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Biomimetic Responsive Space Divider for Co-Working Environments: An Interactive Design Approach

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Responsive Architecture, Interactive Design, Co-working Environments, Color Theory, Adaptive Space Divider

Abstract: This paper presents the development of an innovative responsive space divider designed to enhance co-working environments. This study seeks to create an adaptive architectural feature that reacts to user activity, ultimately boosting productivity, collaboration, and well-being. It draws on principles from interactive architecture, color theory, and user-centered design. The design approach was inspired by the remarkable color-changing abilities of chameleons, leading to the creation of a fortune teller-themed device that highlights four distinct color combinations. The prototype employed an Arduino-based control system that processes data from motion and sound sensors to enable the divider to switch between four operational modes: focus, learning, collaborative, and socializing. Every cell of the space divider is associated with a unique color palette informed by the principles of color psychology, creating an optimal environment for various performance tasks within the interior space. The fabricated prototype employed a complex methodology, combining digital modeling with physical prototyping. The study selected PET fabric as the primary material for the divider pieces, aligning environmental goals with durability and aesthetic qualities. The creation of this responsive space divider prototype highlights the possibilities of integrating interactive technology with architectural elements, promoting more flexible and user-focused work environments. This project lays the groundwork for future explorations into interactive architecture in co-working spaces, potentially transforming the design and interaction within shared workspaces.

1. Introduction

The emergence of co-working spaces has transformed the modern work environment, providing an innovative alternative for remote work while alleviating the isolation that can accompany it. In recent years, shared workspaces have become increasingly common, especially among freelancers, entrepreneurs, and small businesses looking for flexible and collaborative work environments [1]. Nonetheless, the design of these spaces poses distinct

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challenges, especially when it comes to finding a balance between fostering collaboration and ensuring privacy and concentrated work. A key aspect of designing co-working spaces is the idea of flexibility and adaptability. Individuals using these environments expect the furniture and arrangement to support a diverse array of functions and activities, spanning from solitary focused tasks to collaborative group efforts and social engagements[2]. The necessity for multifunctionality encompasses every element of the space, particularly partitions and dividers, which are essential in shaping and reshaping the workspace as required.

Considering these changing requirements, the domain of interactive architecture has developed into a compelling path for designing spaces that are more responsive and adaptable. Interactive architecture, known for its capacity to react to environmental stimuli and user behavior, presents promising solutions to the evolving needs of co-working spaces [3];[4]. Incorporating elements of responsive design can enhance user productivity and satisfaction in co-working spaces, resulting in more efficient and enjoyable work environments. The incorporation of color theory into interactive architectural features offers an interesting chance to improve the functionality of co-working spaces. Studies indicate that colors can have a profound effect on human emotions, cognitive performance, and behavior [5]. Utilizing this understanding in the creation of responsive architectural features could enable the development of spaces that not only adjust physically to the needs of users but also provide psychological support for various work modes and activities.

This research aims to create and prototype a responsive space divider tailored for co-working environments, taking cues from interactive architecture and color theory. The divider is crafted to adapt to user behavior in the co-working space, employing color changes to enrich the type of activity that users participate in. The divider seeks to enhance user productivity and satisfaction with space, thereby fostering a more effective and efficient working environment. This paper will outline the conceptual development, design process, and prototyping of the responsive space divider, examining its potential influence on the dynamics of co-working spaces and the overall user experience. This research aims to enhance the existing knowledge surrounding interactive architecture and its relevance in modern work settings.

2. Literature Review

Co-working spaces have become a notable trend in contemporary work environments, providing adaptable and collaborative environments for a variety of professionals. These spaces are defined by their capacity to cultivate a sense of community, stimulate creativity, and enhance productivity among individuals from diverse backgrounds and sectors.[6]. The rise of co-working spaces can be attributed to changing perceptions of work. More self-employed individuals and professionals are looking for environments outside their homes to alleviate feelings of isolation and enhance their work-life balance.[7]. Co-working spaces are frequently linked to freelancers and self-employed individuals; however, it is important to recognize the diverse range of user groups that can be identified, such as self-employed workers, small businesses, large corporations, remote employees, and students. [8]. Individuals appreciate co-working spaces for the chances they offer to engage in informal interactions, exchange knowledge, and collaborate on ideas with fellow co-workers.[9]. Co-working spaces enhance users' self-efficacy and performance by fostering a healthier balance between work and personal life, while also facilitating access to both professional and social networks.[10]

Although co-working spaces are becoming increasingly popular, there is still a scarcity of academic literature and quantitative research addressing this topic.[11]. Several studies have examined particular facets of co-working, including knowledge dynamics [12] and its contributions to urban creativity and economic growth.[7] Fuzi discusses the promotion of entrepreneurship, as highlighted by Mariotti and Townsend. Nonetheless, there is a limited amount of research available regarding user preferences for the characteristics of co-working spaces [6]. Co-working spaces generally blend informal and creative environments with practical workspace features. [13] The traditional physical design typically includes an open-floor layout with communal work areas to encourage collaboration. In contrast to conventional multi-tenant offices, co-working spaces provide a range of informal environments and amenities, including coffee corners, kitchens, meeting rooms, round-the-clock access, internet connectivity, printing services, lounge areas, and various other casual spaces. [14]

Earlier research on user preferences in multi-tenant offices has highlighted several key factors, such as location, the exterior and layout of the office, decor, available facilities and services, quiet rooms, recreational areas, ICT (Information and Communication Technology) and equipment, privacy, and the overall office environment. [15] Studies indicate that personal traits like age, gender, duration of office presence, and specific work activities can affect preferences regarding various aspects of the office workspace. [16]. Understanding user preferences regarding the features of co-working spaces is essential for owners and managers aiming to enhance their offerings and draw in more tenants within a competitive landscape.

