Transformative Furniture: A Move Towards Socio-Spatial Adaptability

Transformeeruv mööbel: samm ruumi sotsiaalse kohanemise poole

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Author's Declaration

I have written the Master's thesis independently.

All works and major viewpoints of the other authors, data from other sources of literature and elsewhere used for writing this paper have been referenced.

Master's Thesis Objective & Task

2014 / 2015 academic year, 4th semester Student: **Mohammad J. Almutawa**, 132132MADMM Field of study: **Design & Engineering** Supervisor: **Martin Pärn**, Chair of Design

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Transformative Furniture: A Move Towards Socio-Spatial Adaptability Transformeeruv mööbel: samm ruumi sotsiaalse kohanemise poole

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The objective of this thesis is to study shared living spaces, with focus on spatial limitation and personal independence. The goal is to develop a product solution in the form of transformable furniture to address the issues uncovered.

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Abstract

Through the study and exploration of different aspects surrounding shared living spaces, issues with spatial limitations, boundary definition as well as user independence were uncovered. This resulted in the research and ultimate development of a modular, ultra-configurable compact living node designed with multiple users in mind.

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1. Prologue

Some of the fundamental needs of people revolve around safety and belonging. (Maslow 1943) To shelter themselves, they inhabit spaces that they start calling home. One of the intrinsic properties of modern habitable spaces is that they are fixed in size, meaning that more often than not, the occupants become spatially limited and find themselves confined and restricted. A rapidly growing world population only makes things more urgent, meaning personal habitable space is becoming a greater commodity.

Humans like any organic being, evolve, grow and shrink, needs included. It can be observed with time that people will find themselves in abundance or in shortage of space depending on their needs. When looking at a family unit; adaptable needs are easily illustrated by the transition from a single individual to a couple and then the addition of offspring who age and grow with their own specific needs at different stages of their life, which in turn then depart to find places of their own, creating and repeating the same cycle.

However, the nature of current habitable spaces is rigid and unchanging, and once homes are considered for what they actually are, a second skin to everchanging, ever-growing, ever-evolving users, a serious issue arises. The characteristics of a skin and space clash, for skin must be flexible and unhampering to the body it envelopes.

1.1 Objective & Scope

The work of this paper aims to study and explore the various facets of spatial limitations and issues arising from changing needs to better understand the underlying problems, in hopes of discovering useful insights to exploit potential design opportunities.

The scope of research and design will include a look in to architectural design and layouts, spatial diversity, user habits and preferences as well as furniture typology and applications.

1.2 Outcome

The expected outcome is to be in the form of a unified design or designs that address the limited space and changing needs issues. The design would also take into consideration the needs of the targeted user base, as well as emerging market trends. The design will be focused on creating a platform product solution focused particularly on addressing the overall need for an intervention rather than solely on the feasibility of construction and manufacturing of one single product.

2. Methodology

This section aims to explore the various methods in which the research and development was conducted, as well as illustrating how various techniques could be used meaningfully to reach a final product outcome. The overall structure of this paper will follow the double diamond model. (Design Council 2015)



Fig 1.0 Double Diamond Model

2.1 Double Diamond Model

Outlining what deliverables are expected at what stage of development, the double diamond model is a simplified graphical representation of the design process created by Design Council UK. It is split into four phases, the first is the 'discover' phase and it is aimed at going wide with the research to uncover and gather the most information surrounding an issue to get a better understanding of the larger topic. The second stage is the 'define' phase, which narrows down the research to expose insights, frame the potential issues and uncover opportunities. The third stage is the 'develop' phase where concepts and possible solutions can be explored, and even include further specific research to create even more refined concepts. The last stage is the 'delivery' phase where a concept is finalized and showcased, at this stage the deliverables should be met.

2.2 Discover

2.2.1 Giga-Mapping

Giga-mapping is a technique, which maps out all dimensions of a particular subject to reveal links and connections between different entities. It employs systems oriented design and thinking to reveal an issue under completely different light with the placement of high significance on the causal factors between the entities as well as an overview of the entire relationship of the network to itself and outside influences. (Sevaldson 2011)

Giga-mapping is exceptionally useful when looking at a broad topic, as it organizes information in a systematic way and highlights 'cause and effect' on a larger scale to generate a wider understand of the issues.

2.2.2 Issue Mapping

Through the use of phenomenological observations (Lester 1999), issue mapping is a method in which situations are observed and documented then analysed. After analysis, observations are categorized and clustered together into problem areas which are then further analysed and simmered down to root issues. Throughout the entire process, user profiles have to be taken into account and all involvement from primary, secondary and tertiary users should be considered. Issue mapping deepens the understanding of the root issues around a topic but it's only useful when the scope is narrowed down and contained.

2.2.3 Spatial Programming

As a practical and visual design analysis method, spatial programming helps in setting and identifying the constraint of a space as well as to determine different layout alternatives that can be achieved. Occupants are taken into account as multiple scenarios are explored simultaneously to distinguish commonalities and clashes.

2.2.4 Circulation Diagramming

Once spatial programming is completed and layouts are inferred, circulation diagramming can begin. This technique involves overlaying several rich layers of information on the established spatial layouts to identify and illustrate the flow of paths, the density of nodes, the location of hubs and efficiency of service space. (Lynch 1960)

2.2.5 User Probing

Through questionnaires and interviews, the purpose of probing users is to gather and aggregate insights and information about how the spatial use can differ between different target groups as well as discover preference and hear feedback on different issues.

It is an important and crucial step as the aim is to gather qualitative data from interviews to uncover further issues. Questionnaires take a more quantitative approach to see how these issues affect and reach out across the demographic.

2.2.6 Mood-boarding

A collection of visual material that is gathered and categories according to topic that inspire and communicate the mood of certain key points. (Wagner 2008)

This method is useful in turning tacit knowledge into shared knowledge. It also helps in developing a feel of what the topic is about, to see how others view certain issues and set a tone for further research or development.

2.3 Define

2.3.1 Insights

The gathered research is then analysed and summarized to identify and define the uncovered issues for further development. Opportunities are outlined to highlight any potential avenues for development and linking the research to possible design interventions.

2.3.2 Brief

A project brief is defined based on the insights and opportunities. The brief consists of what challenges are to be tackled, whom an intervention is for and why is it significant. Major themes for development should be uncovered and a proposal can be made to further define and specify the project goals.

2.4 Develop

2.4.1 Concept and Design Development

Based on the brief requirements, concepts are generated and developed to tackle the discovered issues. Concepts are analysed, evaluated and then further evolved to better refine the ideas and reach a point where they can be viable interventions to the issues.

2.5 Deliver

2.5.1 Design Deliverable

This is when a final solution is unveiled, showcasing the design embodiment. This phase also highlights the systems that make it possible and add any supplementary material if available, such as a business plan, marketing strategy or branding that add additional value to the product.

Delivery also includes the potential to launch a product to market, however that point will not be reached in this paper as it is aimed at exploring the need for a intervention and only sets a framework for the development of a future product.

3. Research

3.1 Living Space

3.1.1 Starting Point

Looking into living space is a crucial focal point in understanding some of the issues that arise within homes, which can impact users. 'Living space' does not only mean solely the space but should include the users and an understanding of their various needs. Also, Space should be categorically differentiated on both the macro and micro levels: from the various types of spaces to the different sub-spaces within.

The process started with the central focus on living space then zoomed in and dug deeper by asking 'why' questions and zoomed out and looked wider by asking 'what' questions. By going deeper, workings between entities on a micro level were observed. By looking wider, relationships between these entities and the system as a whole were unearthed.

