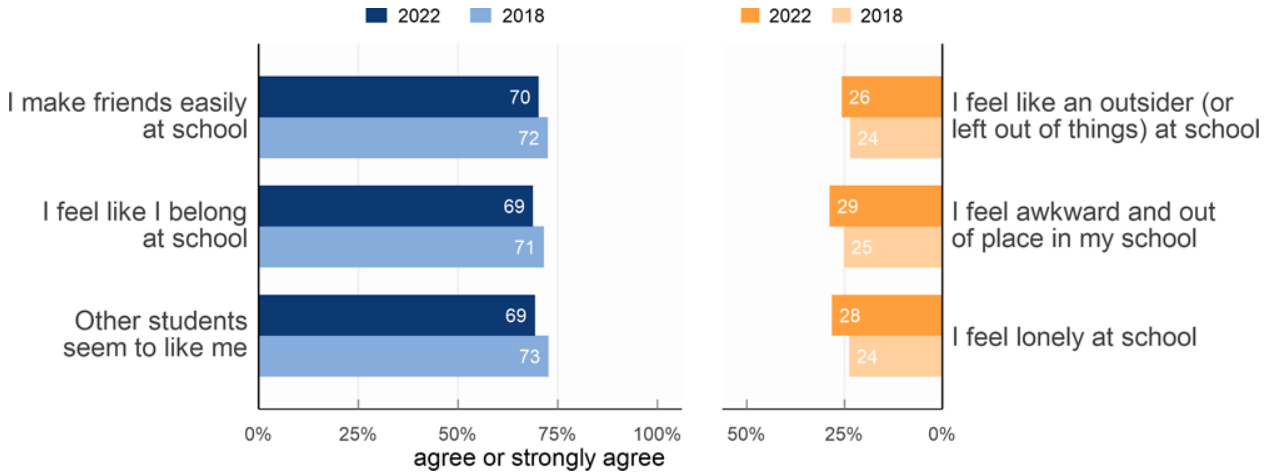

Table 6. Students' sense of belonging at school in Türkiye
Note: Numbers inside the figure correspond to percentages.
Source: OECD, PISA 2022 Database, Table II.B1.1.4.

These results provide useful cues on students' social belonging and life satisfaction in schools. In an attempt to deal with these concerns, it is important to think about how school organization and environments may shape students' social and emotional growth. To start with, the design of social areas might play an important role in school settings to help students feel less alone and ostracized. Common areas can be created in school buildings where different social groups can come together. These areas should be places where students can rest, chat, and do activities with small groups.

Another important element is that in order for students to feel like they belong at school, their environment should be supported by visually impressive elements that reflect their identity. Placing students' artistic contributions on school walls and areas where their personal projects are exhibited can allow them to embrace the school's identity more. Additionally, flexibility and inclusivity are of great importance in school design. Schools should be suitable for students with different needs and should be designed to create spaces where everyone feels accepted. This can give the student the sense of belonging.

Nature-based school planning also psychologically soothes the pupils and makes them better able to cope with stress. Green spaces provide room for dialogue and interaction with nature. Natural surroundings and green spaces also maximize the psychological well-being of the learners and allow them to better identify with the school. Student participation can make a big difference in school design. Asking for students' opinions in the physical structure of the school makes them feel valued. A design in which students participate more in the school environment can increase the sense of belonging.

All these elements can help ensure that students do not feel lonely, their sense of belonging is strengthened, and they achieve a higher life satisfaction. The physical structure of the school has a significant impact on students' mental state and social relationships. These types of designs can enable students to have healthier relationships with each other and feel more connected to the school. In the years ahead, as education technologies continue to evolve, the phygital approach will become even more prevalent. Adding the likes of the Internet of Things (IoT), artificial intelligence (AI) and augmented reality (AR) into the picture will make education spaces even more intelligent, responsive and student-focused. This will positively affect student success and satisfaction by increasing the synergy of both physical and digital components.

The acceleration of digitalization and technological developments in the field of education has paved the way for the restructuring of physical classrooms and the emergence of phygital education models. When the effects of physical environments on learning are combined with the flexibility and accessibility offered by digital tools, students can be offered richer, interactive and personalized educational experiences. However, in this transformation process, there are steps that need to be taken in matters such as infrastructure, teacher training and digital literacy. It is critical for educational institutions to develop strategies that blend the best of both worlds for the education models of the future.

As a result, digital, physical and phygital educational environments emerge as dynamic building blocks that complement each other. Considering the advantages offered by each model and the challenges it brings, the development of integrated and flexible education systems will both increase students' academic success and create an inclusive learning environment.

6.Conclusion

This study discusses the influence of knowledge about digital transformation on the reshaping of physical as well as virtual classrooms, with emphasis on the limitations of traditional school infrastructures in adapting to new technologies. By reviewing existing educational models, such as Montessori, Waldorf, AltSchool, and purely virtual systems, this work proposes a theoretical approach to the incorporation of "phygital" learning spaces that draws upon the benefits provided by both physical and virtual spaces. Hybrid learning environments can result in improved outcomes in learning, facilitate access to education, and provide a plan of action to schools in the future.

That the school buildings in Türkiye are based on old and standard architectural projects is among the serious obstacles to meeting today's modern educational needs. Some solutions can be determined for restructuring outdated-style education buildings according to contemporary educational needs. Modular training areas need to be planned. Flexible classrooms, group work-oriented sitting areas, and multi-purpose halls should be available. In this way, students will be able to receive education based on different models of learning. It is necessary to develop infrastructure and make architectural transformation to be able to use artificial intelligence, virtual reality, and other digital education tools effectively. State-initiated change initiatives must be introduced to make existing structures more advanced, and especially newly built schools must be designed according to modern architectural solutions. This transformation is inevitable to accelerate the process of digitalization of education and provide students with more effective learning environments.

There are some limitations of this research. The first of these limitations is that this model is purely theoretical and has never been applied in practice and therefore its findings aren't particularly usefulSecond, the realization is hindered by different legal, financial, and technical infrastructures in various locations. Upcoming research can examine how to develop instruments used to measure the impact of phygital environments regarding participation, school achievement, and well-being. Researchers can collaborate to discover how educational psychology, information technology, and architecture can be integrated to optimize hybrid environments.

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Conflict of Interests

The Authors declare that there is no conflict of interest.

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