This research aims to develop and examine an innovative responsive space divider for co-working environments, incorporating concepts from interactive architecture, color theory, and user-centered design. The project aims to develop an adaptive architectural element influenced by the adaptability of chameleon skin, responding to user activity via a sensor-based system. The study seeks to establish optimal environments for diverse job activities in shared workspaces by examining color psychology and utilizing sustainable materials and accessible technology. The responsive space divider is intended to improve productivity, collaboration, and well-being by accommodating various work modes, such as focus, learning, collaboration, and social interaction. This method tackles the issues observed in co-working environments, where flexibility and adaptability are essential for accommodating varied activities and user requirements. The following sections will outline the methodology utilized in developing this prototype, encompassing conceptual development, design process, color selection, prototyping, and technical implementation. This thorough approach seeks to enhance the existing knowledge on interactive architecture and its practical implementations in contemporary work environments.

3. Methods and tools

The methodology for developing the responsive space-divider prototype employed a systematic and iterative approach, as seen in the workflow chart (Fig.1). The approach started with idea creation, drawing inspiration from the chromatic adaptability of chameleons and the tenets of color theory. This was succeeded by a design process that encompassed scenario-based planning, unit design testing, and color choices. The prototype phase encompassed digital modeling, physical prototyping, and the technical implementation of sensing and actuation systems. The approach aimed to provide a comprehensive and cohesive strategy for designing a practical and aesthetically pleasing responsive space divider for co-working settings.

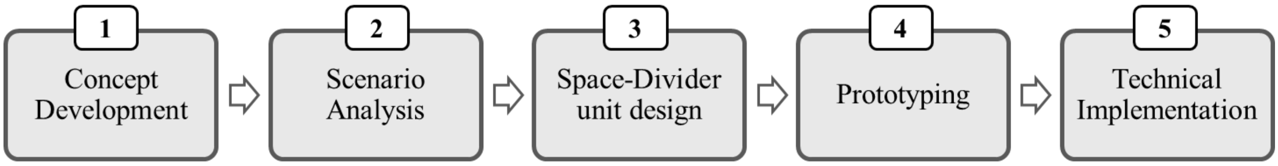


Fig.1: Workflow diagram illustrating the methodology for developing the responsive space-divider prototype, source: created by the author

3.1. Conceptual Development

The design of the responsive space divider was inspired by the chameleon's adaptable color-changing capabilities which are distinguished for their skin's ability to alter color in response to their emotional condition and the arrangement of crystalline structures inside their skin cells [17]. These biological phenomena provided a robust basis for exploring flexibility in the divider design. The chameleon's skin is considered a conceptual mechanism for the responsiveness of the devised divider which is abstracted as a surface made up of several color-altering cells (Fig.2,Fig.3) and by utilizing the emotional and psychological impacts of color, as delineated in Elliot's 2015 color theory study [18], the divider aims to provide a healthy and effective work atmosphere for individuals in co-working spaces.

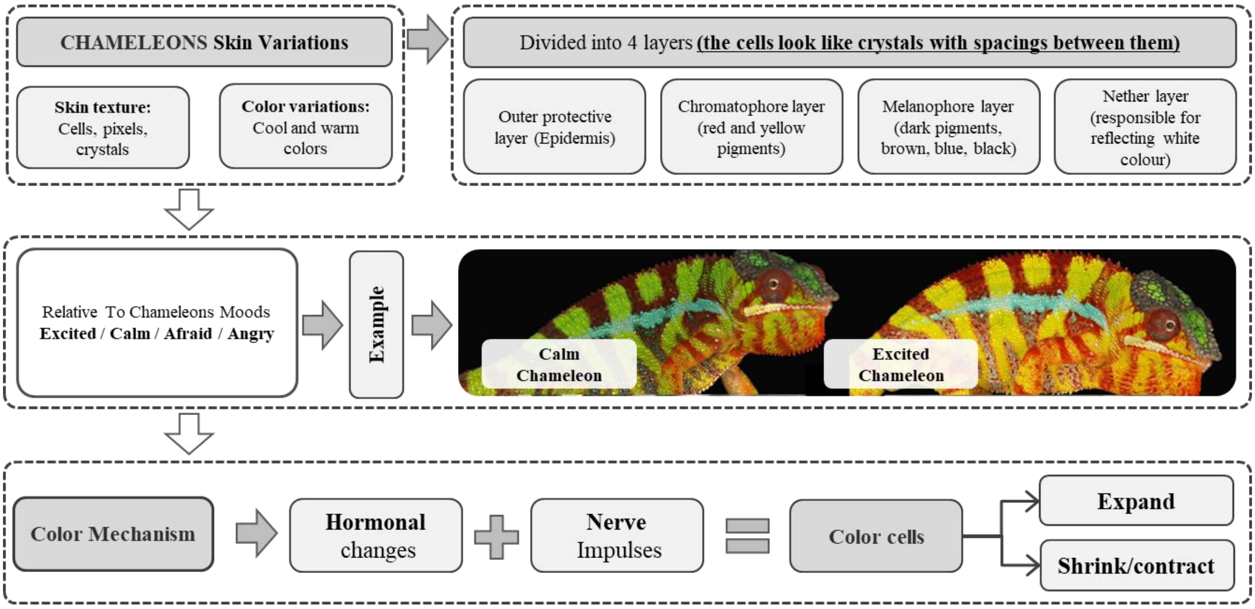


Fig.2: The chameleon and its coloring mechanism, source: created by the author

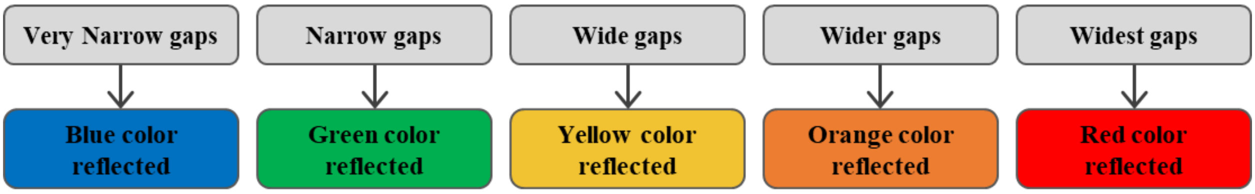


Fig.3: The chameleon reflected colors based on the gaps between crystal structures, source: created by the author

3.2. Design Process

Emphasizing four main working modes that are common in co-working environments: focus mode, learning mode, collaboration mode, and socializing mode, the design process followed a scenario-based approach (Fig.04). This strategy is in line with current studies on activity-based working, which highlights the need of offering different ambiences to be suitable with the characteristics of various work tasks [19].