3.1.2 The Giga-Map



Fig 1.1 Giga-Map of Living Space

The resulting giga-map was split up into four quadrants. First being living space and going deeper into what the space consisted of, such as areas and rooms, then going even further into what the issue areas are and their underlying causes. For example, one such area is the kitchen and upon further examination, a facet of the kitchen is storage, and when looked at more specifically, one of the items that could be stored is food and issues such as effective cold storage, and supply management would emerge.

When looking wider into living space, other types of space can be defined, looking both at physically constructed spaces as well as abstract spaces and their perception. It is important to differentiate between different clusters, which are classified according to their type of construction, the spaces within these constructions, and the items that they hold inside these spaces.

It's vital to identify user clusters followed by further targeting users within those clusters. Clusters include family units, single occupants, temporary occupant, etc. followed by specific users such as parents, students, children, etc. After looking at users, the next step was to zoom out and look at how these users behave and interact with a living space and one another, specifically in the context of social needs and structure. We can then look at the diversity of personalities, relationship dynamics, important of social hierarchy and how these factors are sources for a shift in values, technology reliance and social detachment.

3.1.3 Discovery

At first glance, the issues seem superficial. Storage was a recurring theme over the course of the giga-map and was an article of small or mismanaged living spaces.

The most significant discovery was that in cases where you only have a single occupant in a space, the majority of the problems seem to either vanish or be negligible, and issues seem to occur primarily when another user is added to the space.

In fact, the more people introduced to the space, or the larger the user cluster sharing the space is, the more clash and conflict occur and more issues become relevant.

Single occupants have no one to clash nor conflict with within their own space, thus the same issues that may show up with multiple occupants are ignored since they would be self-generated.

3.2 User Observation

3.2.1 Targeting

The need for phenomenological observation was the next step to determine what the cause for the clashes between users and multiple occupants that shared a space and why single occupants are seemingly immune to it.

The targeted users ranged from students to young couples and new parents, ages ranging from 20 to 30. They were selected as targets because they are on the threshold of shared space occupancy. Students starting college usually move to dorms and start living with new people, young couples takes the

angle of a relationship and moving in together, and new parents explore the situation of an incremental addition of a member to a family unit in a living space.

3.2.2 Issue Map

As living spaces are private, the consent of occupants was crucial to the observation process. Observations were made through watching interactions between the users to one another, objects in the space and the space itself. The observations were then noted down without any analysis for the purpose of recording and preserving the instances from personal interpretation.

These instances were then analysed and given possible meanings, interpretations and reasons as to why they occur. Similar reasons are then clustered together to discover root causes of the issues.



Fig 1.2 Issue Map

Three cases were observed and analysed for the issue map. First case revolved around five individuals moving into a shared house together, second was a young couple that just moved in together and lastly was a couple with a young child. When sharing a house with other individuals they haven't necessarily lived with before, subjects at first showed enthusiasm and excitement towards each other and a sense of exploration and discovery towards the space. They tried to integrate themselves into the environment and social order as well as connect with one another. When it came to personal belongings, placement was key as space was limited and there was some struggle over storage. Barriers were clearly defined between occupants as each user tried to gain the most privacy. Users were more independent and did the bare minimum when it came to shared responsibilities.

In both couples' cases, responsibility was a key determinant for the function of the household. House chores meant that there had to be a system in place and a social order. Barriers and privacy was not an issue in one couple's case, as they worked more synergistically together and shared the same values. However, only in the case of the couple with a child does privacy comes in, where space seems to shrink and they must provide extra room for the child. Storage and placement also comes into play with a child as things have to be organized a certain way to ensure the safety and cleanliness of the space.



Fig 1.3 Overlay of Issue Map & Giga-Map

3.2.3 Discovery:

When boiled down, what can be seen is that the issues are reduced down to two root causes, organization and communication. Issues such as storage and placement as well as integration and collection fall under organization of space. They're issues between users and objects or users and the spaces where the management of objects and preferences of users are what cause the conflicts.

Alternatively, communication was also an issue with connection between users, the delegation of responsibility, and personal independence being the reasons for communication breakdowns and clash in the living space between occupants.

Findings are reaffirmed when overlaying and cross-referencing both the issue and the giga-map (*Fig 3.*) to show that it is primarily organization and communication that are the root culprits.

3.4 Spatial Studies

3.4.1 Programming

In order to see how individuals use and occupy a space, we must first program a space for different living situations and analyse what happens. With the rising cost of living and increase in apartment prices, young people are opting to live in smaller spaces under 30 square meters, which happen to be the least affected by the rise of price in the Estonian real estate market. (Eesti Statistika 2012)

For the programming, a standard block apartment layout under 30 meters squared was used and incremental analysis was made as different users occupied the space, changes to the spaces were noted as well.



Fig 2.1 Apartment Layouts

Layouts were optimised for each scenario of users. It can be seen that in each case a form of compromise is made. In the single occupant scenario, the user would have all the amenities that they would need and would even end up with more space available. This excess space gives the occupant an opportunity to expand, however, leaves ample room for inefficiency.

When a roommate is added to the space, the layout can change drastically, most notably the sacrifice of a lounge for the addition of a bedroom. This is for the pursuit of privacy and individuality. The loss of a lounge means that socializing and spending time together does not carry much importance to the occupants. They only share the other amenities as a form of necessity.

In the case of a couple, although it is the same amount of occupants as the roommate scenario, the layout and programming stays almost unchanged from the single occupant case. This is because their use of space overlaps each other and the social structure is in a way where interaction is crucial.

With the addition of an offspring to the couple scenario, not much seems to have changed to the apartment layout, however in this case, the living room would have to double up as a temporary bedroom. In most cases the parents sleep in the living room and the child occupies the main bedroom because of the difference in sleeping hours, however this changes when the child grows up and starts sleeping later than the parents. The sacrifice of privacy is the main issue in this case.

3.4.2 Circulation

To add a rich layer of information on to the programming, circulation is then mapped out to see how various occupants move through the space, as well as see how well the space flows and whether there would be any bottlenecking or conflict areas.



Fig 2.2 User Circulation

With a single occupant, paths spread and branch out giving the occupant abundant room to move. However, the spread out path create excessive, inefficient and often unnecessary transits.

Roommates have a strong separation and division in flows that only overlap in common use amenities such as the kitchen and bathroom. The division generates unique paths for the individuals that minimize interaction and possible conflicts yet aren't as efficient at utilizing the flow effectively.

The flow of a couple in the space is the most optimal as they use the majority of the space and synergize well together as they utilize the same paths to an extent. Crossing paths are great for interactions, which are important for couples but could be a source for clash and conflict between them also.

A child added to the mix generates additional routes in the space. The space is now crowded with heavy flow paths and overlapping uses.

3.4.3 Nodes

Nodes are the spaces where individuals spend a significant amount of time and serve as attractor points that paths start from or head toward.



Fig 2.3 User Nodes

Nodes are spread apart in the single occupancy scenario leaving an airier and spacious feeling space, however a large amount of the apartment remains unused.

The distinct division of paths in the roommate's case translates over to the nodes with even clearer barriers of separation between them with a few cases of overlapping use.

The couple's nodes are spread out efficiently as they tend to use the same areas together, however this leads to decreased privacy and independency for the users.

Critical mass occupancy is achieved when a child is added, as there is just not enough room to expand. Clashing use of the living room is also evident as it ends up doubling as an extra bedroom.

3.5 User Probing

3.5.1 Surveying

In order to better understand the demography, a survey was conducted to assess what the living situation was for various users. The questionnaire tried to establish a baseline for a future design by finding out how many users across a wide sample size live with a partner or roommate, if they experience any form of restriction, what qualities they value most in a space, and what traits or factors they seek in their current living space.

3.5.2 Demography



Fig 2.4 Demographic of Survey

The questionnaire was shared with college students and young professionals and received 82 respondents. The respondents were primarily under 30, with 50% between 18-25 and 46.3% between 25-30. Majority of the respondents rented their space (80%), lived in Europe (85%) and shared the space with someone else, either a roommate (43%), a partner (31.6%), or a partner and children (6.3%). Living spaces they occupied were predominantly under 50 square meters, with 25% of respondents living in spaces between 30 to 50 square meters, 20% between 20 and 30 square meters and 16.2% under 20 square meters.



Fig 2.5 Gauging Connection to Space

Respondents that were satisfied with the size of their space was higher than expected, with 87.6% saying their space was adequate in size and 45.1% felt that their space was too small or would like more room.

When asked what concerned them the most when looking for a flat, cost (55.6%) and location (37%) were the biggest factors that they considered in a place, size (3.7%) played a minimal role. Users were also asked about the level customization they've done to their space, specifically whether it was a

drastic and permanent change or temporary and decorative. An overwhelming 72.6% of users have made changes to their living space but only 11.3% of which was permanent.



3.5.4 Users to Users

Fig 2.6 Gauging Connection to Others

When living with others, 38.3% of respondents valued privacy in a space, whereas 28.4% wanted a place where they would feel independent. Only 4.9% looked for a space that was cheap and 8.6% for somewhere spacious.

A considerable amount of respondents enjoyed sharing a space with others and got along (86%). To gauge the degree of independence and individuality of shared space users, they were asked how much they relied on others and how their routines or schedules were affected by the others in the space. 76.9% of users said they relied on others to a varying degree and 23.1% only relying on their self. It is also reflected in personal routines and schedules with 87.6% of respondents having to alter or change their routines and schedule to some degree to better suit others in the space and 12.5% that are unaffected by other's presence.

4. Insights

4.1 The Space

4.1.1 Organization

One of the first things that became clear through initial giga-mapping was the fact that spatial organization was a major issue.

The layout of the space defined by walls, furniture or personal affects impacted the users of the space. The smaller the space is, the bigger the impact on organizational factors. Storage is an issue with multiple users especially when one user has more personal belongings than the other.

Most interesting insight was that most organizational issues vanish or become negligible when a user lives on their own. The only issue they may still be confronted by is that if the space is below a certain area in size, where they would feel cramped.

4.1.2 Efficiency

The purpose of the spatial study was to determine the efficiency of space in terms of occupancy, layout and how much waste there was. It was observed that for a 30 square meter apartment that a couple is the most efficient type of occupancy for a space as there is a lot of synergy between them and utilize the same furniture and room for the same purposes rather than in the roommates case. With roommate, barriers are more dominating over the space and create inefficiencies in flow. In a single occupant's case, there was ample room and space for the user but much went to waste, as it was excessive. The flow became long and unnecessary. Critical mass occupancy was achieved when a child was added to the equation. The space can handle

a child but it created a need for more space and resulted in transitionary spaces, which have to take on two roles such as the living room becoming a temporary bedroom.

4.1.3 Adaption

The space notably adapted with different occupancy scenario, from layout to circulation and location of nodes.

The space could fit a single occupant's needs and more, as it was large in space. The space was divided into a lounge area, a bedroom, a bathroom and a kitchen.

When roommates are occupying the space, the lounge is sacrificed for an additional bedroom and increased privacy. The kitchen and bathroom are shared and the kitchen becomes a possible social node for the occupants.

Couples occupy a similar arranged space as a single occupant. They opt for a layout that provides a lounge and a bedroom, however possible workspace is often sacrificed or relegated to a dining or coffee table. The arrangement also stays the same with the addition of child however, now the lounge doubles up as a second bedroom, usually at the expense of privacy and comfort.

4.1.4 Time

Looking at the spaces with respect to time revealed a clash between the static properties of living spaces and the dynamic nature of functionality within that space. Time dictated to a large degree the functional use that was required from the space.

The spatial requirements during different times of the day means the space needs to be able to adapt to serve them. A space during the daytime is required to be active and social, users in it are encouraged to interact and socialize however, during the night users require quiet and privacy, barriers are prominent and communication is minimal.

This is reflected in the notion of a living room as a 'day room' and the bedroom as 'night room'. Living rooms are social and actives spaces that users get together in for the purpose of communication or entertainment. Bedrooms are the opposite of that, required to be dark, quiet and private places where users can relax and go to sleep. (Peters 2014)

4.2 The Users

4.2.1 Communication

Through phenomenological observations done for the issue map, communication stood out as a root cause for several users living together.

Occupants need to communicate to each other the levels of connection they seek, degree of privacy they need, the responsibilities they expect from others and yet still feel independent themselves.

Single occupants do not face communication as an issue since they have no one to communicate with. Roommate occupants valued privacy over all else since they usually have no personal connection with their roommates; they also put emphasis on communicating barriers. Couples value responsibility and connection with each others and share similar core values but usually meaning privacy and independence is reduced in this case, and even further reduced when a child is involved.

4.2.2 Environmental

User satisfaction with the size of their living space was quite high, with a percentage of occupants wanting some more space. Cost and location were determining factors to users when looking for a space however size of the living space did not matter so much. Many users have customized their space to a degree or intend to, however very few have done any permanent renovation.

4.2.3 Social

Privacy was a valued quality for a space by a large amount of users, more so than cost and size. However a vast majority of respondents enjoyed living with others, but at the cost of personal independence. Users found themselves relying to a degree on others when sharing a space as well as adjusted their lifestyles and routines to better mesh with other users of the space.

4.3 Intervention Opportunities

The occupant scenario that stood out significantly was the couple's case. The synergistic relationship between the two users and their overlapping use of space make them an interesting target for design.

With cost being a deciding factor in the selection of a space, as well as users being in need of bigger space, it is important to get the most out the living space through achieving greater efficiency. Space could be transformative and able to adapt with the occupants as their needs change.

Communication is fundamental between couple so a space should be able to reflect the user's behaviour and preferences at any moment, such as the degree of connectivity, amount of privacy and level of responsibility towards each other. However, it should be implemented with a degree of independence to retain the individuality of each of the occupants and offer them an option for self-reliance.

With a large segment of the users renting a space, any intervention needs to be non-permanent as many property owners have rules in place to limit drastic change to their property by tenants.

5. Brief

5.1 Theme

5.1.1 Dipolarity in Spaces

As exemplified by the user survey, a significant portion of the respondents occupied spaces less than 20 square meters. A large quantity of young people are starting to move towards and inhabiting smaller spaces, as it is most affordable for them. (Porterfield 2013) However, this migration towards smaller space means there's a sacrifice in functionality and space as bedrooms and living rooms are integrated to maximize space.

Living rooms and bedrooms serve different functions and as a space where you spend a third of your life, the bedroom, has very specific requirements. According to sleep expert, Brandon Peters M.D., your sleep environment and the quality of your sleep can affect your entire life and even impact your relationships. (Peters 2014) Factors such as noise, light, temperature play a huge role. Sleeping environments should be preserved as a place of relaxation and sleep, however with small spaces, this sleep environment seeps into the active and social living space.

One proposal is to have a space that can switch state between sleeping space and an active social space. A way to achieve that is through the introduction of a transformative furniture piece that can take on several roles at different times and adapt to the socio-spatial needs required.