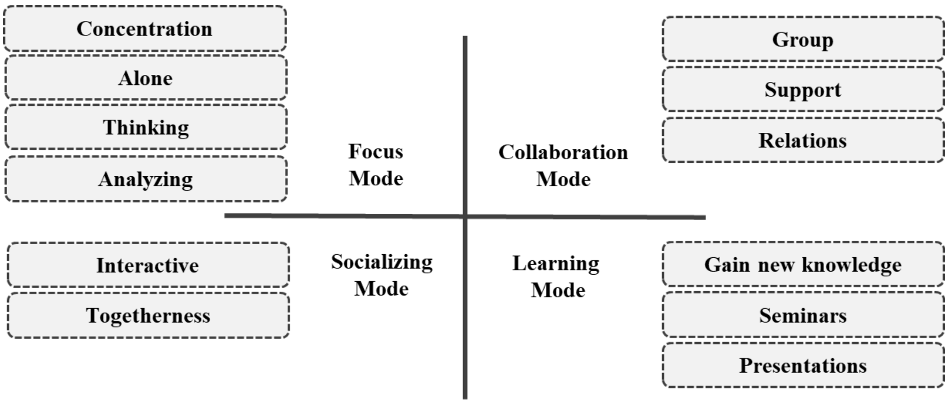


Fig.4: The four common working modes in co-working spaces, source: created by the author

Table 1: Scenario-based co-working activity and response matrix, source: created by the author

Activity		IF: No. of	IF: Sound high	IF: Sound low	IF: Motion	Deduction	Then: Mode	Then: Response color
Physical Activities	Reading, writing, sketching	1	□	■	□	User maybe working silently with interrupting periodical sound	Focus	cold color
			■	□	□	User maybe working silently with frequent sound	Focus	Tones of cold colors
		2	□	■	□	Users maybe working silently with interrupting periodical sound	Focus	cold color
			□	■	■	Users maybe having presentations between them with one of them standing or moving	Learning	Mix of warm and cold tones
			■	□	■	Users maybe having discussions while they are sitting or moving	Collab.	Mix of warm and cold tones
		3 +	□	■	□	Users maybe working silently with interrupting periodical sound	Focus	cold color
			□	■	■	Users maybe having presentations between them with one of them standing or moving	Learning	Mix of warm and cold tones
			■	□	■	Users maybe having discussions while they are sitting or moving	Collab.	Mix of warm and cold tones
	Hands on work	1	□	■	□	user maybe working with tools and tasks that need precision	Focus	cold color
			■	□	■	user maybe working with tools and tasks that needs movements and involves sound	Focus	Tones of cold colors
		2	□	■	■	users' activity will generate sound, and will involve movements	Collab.	Mix of warm and cold tones
			■	□	■	users' activity will involve movements, but if their sounds are raised to higher levels	Socialize	Warm color
		3 +	□	■	■	users' activity will generate sound, and will involve movements	Collab.	Mix of warm and cold tones
			■	□	■	users' activity will involve movements, but if their sounds are raised to higher levels	Socialize	Warm color
	Rehearsals	1	□	■	■	user maybe rehearsing his role in a play, with sound and motion	Focus	cold color
		2	■	■	■	users maybe rehearsing for their roles with sounds and periodical motion	Learning	Mix of warm and cold tones
			■	□	■	users maybe rehearsing for their roles with higher sounds and frequent motion	Socialize	Warm color
		3 +	□	■	■	users maybe rehearsing for their roles with sounds and periodical motion	Learning	Mix of warm and cold tones
			■	□	■	users maybe rehearsing for their roles with higher sounds and frequent motion	Socialize	Warm color
Digital Activities	Webinars and online meetings	1	□	■	□	user maybe attending an online meeting as a participant - listening with minor interaction with no movement	Focus	cold color
			■	□	□	user maybe attending an online meeting as speaker - interacting with viewers with no movement	Focus	Tones of cold colors
		2	□	■	□	users may be attending an online meeting as participants - listening with minor interaction with no movement	Focus	cold color
			■	□	□	users may be attending an online meeting as participants - Discussing with high interaction with no movement	Learning	Mix of warm and cold tones
			■	□	■	users may be attending a meeting with an abroad friend or family	Socialize	Warm color
		3 +	□	■	□	users may be attending an online meeting as participants - listening with minor interaction with no movement	Focus	cold color
			■	□	□	users may be attending an online meeting as participants - Discussing with high interaction with no movement	Learning	Mix of warm and cold tones
			■	□	■	users may be attending a meeting with an abroad friend or family	Socialize	Warm color
	Working	1	□	■	□	user maybe working on digital tasks	Focus	cold color
			■	□	□	user maybe working on digital tasks with high sound in the background	Focus	Tones of cold colors
		2	□	■	□	users maybe working on digital tasks	Focus	cold color

Activity	IF				Deduction	Then	
	No. of	Sound high	Sound low	Motion		Mode	Response color
		□	■	■	users maybe working on digital tasks, with medium level of interaction	Collab.	Mix of warm and cold tones
		■	□	■	users maybe working on digital tasks, with high level of interaction	Socializ e	Warm color
	3 +	□	■	□	users maybe working on digital tasks	Focus	cold color
		□	■	■	users maybe working on digital tasks, with medium level of interaction	Collab.	Mix of warm and cold tones
		■	□	■	users maybe working on digital tasks, with high level of interaction	Socializ e	Warm color

(Table 1) illustrates a comprehensive scenario-based approach to activity classification in co-working environments, mapping various activities to four distinct working modes. Physical and digital activities are categorized based on three key parameters: number of people (1, 2, 3 or more), sound levels (high/low), and motion. For instance, solitary activities like reading or laptop work typically align with the Focus mode, characterized by cold color responses, reflecting the need for concentration. When two or more people engage in presentations or discussions, the mode shifts to Learning or Collaborative, represented by a mix of warm and cold tones. The Socializing mode, indicated by warm colors, emerges in scenarios with higher levels of interaction and sound, such as group rehearsals or informal online meetings with friends and family. This systematic classification demonstrates how different environmental conditions and group dynamics naturally transition between these four working modes, allowing the space to adapt its response through color accordingly.