5.1.2 Bedroom vs. Lounge

The challenge is to combine a sleeping and living areas spatially yet differentiate between them. Based on the number of occupants in a space, a

single user may only need either a bedroom or a lounge depending on the time of day or what is needed at the moment, so in this case a piece of dualpurpose furniture would be close to ideal as it can switch functions when needed. However with multiple users, the need for a bedroom and a lounge may exist simultaneously and independently for each user where one might want to sleep and the other may not. In this case standard dual-purpose furniture will not work, thus necessitating the need for transitionary middle state that satisfies both needs.

5.1.3 Transitionary Levels

A transitionary middle state in regards to transforming furniture would mean that the furniture would have to exist in a state that satisfies the properties of both functions. It is no longer simply just one function or the other but can transition and exist at any point between functionalities. This can create a high level of independence for couples, as they would no longer limited by others when it comes to personal use.

5.2 Targeting

Based on the responses from the survey (Fig 2.4), half of the respondents were between 18-25, with 80% of respondents are renting, 81% living with a roommate or partner, and 61.3% living in spaces under 50 square meters.

The aim is to reach out to multiple user living together, specifically couples aged between 18-30, that are students or young professionals, who rent a space under 30 meters squared. The reason young couples were specifically selected was because they're on the threshold of transitioning from single living and personal independence to shared, synergistic and symbiotic living with others.

The space plays a major role as well with a large portion of respondents living in spaces that are less than 50 square meters, with a sizeable percentage living in less than 20 square meters. A middle ground was reached to look at spaces that are 30 square meters and under, to specifically address the segment of users that felt that their space was either too small or wish that their space was a bit larger.

5.3 Objective

In light of the uncovered insights and potential intervention opportunities, the objective is to develop an adaptable intervention that is able to transform a space by offering transitionary states of use, as well as achieving a higher degree of space efficiency to give users a feel of a bigger home environment. It should also be able to communicate boundaries privacy and connectivity of users to each other whilst maintaining independence of both occupants during use.

6. Conceptual Development

6.1 Precedents

Identifying and studying precedents is crucial, as it illustrates the different approaches formerly explored and revealing the successes and shortcomings of previous design interventions.

6.1.1 Dynamic Spaces

In small open studio apartments, having moveable walls can dynamically restructure the same space. It is a great way to create the illusion of multiple spaces through the overlaying of functions onto each other. The wall's movement creates different spaces with different functions for the occupants to use.



Fig 3.1 Six-in-One NY Apartment

One New York resident, Graham Hill, did just that. He purchased an apartment 2010 and spent two years remodelling it. His creation is a 39 square meter apartment that houses the functionality of a 102 square meter apartment. It was made possible by creating different spaces through the

manipulation of walls, which moved on rail system. He managed to squeeze 6 rooms into one space. (Dirksen 2012)

The concept was also done previously by Hong Kong architect Gary Chang to add more room to his 32 square meter apartment. By hiding functionality behind walls, he added a staggering 24 different configurations to his apartment at a steep cost of \$231,700. (Pomfret 2010)

The obvious benefit of this approach is that it crams more functionality into space and creates highly adaptive and dynamic spaces. However, the construction of these transformable spaces involves major renovations and drastic change to the existing apartment, which carry a hefty price tag and more often than not, impossible for renters to carry out on their own initiative.

6.1.2 Pop-up Furniture

This precedent is very similar to the dynamically adaptable spaces approach but takes on a furniture angle. It involves the introduction of an item to a space that serves many functions or serves just one function but then gets out of the way when not in use by becoming compact in size.



Fig 3.2 Hack by Konstantin Grcic + Vitra

Designer Konstantin Grcic created a table and cubicle system for offices that adapts to the demands of the office, it is a compact package that can be kept out of sight until needed. When brought to use, it can adjust to the requirements of the user and the space. (Grcic 2014)

Atelier OPA from Japan designed The Kenchikukagu, a series of portable, mobile pop-up furniture that consist of an office, a guest bedroom and a kitchen. The series had the ability to change or define the interior of a space. They dubbed this style of pop-up furniture as "Architectural furniture". (De Castro 2013) This approach is best in small spaces where permanent change and major construction is not an option. It is also a more cost effective approach compared to moveable walls for instance. However, pop-up furniture is usually a temporary solution that isn't very convenient for day-to-day use.

6.1.3 Evolutionary Design

A long-term approach to adaptable designs, which follow the lifecycle of the users or the space and adapts to grow with them over time.



Fig 3.3 Rocky by Jäll & Tofta

One example of such an approach is Rocky, a crib designed by Jäll & Tofta. The crib acts as a four-in-one furniture that evolves with the growth of a child. It is a rocking chair, a baby cradle, a standard cradle and a children's bed. (Jäll & Tofta 2010)

On a larger scale, Noticias Arquitectura released a CHK (Container Home Kit), which allows users to build a container home that can be enlarged or shrunken as the needs of the occupants change over time. (Noticias Arquitectura 2006)

In the long run, this approach is very effective. It provides room for growth and development so the users don't necessarily need to desperately intervene when the situation necessitates it. However, much planning and foresight has to be taken into account when going with this approach, as it would require a substantial upfront cost for a future investment that may or may not be needed.

6.1.4 Convertible Furniture

Convertible furniture is furniture that switches from one state to another to serve one or more functions. Much like pop-up furniture in approach,

convertible furniture alternates between existing types of furniture whereas pop-up furniture creates its own typology.



Fig 3.4 Ikea Sofa Bed

The most typical and overdone types of convertible furniture out there are sofa beds. Ikea, a Swedish furniture manufacturer, has a wide range of sofa beds whose aims are to create an affordable solution for customers with small spaces and low budgets. (Ikea 2015)

Designer Aïssa Logerot, created a novel and unique piece of convertible furniture, which switches states between a stand-up mirror and an ironing board. Her concept is more thought out with the intentional link between ironing clothing and dressing up. (Logerot 2009)



Fig 3.5 Studybed

Another example of convertible furniture is the Studybed. It is a solution aimed at students that require a place to study and sleep. Studybed, as the name implies, is a desk during the day and a bed during the night. (Studybed.co.uk 2011)

Convertible furnishing usually offers a more affordable alternative to their non-combination counterparts, and take up less space. They're more suited
for active day-to-day use and constant transformation as opposed to pop-up furniture.

6.2 Precedent Analysis

6.2.1 Evaluation Chart

To better understand the strength and weakness of each precedent approach, they were analysed with an evaluation chart to gauge certain vital criteria. (Cross 2000)

Each approach is assessed on cost, spatial efficiency, adaptability, interactivity and permanence. Cost reflects the amount of financial and logistical means required for implementation, as cost is a deciding factor to the target group it was given a higher weight and more importance was placed on achieving lower costs. Space efficiency takes into account how much space is utilized and how much function is put out in return. Adaptability and interactivity reflect how responsive a design would be to the environment and the user, these factors were given more weight because of their importance. Lastly, permanence was considered, this takes into account the level of construction and permanent change required to achieve the design, since the a majority of the users surveyed were renters, the lower the permanence, the better.

			Dynamic Spaces	Pop-up Furniture	Evolutionary Design	Convertible Furniture
Weight	x1.5	Cost	High (1)	Medium (2)	High (1)	Medium (2)
	x1	Space Efficiency	High (3)	Medium (2)	High (3)	Medium (2)
	x1.5	Adaptability	Medium (2)	Low (1)	Medium (2)	Low (1)
	x1.5	Interactivity	High (3)	Medium (2)	Low (1)	High (3)
	×1	Permanence	High (1)	Low (3)	Medium (2)	Low (3)
		Weighted Total	13	12.5	11	14
		Score (%)	66.7	64.1	56.4	71.8

6.2.2 Results

Convertible furniture came out on top with the set criteria, it was the best fit for users that wanted something affordable, yet space efficient and non-permanent.

Dynamic spaces came out second, it provides superior space efficiency, adaptability, and interactivity however, it comes at a hefty price tag and a prerequisite of space ownership.

Pop-up furniture scored very similar to convertible furniture but with a lower score in interactivity. Evolutionary design scored the lowest as it involved a greater upfront cost and provided little user interaction.

6.2.3 Take-Away

After evaluating each precedent and different approaches to modifying and impacting living space, a few elements stood out as advantageous and should be implemented in the final design.

Elements include, the spatial efficiency and interactivity of Dynamic spaces, the non-permanence and new typology of pop-up furniture, the adaptability of evolutionary furniture and the cost and practicality of convertible furniture.

6.3 Concept Generation

Through the exploration of precedents and the identification of each of their strengths and weaknesses, elements can be taken and combined to create new concepts. Several strategies for creating transitional spaces are proposed.

6.3.1 On-Demand Range



Fig 4.1 On-Demand Range Concept

As the presence of furniture in a space can define the function of the space, having a furniture range that can appear and disappear on demand means the definition of the space can readily change on demand too.



Fig 4.2 On-Demand Range Schematic

And adaptation of a bedroom/living room in this case would be to have a bed unit and sofa unit that can show up and disappear when required, overlaying the functions of both spaces into a single space.

Such an approach can be costly, as it requires multiple specialized furniture components in order to transform a space. In a dual use scenario where both a living room and a bedroom are needed, the lack of a barrier or physical separation between the functions endangers the sanctity of the sleeping environment.

6.3.2 Shifting Boundaries



Fig 4.3 Shifting Boundaries Concept

Having static walls to divide two spaces means you create two permanent spaces that exist whether you use them for not. Such a strong division is important to preserve both the living and the sleeping environment, however each space would require 'service space' or room for circulation and movement. Having double service spaces in the space will just eat up from the usable space and lower the efficiency. So what if the service space can be moved from one space to the other when needed?



Fig 4.4 Shifting Boundaries Schematic

The concept is to be able to shift the boundaries between two spaces to create more room in one space than the other when needed and vice versa. By combining mobile furniture and a divider between, spaces can easily be shifted from one zone to the other.

This approach eliminates the need for double service space, but creates the space when needed, in essence it can collapse a bedroom to it's bare minimum in order to maximize living space and expand the bedroom at night to give occupants a place to sleep.

Although less spatial efficiency is achieved than with on-demand furniture, the strong division gives users more independence.

6.3.3 Dynamic Divider



Fig 4.5 Dynamic Divider Concept

Playing on the same theme of saving service space and creating spatial efficiency through the absorption of circulation space, the creation of a single piece of furniture that can transition from one state to the next would result in even more spatial efficiency.



Fig 4.6 Dynamic Divider Schematic

To compress a sofa and a bed into a single unit that is able to take on both functionalities, a shifting divider can be placed in the centre of a standard bed to transform the foot of the bed into a couch on one side. When the divider is pushed out to the edge of the bed, the couch disappears and a standard bed emerges. Divider could also accommodate multiple users, so it can shift independently on each side, so it can remain a couch on one side and a bed on the other.

This is a very economical approach as it creates an accessory to a standard bed and would be aimed towards creating a cheaper temporary solution to users with less financial means.

6.3.4 Adaptable Module



Fig 4.7 Adaptable Module Concept

Inspired by pop-up furniture, rather than trying to take an existing bed or existing sofa and making them behave in a way that would fit the space, it is possible to break free from the typology of both pieces of existing furniture to create a new typology that can achieve the same results.



Fig 4.8 Adaptable Module Schematic

Having a single module that can serve as bedding when needed, seating when needed and a division between both would mean it could squeeze a high amount of functionality into minimal space thus greatly boosting spatial efficiency. Also, it is possible for multiple individuals to use the same module independently to serve them best. The module doesn't only reorganize the service space and shifts it across the threshold but it also takes elements from the on-demand approach by utilizing the space of the unused furniture that was previous occupied.

6.4 Concept Analysis

6.4.1 Evaluation Chart

Each concept was assessed and evaluated on an evaluation chart to better understand the strength and weakness of each approach. They were analysed with the same pertinent criteria used to analyse the precedents. (Cross 2000)

			On-Demand Range	Shifting Boundaries	Dynamic Divider	Adaptable Module
Weight	x1.5	Cost	High (1)	Medium (2)	Low (3)	Medium (2)
	x1	Space Efficiency	High (3)	Low (1)	Medium (2)	High (3)
	x1.5	Adaptability	High (3)	Medium (2)	Medium (2)	High (3)
	x1.5	Interactivity	High (3)	Medium (2)	Medium (2)	High (3)
	x1	Permanence	High (1)	Medium (2)	Low (3)	Low (3)
		Weighted Total	14.5	12	15.5	18
		Score (%)	74.4	61.5	79.5	92.3

Fig 4.9	Concept	Evaluation	Chart
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6.4.2 Results

The On-Demand Range concept did well on space efficiency, adaptability and interactivity however the score was impacted due to the high cost and relative permanence of the approach. The Shifting Boundaries concept did relatively low on spatial efficiency, as it didn't produce as much utility for the amount of space. The cost was average, as it required the standard sets of furniture. The bulk of the combination makes for higher level of permanence.

The Dynamic Divider was the best in terms of cost. It used an add-on approach and only one piece of standard furniture to convert the surroundings into a multifunctional space, similar to the Shifting Boundaries concept yet more refined.

What stood out the most was the Adaptable Module concept that was best all around. Although entailing a higher cost than the Dynamic Divider concept, it offered a high level of spatial efficiency, adaptability and interactivity. It also provided a large degree of independence to users. The small form factor means also it has a little footprint in the space and low permanence.

7. Design Development

7.1 Objective

Based on the concept evaluations, a decision was made to develop the adaptable module concept further as it showed great potential for impact. The adaptable module concept provides many design challenges, such as establishing a new typology that would work for the user and the environment, providing multi-functionality in a limited form factor, and developing a delivery system for those functions.

The module will act as a transitionary piece of furniture in an open yet small living space for couples. It shall consist of sleeping units, a seating and lounging unit and a possibility for a work unit. Each of these elements will have to be able to appear and vanish from the module as needed, as well as provide full-fledged comfort, practicality and independence to the users. The module does not only adapt itself but should also transform the surrounding environment to fulfil a higher socio-spatial function.

7.2 Sleep Space

7.2.1 Essentials

Comfort and privacy are key when it comes to any sleeping area, and to preserve those qualities, one must be able to take into account light, sound and other forms of disturbances.

The challenge comes when having to take into account the users, a couple sharing a single space. To go a step beyond that they're not only sharing a single space but also a single piece of furniture in that space. Experts suggest that there has to be a balance between emotional distance and physical distance, such that couples should sleep on the same bed for intimacy and emotional connection, yet should also be able to be independent enough to sleep with comfort. (Lott 2013)

Double beds are ideal for couples as they provide a large enough sleeping surface to accommodate both users. However, a double bed as one unit exists for two users whether one, both or none of them use it. An option has to be provided that can adapt the bed to the needs of the moment as opposed to the needs of peak time.

One way this could be done is by dividing a double bed into two single beds that can function independently for each of the users, yet come together when both are in use to form a single unit. To adhere to the preservation of the sleeping space, a barrier should be in place to increase privacy and comfort by separating the bed from noise, light and other nuisances.