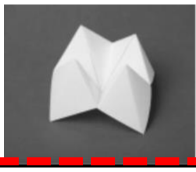
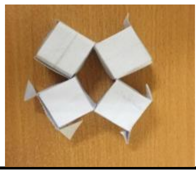
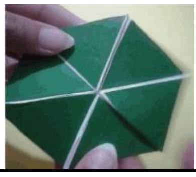
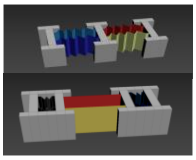
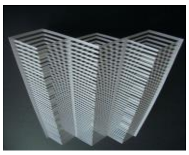
3.3. Space-Divider unit design

Extensive investigation on unit design took account for several geometric forms and folding techniques, evaluated trials included the following seven options:

1. Fortune teller: Has eight possible colorful faces inspired by origami.
2. Rotating Cubes: Two-rotating cubes are a system of linked cubes rotating to show varying colors.
3. Rotating Donut: Circular with segment rotation.
4. Hexagon: Folding paneled hexagonal construction.
5. Rotating star: A unit fashioned like a star with rotating points.
6. Folding Louvers: Six-fold color folding panel design is basic.
7. Spine fold: An arrangement with folding colorful panels centered on the spine.

Upon conducting a thorough analysis, as illustrated in (Table 2), the selection of the fortune teller's design was made due to its demonstration of both creativity and realism, a characteristic that is prominently emphasized within the table itself. The rationale behind the selection of the design was grounded in specific considerations. This design features eight uniquely colored faces, with four of these colors arranged in an alternating pattern on each opening of the mechanism. This collection of faces offers a varied array of color choices, all the while maintaining a fundamental representation of their structural components.

Table 2: Design trials comparison table based on innovation degree and color ambiences, source: created by the author.

Trial No.	**Basic Information**		**Innovation**		**Color ambiences**	
	Name	**image**	**concept**	**Existing applications**	**Range of colors**	
1	Fortune Teller		It has eight possible colorful faces inspired by origami	No	8 colors/face (4 warm and 4 cold)	32 colors/4 units (16 warm and 16 cold)
2	Rotating Cubes		Two-rotating cubes to show varying colors.	No	2 colors/face (outer faces and inner faces hide when unit is closed	Two color themes options
3	Rotating Donut		Circular with segment rotation.	No	2 colors /face (1 warm and 1 cold)	4 colors/ units
4	Hexagon		Folding paneled hexagonal construction.	No	1 color/ face	3 colors / unit
5	Rotating Star		A unit fashioned like a star with rotating points.	No	4 colors per face	8 colors / unit
6	Folding Louvers		Six-fold color folding panel design is basic.	Yes	4 Colors (2 warm and 2 cold)	Shows warm and cold colors at the same time
7	Spine Fold		An arrangement with folding colorful panels centered on the spine.	Yes	8 colors/face (4 warm and 4 cold)	32 colors/4 units (16 warm and 16 cold)

The Fortune Teller model was chosen for the responsive space divider prototype because of its exceptional performance in various functional areas. All designs were assessed according to their level of creativity and color schemes, with the Fortune Teller model distinguishing itself for multiple reasons. At first, it provided the maximum amount of potential color combinations (8 faces), allowing for enhanced adaptability to several work styles. Secondly, its origami-inspired folding mechanism facilitated seamless transitions between states, augmenting the interactive experience. The design's compactness when folded and its capacity for substantial expansion rendered it optimal for space-efficient use in co-working settings. Furthermore, the symmetrical architecture of the Fortune Teller model guaranteed stability and facilitated production, which are crucial factors for large-scale deployment. Although alternative designs such as the Rotating Cubes and Hexagon showed potential, they did not possess the Fortune Teller's superior equilibrium of intricacy, utility, and visual appeal. This thorough assessment of functional elements, in addition to color diversity, confirmed the Fortune Teller as the optimal selection for our responsive space divider prototype.

3.4. Color Selection

Based on the color psychology rules, each mode was linked to a particular color palette. Cool blues and greens were chosen for the focus mode to help to lower stress and encourage concentration. Purples and blues were used in the learning mode to boost cognitive functioning.

Warm yellows and oranges were utilized in collaborative spaces to inspire energy and creativity; vivid reds and pinks were employed in socializing areas to promote engagement and enthusiasm (Fig.5).

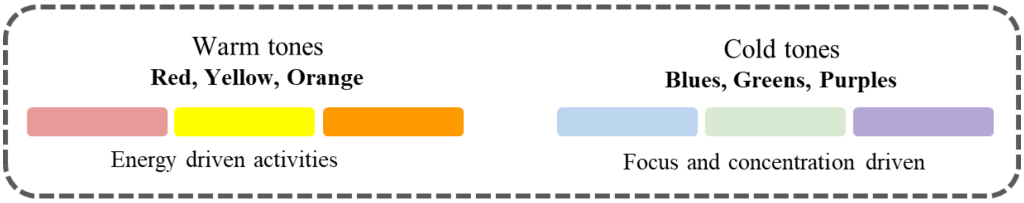


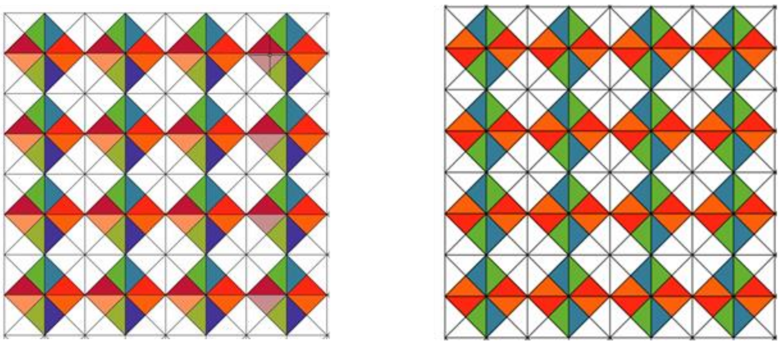
Fig.5: The used color pallets for the different working modes, source: created by the author