A method to achieve this goal would be to somehow be able to fold the double mattress in the middle when not in use, and to store it upright. This way it would be taking up a minimal amount of space, boosting spatial efficiency. However when one person would like to sleep, only half of the mattress can be folded down 90 degrees so that the person occupying the mattress would be sheltered from noise and sound by the upright half of the mattress creating the aforementioned protective barrier.



Fig 5.1 Sleep Space Sketches

7.2.2 Systems and Evaluation

	cl					
	Sieep Space		Single Folding	Dual Hinged	Couch Integration	Single Hinged
	x1.5	Comfort	Medium (2)	High (3)	Low (1)	High (3)
ŧ	×1	Complexity	Low (3)	Medium (2)	High (1)	Medium (2)
eig	x1.5	Independence	High (3)	High (3)	Medium (2)	Low (1)
≥	x1	Reliability	Medium (2)	High (3)	Low (1)	High (3)
	x1	Divisiveness	High (3)	Medium (2)	Low (1)	Low (1)
		Weighted Total	15.5	16	7.5	12
		Score (%)	86.1	88.9	41.7	66.7

Fig 5.2 Sleep Space System Evaluation

The possibility of a single folding a mattress means that it can be compacted into a smaller space with little complexity. However, when comfort is taken into account, folding a mattress would create major wear and tear at the folding point thus decreasing comfort for the user.

A dual mattress hinged system is essentially the same as a folding system but relegates the folding point to a mechanical hinge. Wear and tear in this case would be minimal. With each user having their own personal mattress, independence while use is high, as they can not only decide when to use it, but also adds the possibility for individual mattress customization.

Involving couch integration as part of the mattress would conserve a lot of space, as it would reduce the need for redundant cushions. This would involve folding or hinging a mattress asymmetrically to provide a sitting surface, but this would require special-made mattresses. This method also sacrifices the possibility of a barrier for one user.

The simplest approach would be having a single hinged sleeping surface, much like the Murphy bed systems. This approach provides comfortable sleeping surface as well as a simple system, however this means a workspace would be sacrificed and it would not meet the objective requirement of full user independence.

The system that scored best was the dual mattress hinged system, followed closely by the single mattress folding system. The dual mattress hinged system will be taken forward for further development.

7.3 Lounge Space

7.3.1 Essentials

The lounge space is the space occupied when users are not asleep. It is where they gather and socialize. It is also the space where the users can seek entertainment options, host guests, and generally bond together.

Couches have taken a heavy role in providing a comfortable surface to lounge on. When the sofa was introduced in the 1600s, it took off rapidly. Before the sofa's introduction, people sat on hard upright surfaces and the idea of padding or cushioning a sitting surface was uncommon. Now couches are here to stay, they are a sign of comfort and relaxation. (Davis 2009)

A pleasant and cosy lounging space has to be provided in the module for occupants to relax on and be comfortable. Users will spend the most time on the couch or sofa when neither working nor sleeping, it is where they will bond and entertain themselves.

To work with the module's vision, the space has to be offered when needed and vanish when not in use. A simple way to achieve that is by using the underside of the bed for the couch. If the bed was to rotate upright, then the couch could somehow be attached to the underside so it is visible and functional when the bed is away and invisible and unhampering underneath the bed when the bed is in use.



Fig 5.3 Lounge Space Sketches

7.3.2 Systems and Evaluation

	Lou	inge Space		5	0	0
	Lounge opdee		Lowered	Mattress extension	Fold up	Middle-Break
	x1.5	Comfort	High (3)	Medium (2)	High (3)	Low (1)
t	×1	Complexity	Medium (2)	Medium (2)	Medium (2)	High (1)
eig	x1.5	Ease	Low (1)	High (3)	Medium (2)	Low (1)
≥	×1	Reliability	Medium (2)	Low (1)	High (3)	Low (1)
	×1	Divisiveness	Medium (2)	Low (1)	High (3)	Medium (2)
-				· · ·		
		Weighted Total	12	11.5	15.5	7
		Score (%)	66.7	63.9	86.1	38.9

Fig 5.4 Lounge Space System Evaluation

Several systems were considered, one of which was the lowered seating system, and it involves a sliding join that moves the seating down so the mattress can fold over on top of it. Although this system would be comfortable to sit on, it would be difficult to implement and use. It would also take up space when the module would be in a compact non-use state.

The mattress extension approach is very similar to the couch integration approach; it uses the existing mattress as a sitting surface. Although efficient, this approach would mean that one of the mattresses would have an additional central joint, which would drastically reduce comfort and usability.

The fold up system is a simple pivot point that would hinge the seating surface up underneath the mattress. This approach is non-complex and would be easy to use as well as provide a high degree of comfort. It would increase the module's compactness in the non-use state.

By moving the pivot point towards the centre of the sitting surface, this means the joint can act as the bed leg when the bed folds down. However, this middle break comes at the cost uncomfortable seating through wear and tear at the hinge point.

As it scored highest overall and offered the simplest solution, the fold up system will be taken for further development.

7.4 Work Space

7.4.1 Essentials

One of the uncovered insights from the research was that when users transition from being single occupants to a couple sharing the same space, workspace is often sacrificed to accommodate for both occupant's presence.

When the target group is students and young professionals aged 18 to 30, the lack of workspace is a great hindrance. So the integration of a desk or workspace to the module would be great as it gives back a space that was previously lost to the users.

A desk could be attached to the module in a similar fashion as the couch, by using the underside of the bed. So when the bed is upright, the desk is usable, and when the bed folds down, the workspace would vanish out of sight.

The challenge with a desk is that it is an active environment, which would be cluttered with an assortment of items, which are laid out to accomplish work. Having to remove those items to be able to use the bed is not only a hassle, but could jeopardize work and disrupt the thought process. (Giang 2013)

There are many products on the market that solve this issue. For instance, the 'studybed' mentioned in the precedent analysis, uses a stabilized desk system, which allows the user to lower their desk without having to remove any of the items. (Studybed.co.uk 2011) A similar approach could also be used with the adaptable module to keep the workspace undisturbed and make for a better overall experience.



Fig 5.5 Work Space Sketches

7.4.2 Systems and Evaluation

			(-0-		 O	
	Work Space		Stabilized	Frame-Top	Fold down	Rotated leg
	x1.5	Comfort	High (3)	Low (1)	Low (1)	Low (1)
ŧ	×1	Complexity	High (1)	Medium (2)	Low (3)	Low (3)
eig	x1.5	Ease	High (3)	Low (1)	Medium (2)	High (3)
∣≥	×1	Reliability	Low (1)	Medium (2)	High (3)	High (3)
	×1	Divisiveness	High (3)	Low (1)	High (3)	Low (1)
		Weighted Total	14	8	13.5	13
		Score (%)	77.8	44.4	75.0	72.2

Fig 5.6 Work Space System Evaluation

With desk spaces usually hosting an assortment of different items, having a stabilised system makes sense, as it provide great ease between switching states as the belongings can stay on the desk top undisturbed. Also, it can provide the possibility to fold up and vanish in the non-use state. Although, this system is complex, it provides the most comfort and ease for users.

The frame top system uses the top of the folded up mattress to provide a surface hence decreasing the footprint of the desk and can stay fixed so when the bed pops open it can provide leg support. There are two issues with this system, firstly, the height of the desk would be non-standard which means, it will not be comfortable and the short projection length over the side means comfort is jeopardized again by the lack of adequate legroom.

A fold down table-top is a simple solution that provides a desk at the right height and sufficient legroom, but it takes away the convenience of letting the items on the desk remain in place when the bed is in use.

An even simpler approach would be a fixed table-top, which acts as a leg when the bed is folded down. However, it suffers from the same issue as the fold down top, by forcing the user to clear the desk when the bed needs to be used. The system also causes a reduction in legroom.

The stabilized desk system is set apart from the others by providing a high degree of ease and usability to the module as a whole. As it was the top scoring system, it will be further developed as a part of the module.

7.5 Integration

7.5.1 Combined Module



Fig 6.1 Multi-states of Combined Module

With the parts combined together, the module is formed creating several unique states to better adapt to the spatial and social needs of the users. In the non-use state, the module is closely packed and unobtrusive, this is the fully closed state. The sleep state is the state in which it is the most open, ideal for when both users would like to sleep and share a single sleeping surface; all other functions are hidden underneath.

There are seven other hybrid states in which a combination of sleep, work, lounge and non-use can be combined for a higher level of control over the space.

The individual independence and interactivity of users with the module is a high priority when it comes to implementation. In this case the user will be able to use any of the functions provided by the module irrespective of what the other user is doing with the module. In essence giving users complete freedom to do what they want, when they want.

The entire module as a whole must be one succinct unit that would work well together and fulfil the objectives aimed for in the brief.

As a furniture piece with a mash-up of functionality, it must break free from the currently existing typologies to create its own unique one. It must do so to become a single homogenous unit rather than a sum of hacked parts assembled together.

7.6 Design Embodiment

The module as a whole must be one succinct unit that would work well together and fulfil the objectives aimed for in the brief.

As a furniture piece with a mash-up of functionality, it must break free from the currently existing typologies to create its own unique one. It must do so to become a single homogenous unit rather than a sum of hacked parts assembled together.

Three possible thematic approaches were identified for the unification of the parts.

7.6.1 Bare



Fig 7.1 Bare Moodboard

The bare theme focuses on the honesty and sincerity of connecting multiple different elements together. It showcases the various different systems and materials used instead of hiding them. The bare theme purposely embraces and does not shy away from the hacked elements.

What this means for the module is that it could embrace the standard furniture typologies and communicate the true nature of the construction. Mechanical parts can even be left bare, as a focal point to convey the motion.



Fig 7.2 Skin Moodboard

Rather than exposing all the elements and connections, the skin theme highlights different components in a design through a unified visual language. The theme tries to communicate the unique different parts so they're distinguished yet unites them all as a part of a bigger unit.

In this case, the module would shy away from the standard furniture typologies and try and define its own visual language. The different functions will still able to convey their purpose yet feel part of a larger united whole.

7.6.3 Shell



Fig 7.3 Shell Moodboard

The shell theme is all about unifying all the different components into a single unit. It is drastic in the sense that it makes all the separate parts almost indistinguishable. This approach is best for a minimal and cleaner product, but not ideal at communicating what the product actually offers.

So for the module, this means hiding up all the components in the larger whole of the combined unit, only revealing the individual parts when needed.

7.6.4 Theme Strategy

For the final product to be complete, a theme must be picked, as it will be the basis in designing and unifying all the parts to create a homogenous unit.

All the themes have their own merit, which makes them unique, however, they are not absolute. The themes seep over one another and the lines between them are blurred.

For the final design of the module, the main theme that will be focused on is the Skin theme, as it is a middle ground approach between the two extremes, yet elements of both the shell and bare theme maybe used to enhance the over all product and experience and tie them all together.



Fig 7.4 Design Embodiment Sketches

8. Design Outcome



Fig 8.1 Introducing Elemental

8.1 Overview

The outcome from the design process is Elemental, a modular, ultraconfigurable living node made for two. Elemental possesses the power to define the space it's placed in through its ability to morph and transform to the users needs.

The name derives from 'element', which means an essential part of something abstract; it is a component that may define the larger whole. Element also refers to the forces of nature, which shape and characterize an environment. When one is described as 'being in their element' it means that they are in an environment or situation that they can excel at. (Dictionary.com. 2015)

8.2 The Experience



Fig 8.2 Elemental Transformation

Targeted towards couples in small spaces, Elemental provides the novel solution of adapting a single open space to take on the functions of multiple rooms. It provides each of the users with a curated personal experience aimed at maximizing their self-reliance and eliminating any socio-spatial constraints.



Fig 8.3 Elemental in Active Use

Shown in active use, Elemental utilizes the area where a bed would normally occupy to provide a workspace and a lounging area. The main body of the unit also acts as divider between the two spaces which frames the boundaries and give each user a sense of their own personal space. (Team Office Talk 2013) However, the work and lounge space layout is only one of several unique configurations that Elemental provides.

8.2.1 Configurations



Fig 8.4 Various States of Elemental

Elemental offers nine distinct configurations that take into account what both users need. By separately transforming each hemisphere of the space into different functions, Elemental acts as two poles that can be engaged by users for the purpose of adapting the space around them.



Fig 8.5 Elemental Stowed Away

In the non-use case where users are not engaging with the product, it can shrink and reduce its size to allow for maximum space. Elemental can be moved and placed against a wall thus letting the circulation flow unhindered. This scenario would be ideal for parties and get-togethers where guests can have room to stand and mingle without obstruction. When both users are actively doing the same thing or where one partner is not present, the module can remain against one of the walls and use the rest of the space to serve the in-use function. For example if no work is to be done, it can function as a regular couch, or if only work is being done, then being placed against a wall will make for a more spacious work environment.



Fig 8.6 Sleep and Lounge

Responding to the need for a comfortable, private sleeping space that shelters the users from ambient disturbances, Elemental provides five distinct sleeping configurations. Each of the configurations takes into account what the other user is doing and what the spatial requirements are. Elemental is split down the middle, with each half providing an independent sleeping surface. When one user decides to sleep whilst the other is still active, then one half can be lowered and made into a bed. The most notable feature in this case is that the mass of the upright side of the bed acts as a barrier between the sleeping space and the active space with the mattress able to absorb the sounds of the other user as well as block out some disturbances, such as light to a certain degree. This barrier is important at establishing a strong sense of personal space.



Fig 8.7 Dual Sleeping Mode

Although Elemental provides users with personal individual sleeping arrangements, intimacy and connection between the users must still be maintained. This is where the dual sleep mode comes in. When both independent sleeping sides of the unit are engaged simultaneously, Elemental provides one single integrated sleeping surface where couples can sleep together and rekindle the intimacy and connection between them.

8.2.2 Product Engagement

Interacting with Elemental and transitioning between the different configurations is very simple. There are several integrated touchpoints on the module where users can get a hold and easily manipulate the parts to transform functions.



Fig 8.8 Touchpoints

The outer case overhangs the body of the bed frame providing a lip, which the user can hold. The lip conceals any release mechanism or the need for handles or latches to be visible providing a sleek, uniform and minimal aesthetic. Lowering the bed should be done with a simple hand movement, by pulling out and then down. The bed touchpoint could provide a hidden release mechanism that unlocks the bed and allows it to transition. The same release mechanism could release the bed legs to start rotating and lock after the bed has reached its final position.

In the non-use position, the desk can be stowed vertically. To engage the desk into active use, it can simply be lifted up and folded down. Once the desk is in work mode, it is stabilized, meaning when the bed is lowered, the desk will always remain level to the ground allowing for items on the desk to remain there during active use of the bed, no user involvement is needed in the stabilization of the workspace. To stow the desk away, the user simply lifts it up and slides it down, where it will lock itself into place and will remain in that position until the next time it is needed.

Lifting the edge of the seat case can raise the couch up. The couch will lock itself into place when fully raised and can be disengaged by simply pulling it back down. Unlike the desk, the couch requires user intervention to stow away before lowering the bed.