Using the CMYK (Cyan, Magenta, Yellow, Black) color scheme, which guarantees exact color mixing and reproduction, each unit was designed to display one warm and one cold color, thereby creating a harmonic visual palette. Digital simulations under different lighting circumstances evaluated color perception and ambiance using 3D modeling tools. For the best visual impact and spatial definition, these digital trials helped to choose the best color perception and achieve the space ambiences. (Fig.6,7).

3.5. Prototyping

The prototyping stage consisted of an iterative process of digital modeling and creating an actual physical prototype. Because of its durability, adaptability, and environmental friendliness, PET (Polyethylene Terephthalate) fabric was chosen as the main material for the divider units [20] (Table 3). For this use, PET fabric presents various benefits as follows:

- Strong yet light construction
- Superior color retention qualities
- Against shrinkage and wrinkles
- Capacity of sound absorption
- Reversibility and sustainability



8 colors per each unit (4 warm + 4 cold) 4 colors per each unit (2 warm + 2 cold)

Fig.6: The different trials of the unit colors, source: created by the author

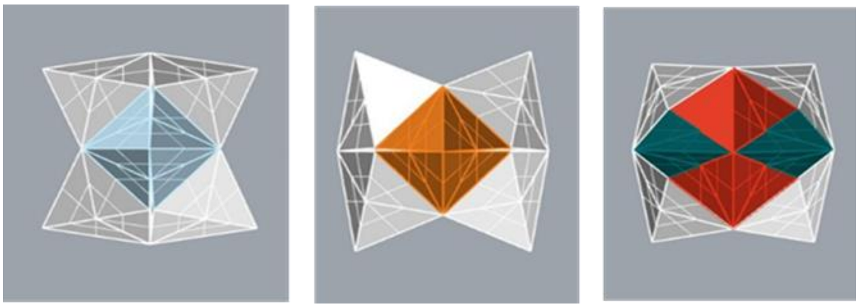


Fig.7: The selected CMYK color system (2 colors per unit: 1warm + 1cold), source: created by the author

Table 3: PET fabric specifications and details [20]

Material	100% recycled polyester with GRS CERTIFICATE	
Available Colors	Black, Grey, Red, Beige, or Custom	
Type	soft, medium, hard	
Width	1mm-10mm	
Weight Range	100-2000 g/m²	
Length	customized	
Application	Bag, basket, storage bin, drawer mat, pad, thermoforming furniture, sound insulation, etc.	

The PET fabric used in the prototype is available in various standard colors, with the option for customization to meet specific design requirements. The fabric weight can range from 100 to 2000 grams per square meter, allowing for flexibility in choosing the appropriate thickness and durability for the space divider. Digital 3D modeling for the prototype was modeled with Rhino software and its parametric plugin Grasshopper started the prototype modeling process by defining the parameters of the shapes controlling all dimensions and all relations. The digital 3D model was created at a 1:1 scale to accurately represent the full-size divider. This enables the folding mechanism to be accurately sized and refined. Subsequently, fabrication templates for the physical prototypes were developed utilizing digital models.

Three preliminary trials of physical models were built:

- First physical model shown in (Fig.8): Designed from paper and wooden sticks, this figure is used as a prototype for the fortune teller folding mechanism. It helped find early design difficulties and enabled rapid testing of the fundamental folding concept. This initial model was created at a 1:5 scale to test the basic folding concept.

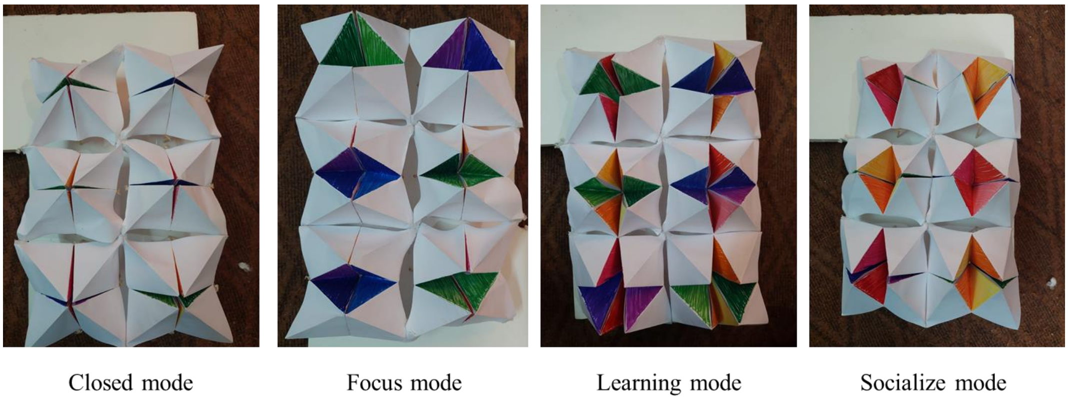


Fig.8: The first study model created from paper and wooden sticks, source: created by the author

- Second physical model (Fig.9): This iteration produced a more solid construction by means of foam board. The foam board revealed structural soundness of the design and let one better replicate the actual material thickness. To experiment with visual effects, this model also included basic color palettes. The foam board model was constructed at a 1:2 scale to better represent material thickness and structural integrity.

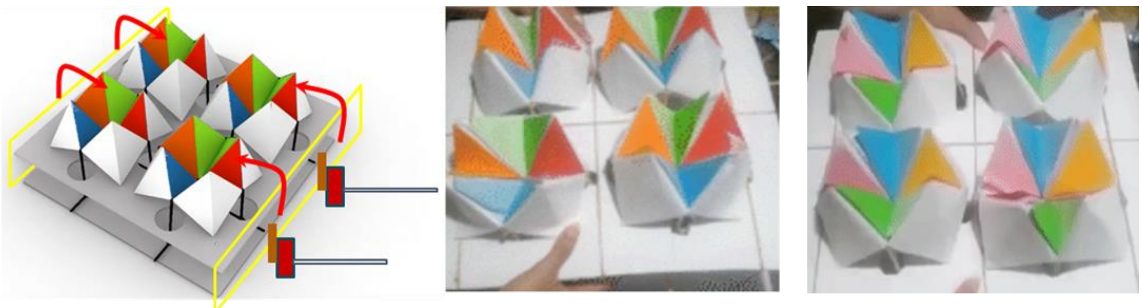


Fig.9: The second physical model created based on parametric model, source: created by the author

- The last physical prototype was built with PET cloth and a more polished internal structure (Fig.10). This model is for testing material qualities, color vibrancy, and folding mechanics, so closely reflecting the anticipated final product. The final PET fabric prototype was built at full scale (1:1) to accurately test material properties and folding mechanics. The full-scale divider unit measures 180 cm in height, 120 cm in width when fully extended, and folds to a depth of 15 cm when compressed and the PET fabric used in the final prototype has a thickness of 0.5 mm, while the internal structure components measure 3 mm in thickness.

Fig.10: The final physical model with a simplified mechanism, source: created by the author

Every prototype version shed important light on the functioning, aesthetics, and possible difficulties in full-scale application of the concept. To guarantee perfect operation and longevity of the divider units, the prototyping process also involved testing of many folding mechanisms and attachment techniques.

3.6. Technical Implementation

The technical execution of the responsive divider prototype incorporated sensing technologies alongside a motorized control system, resulting in an adaptive and interactive installation. The fundamental elements of the system comprise:

- The (Arduino UNO R3) board functions as the central control unit, responsible for processing sensor data and managing the actuation system. The Arduino platform was selected due to its adaptability, comprehensive library support, and user-friendly programming capabilities. [21].
- The MPU-6050 (Motion Processing Unit): sensor, integrating a 3-axis gyroscope and a 3-axis accelerometer, is employed to monitor user movement within a given space. This sensor offers high precision and low power consumption, rendering it suitable for continuous monitoring. The sensor data undergoes processing through a complementary filter algorithm, which facilitates precise motion detection while effectively reducing drift and noise.
- The (Electro Peak KY-037) Sound Detection Sensor Module is utilized for the purpose of monitoring ambient noise levels. This module includes adjustable sensitivity and

provides both analog and digital outputs, facilitating a precise response to the acoustic environment [22]

- The actuation system for the color-changing mechanism is facilitated by a series of stepper motors, specifically NEMA 17, which are regulated by stepper motor drivers. This configuration facilitates precise regulation of the folding mechanism, thereby ensuring smooth and accurate transitions between color states. The stepper motors offer significant torque and precise positioning, essential for preserving the structural integrity of the divider throughout its operation.
- Power Management: A dedicated power supply unit is employed to deliver stable power to all components, incorporating separate voltage regulators for the microcontroller, sensors, and motor drivers to ensure clean power delivery and reduce electromagnetic interference.

The control logic executed on the Arduino board adheres to a state machine architecture, where each state is associated with one of the four operational modes: focus, learning, collaborative, and socializing. The system persistently observes the sensor inputs and employs a weighted decision algorithm to ascertain the suitable state, considering motion intensity and sound levels. The sequence of actuation for altering the configuration of the divider has been refined to reduce power consumption and minimize wear on the mechanical components. This is accomplished via a path-planning algorithm that determines the most effective sequence of motor movements for transitioning between color states.

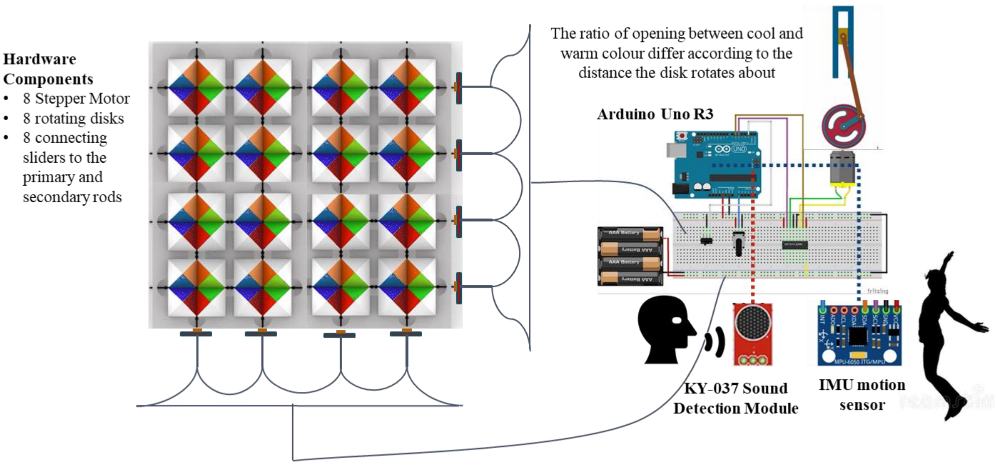


Fig.11: The space-divider digital model illustrating the main electronic components and using a crank- slider mechanism, source: created by the author

(Fig.11) presents a detailed enumeration of the electronic components utilized in the prototype, along with their specifications and functions within the system. This technical implementation allows the divider to effectively adjust to the evolving dynamics of the co-working environment, fostering an ideal workspace atmosphere for a range of activities.

The combination of these sensing and actuation technologies results in a system that can adjust in real-time to the changing requirements of co-working space users, which may improve productivity and well-being by modulating the environment.

4. Results and Discussion

The responsive space divider prototype devised in this work marks considered progress in the field of interactive architecture for co-working spaces. The split provides a dynamic and flexible solution to the difficulties experienced in shared offices by combining color-changing systems with user activity sensors.

The final prototype design employs a fortune teller-inspired unit structure, allowing each unit to display four distinct color configurations. This compact and efficient design enables a wide array of visual combinations. Digital simulations and user feedback indicated that diagonally arranged color patterns (Fig. 12) generated the optimal ambiance for all working modes.

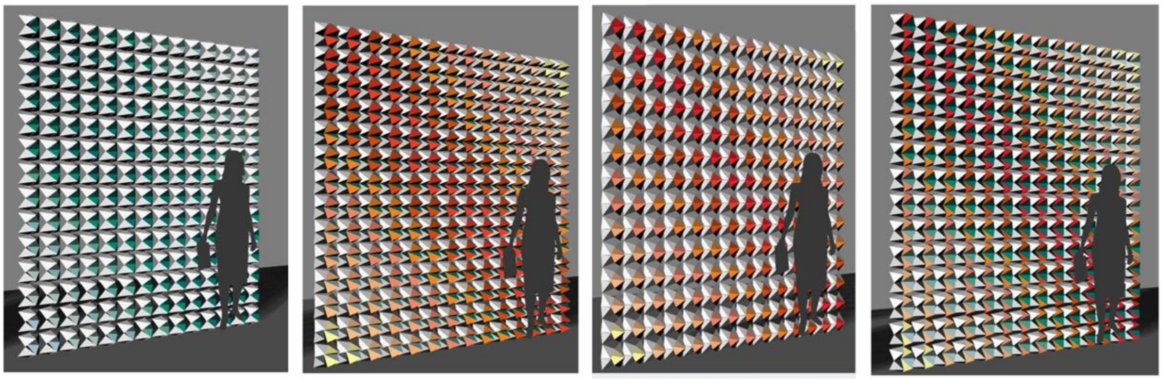
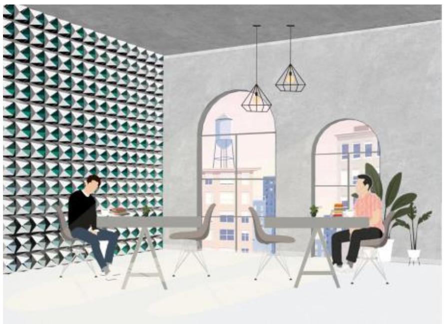


Fig.12: Focus, Learning, Socializing, Collaboration modes, respectively, the divider with diagonally dispersed colors, source: created by the author

The main material used for the divider units is PET fabric that helps to make the prototype durable and sustainable. The lightweight, color-retention, and sound-absorbing qualities of PET fabric make it the perfect fit for this use, therefore guaranteeing long-term performance and visual attractiveness. The design process's scenario-based approach made it possible to create a responsive system that reasonably fits the several needs of co-working space users. The divider can smoothly move between focus, learning, cooperation, and socializing modes by analyzing elements including the number of occupants, sound levels, and motion intensity, thereby optimizing the environment for any activity (Table 4).

Table 4: The four main scenarios that fit the several needs of co-working space users, source: created by the author.

Scenario 1 (focus mode)			
If	no. of people	1 person working alone or multiple persons working in silence	
	Activity	Reading, writing, working on laptops	
	Sound	Low sound	
	Motion	No motion	
	Status	Low level of interaction	
Then	Focus mode represented by cold colors		
Scenario 2 (learning mode)			
If	no. of people	More than 1 person	
	Activity	Reading, writing, rehearsal, online meetings	
	Sound	Low sound	
	Motion	No motion	
	Status	Discussion with high interaction	
Then	learning mode represented by (70% warm and 30% cold)		
Scenario 3 (socializing mode)			
If	no. of people	More than 1 person	
	Activity	Hands on work, rehearsal, webinars	
	Sound	high sound	
	Motion	Frequent motion	
	Status	Discussion with high interaction	
Then	Socializing mode represented by warm colors		
Scenario 4 (collaborating mode)			
If	no. of people	More than 1 person	
	Activity	Reading, writing, hands on work, working on laptops	
	Sound	low sound	
	Motion	Frequent motion	
	Status	Medium level of interaction	
Then	collaboration mode represented by 70% cold colors and 30% warm colors		

With an Arduino UNO R3 board, MPU-6050 motion sensor, and KY-037 sound detection module, the technical execution of the prototype shows the viability of combining low-cost, easily available components to produce a highly functional responsive system. The final physical model's simplified wire-based actuation mechanism helps to improve the system's dependability and simplicity of maintenance even more.

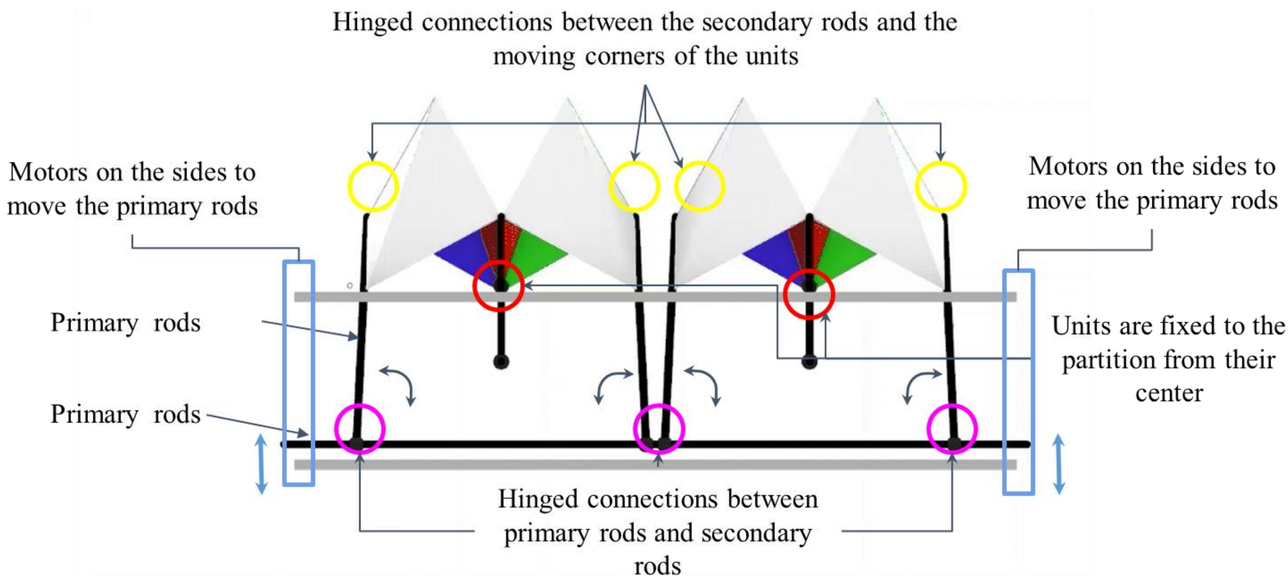


Fig.13: The physical model illustrating the movement mechanism, source: created by the author

Combining computer simulations with actual models (Fig.13, 14) the iterative prototyping approach helped to improve the design and highlight possible difficulties in full-scale application. Providing a strong proof-of-concept for the responsive divider system, the last prototype effectively solves structural integrity, color vibrancy, and smooth operation concerns.

Fig.14: The final physical model using PET fabric material, source: created by the author

The findings of this study line with current studies on the value of flexible and user-centered design in co-working spaces. User enjoyment and productivity depend critically on activity-based working environments that offer various areas to support various work tasks. By building dynamic, color-coded zones that fit different work environments, the responsive divider prototype immediately answers this need. Moreover, the incorporation of biophilic design ideas - shown by the color-changing mechanism inspired by chameleons - has been demonstrated to improve user well-being and creativity in offices. The responsive divider adds to a more aesthetically pleasing and interesting work environment by including color schemes and natural inspired components.

The effective creation of the responsive space divider prototype has several chances for next studies and implementation. Long-term consequences of the divide on user productivity, cooperation, and well-being in actual co-working situations might be investigated in more research. Furthermore, the modular character of the design lets one possible scale and adaptability to fit different workspace layouts and sizes. Ultimately, the responsive space divider prototype shown in this work marks a major advancement in the creation of flexible, user-centered solutions for co-working settings. Using color theory, biophilic design ideas, and interactive technologies, the divider presents a good way to improve the usability, appearance, and functionality of common offices. The responsive divider system has great potential to help shape the future of co-working spaces as the need for flexible and cooperative working conditions keeps rising.

5. Alignment with Sustainable Development Goals

This study on the biomimetic responsive space divider for co-working environments corresponds with and enhances multiple United Nations Sustainable Development Goals (SDGs), specifically SDGs 9, 11, and 12.

5.1. SDG 9: Industry, Innovation, and Infrastructure

The responsive space divider prototype exemplifies innovation in architectural design and workplace infrastructure. This initiative promotes innovation in the built environment by merging interactive technology with architectural components. The utilization of accessible components like Arduino boards and sensors illustrates how advanced solutions may be created with easily available technology, potentially catalyzing new developments in responsive architecture.

5.2. SDG 11: Sustainable Cities and Communities

The project immediately enhances the inclusivity, safety, resilience, and sustainability of human settlements. The responsive divider enhances the functionality and adaptability of co-working spaces, facilitating the creation of dynamic urban work settings. This corresponds with the objective of developing sustainable cities that can adjust to evolving requirements and enhance well-being. The divider's capacity to enhance workspace for diverse activities may result in more efficient utilization of metropolitan areas, thereby diminishing the necessity for large office infrastructure.

5.3. SDG 12: Responsible Consumption and Production

The selection of PET fabric as the principal material for the divider modules reflects a dedication to sustainable manufacturing. PET fabric, frequently composed of recycled materials, adheres to the tenets of circular economy and sustainable resource utilization. The material's durability and adaptability can aid in minimizing waste in workplace furnishings. Moreover, the adaptive characteristics of the partition may facilitate more efficient resource utilization in office design, as a singular system can fulfill many purposes, potentially diminishing the want for supplementary furniture or equipment.

6. Conclusions

This research successfully developed and prototyped an innovative responsive space-divider for co-working spaces by combining ideas from interactive architecture, color theory, and user-centered design. The experiment's results demonstrate how adaptive design features can improve the usability and functionality of shared workspaces. The fortune teller-inspired unit design, chosen after a thorough comparison analysis, has proven to be a versatile and effective method for manufacturing dynamic color-changing surfaces. By employing recycled materials, the choice of PET fabric as the main material for the divider pieces not only ensures lifespan and esthetic appeal, but also adheres to environmental goals.

With four separate working modes: focus, learning, collaboration, and socializing, the scenario-based approach enables the divider to successfully manage various user needs and activities within the co-working space. This adaptability is essential in today's companies, where flexibility and support with varied jobs are highly valued. The integration of motion and sound sensor technologies with a color-changing mechanism represents a significant advancement in responsive architecture. The prototype demonstrates the feasibility of developing intelligent, context-aware architectural features using an Arduino-based control system that includes sound detection modules and motion sensors.

Multiple digital and physical prototypes created during the iterative design process allowed for continuous enhancement of the divider's functional and aesthetic aspects. Addressing difficulties from prior generations, the final streamlined wire-based actuation system strikes a balance between complexity and dependability. Though the prototype seems promising, additional research is needed to determine its long-term usefulness and impact on user productivity and well-being in actual co-working environments. Building on present environmental psychology research, future studies could look at the psychological effects of dynamic color variations on workplace occupants.

The responsive space divider created for this project offers a new perspective on the challenges of building flexible, user-centered co-working settings and contributes to the emerging discipline of adaptable architecture. As the nature of work evolves, such innovative approaches to spatial design will become increasingly important in creating environments that promote productivity, cooperation, and well-being. Ultimately, this devised prototype demonstrates how interactive technologies can be coupled with architectural characteristics to create more flexible and adaptive workspaces. The findings and ideas presented here provide a foundation for future research and development in the field of interactive design for co-working settings and beyond.

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