8.2.3 Mobility



Fig 8.9 Mobility Option for Elemental

For greater command of the space, Elemental should be moveable. In cases where both users are doing the same thing, for example sitting on the couch and watching TV together, having the unit in the middle of the space doesn't make sense. Elemental tries to address that issue by offering the option for mobility where the unit can be pushed freely across the space and can be propped against a wall. That way the room would become more spacious and open.

A retractable wheel system can be installed in the legs of the unit to offer the required manoeuvrability. The system can accommodate for the possibility of one single user operating and moving the module around alone, this is to conform to the brief's user independence requirement. Once a suitable location is picked, the wheels will retract back into the leg offering stability to the module.

8.3 Positioning

8.3.1 Functional Positioning



Fig 9.1 Functional Alternatives

When comparing the features of Elemental to other existing products on the market that can achieve similar functionality, there are three different tiers of products solutions available.

First is the standard furniture set, this is the cluster of products that usually have a single feature, which consumers purchase together with other furniture to achieve the functionality they require. In the case of Elemental, the standard furniture set a user would require is a bed, a sofa and a table to get comparable functionality. This tier of products has a large footprint and would need to occupy a sizeable amount of living space. Having separate standalone products, such as a bed and couch means that when multiple users are occupying the same space, their reliance on one another is significantly lower, where simultaneous use of the bed, the couch and the table is an option.

Second tier of products includes convertible furniture. It is furniture that can take on several functions by changing and transforming itself. This is the

cluster of furniture that consumers obtain when spatial limitations are an issue, thus trying to save space by having furniture that is multifunctional. A common example, the sofa bed, can be used in place of a standard couch and bed. It can transform between both a sofa and bed thus only taking up the place of one and reducing the footprint. Although convertible furniture can save a decent amount of space, often it is at the expense of personal independence. In multiple occupancy scenarios, where the different users want opposing things, one has to make a compromise, i.e. if one user wants to use the bed and the other wants to use the couch. This is because convertible furniture for the most part is absolute with its functions; it can be only one of its multiple states at a time, so in the sofa bed's case, it's either a bed or a sofa.

This is where Elemental comes in, it's in a tier where not only does the product adapt to the spatial needs but also the social and personal needs of individual users. It provides high space efficiency in a similar way as convertible furniture, by transforming itself to serve different functions, however unlike convertible furniture, it also provides transitionary middle states where it can exist as both the different functions simultaneously. The result is a tier of socio-spatially adaptable furniture that can provide independent use for multiple users of a space, yet maintain a small footprint.

8.3.2 Spatial Positioning



Fig 9.2 Layout Alternatives

The layout of a space plays a major role in the levels of privacy and communication within that space. Looking at different degrees of separation and boundaries in a space is useful to illustrate how Elemental would fit with other existing layouts.

With the use of standard furniture, having multiple rooms in a space is the ideal scenario to get a level of separation that provides the users with privacy and independence in a space. The furniture is separated physically based on their functional requirements giving them their own space and providing

users a maximum degree of privacy and independence through a physical barrier between the functions. However, this either requires a larger and more costly space or the need for some form of laborious construction.

In small spaces, having a wall between functions would just consume a large amount of the available room and make the space even smaller. In a typical open plan or studio apartment, the functional needs end up occupying the same space, such that with standard furniture, a user's bed, couch and work space are all in the same room. This provides the benefit of having an airy and seemingly bigger space than a multi-room flat of the same area. However, this layout comes at the sacrifice of privacy and individual comfort of the users.

What Elemental aims to do, is create a boundary to separate between possible functions and communicate where one function ends and the other begins, ensuring that users can have some personal liberty. The separation created may not be as effective as having a physical wall for blocking out sound, light and creating a different space, but it can convey different functional zones and individual boundaries. Elemental works as a middle ground solution, a spatial compromise between the heavy costs of construction for a separating wall and a space devoid of any boundaries.

8.4 Product Specifications

8.4.1 Dimensions



Fig 9.1 Dimensions of Elemental

At it's tallest, Elemental stands at a height of 95 centimetres from the ground. With an elevation that is a little shy of one meter, it is the perfect height for users to handle the unit, to engage the different functions it provides, and lift or move it around when need be.

To accommodate for the use of a standard mattress, as well as some of the components needed to articulate the motion, the length of the module is set to 210 centimetres. At it's most compact state, Elemental is only 52 centimetres wide, however, it can unfold to provide a double bed with a width of 160 centimetres that can easily accommodate two people together.

The depth of the couch when in use is 65 centimetres and provides a cushioned seating surface at an elevation of 40 centimetres. Standards were observed to provide maximum comfort for the users. (Neufert 2000)

The desk also abides by industry standard dimensions; it is 75 centimetres off the ground, running almost the length of the entire module with an ample depth of 45 centimetres to provide a suitable workspace to the users. When the desk is stabilized and lowered, it gives users a clearance of around 15 centimetres, which is plenty of room to fit a closed-screen laptop, books, paper work and other common items found on a desk.



8.4.2 Components

Fig 9.2 Explodometric of Components

Elemental consists of several components that come together to form each of the independent functions. The two bed halves are composed of identical parts, the bed frame holds together slats on which a standard single 80x200 mattress rests on. The frame also integrates folding bed legs, which come down when the bed is lowered. Covering the bed slats is a mesh screen, which hides the bed slats but still allows the mattress to ventilate from beneath. Tying the two bed halves together is the outer casing, which covers all the mechanical components and linkages and provides the touchpoints to manipulate the module.

Attached to the undercarriage of the bed halves are the workspace and the folding sofa components. The desk is placed with its backside secured in rail grooves in the bed slats. A support bar runs from edge to edge underneath the desk ensuring it stays level when in use or secure when stowed.

The couch is attached in a similar fashion as the desk, with rails that secure not only the couch but also the support bar. The bar acts as the support for the underside of the couch and also becomes the legs. The couch consists of a cushion placed into seat case that speaks the same form language as the outer case of the bed. Structurally holding up the unit is the chassis, which comprises of the mechanical components needed to fold and unfold each of the halves. It also houses a retractable wheel system (Up & Drop 2015) that allows for the mobility of the module.

8.4.3 Materials and Processes

Elemental uses natural materials such as wood for most the components, although process and application differ from part to part.

The bed frames are constructed in the traditional method, with four planks of wood attached together with screws. The frame is then kept rigid with the installation of the wooden slats, which then act like beams. The slats are fixed with screws and run lengthwise between the frame planks.

To support the bed in it's active position, wooden legs are fixed on the sides of the frame on a pivot point, which articulates in relation to the movement of the bed. Linkages between the support leg and the chassis can translate the motion of the bed frame to adjust the position of the support leg.

The bed can accept any standard single 80x200 mattress, for user ease and comfort. The mattress is kept in place with straps to ensure that it won't move during the transition between different functional states. A fabric mesh screen is wrapped on the underside of the bed to cover up the mattress and the slats as well as provide breathability to the mattress.

The outer case, the seat case and the desk involve bending wood to form the curved shapes required. To allow the wood to take the desired form, it goes through a wood lamination process. A veneer can be applied to the surface if required. Additional structural support is added between the seat cushion and the case to support the load when in use.

The support bars utilize steel tubing, which could be bent using a tube roller, to form the desired curves needed. Bending is followed by the addition of a powdered coat for aesthetic finishing as well as providing an extra layer of protection to the steel.

The chassis needs to handle all the static and dynamic loads that the module would exert. It is a combination of wooden parts reinforced with steel plates. Joints and connections to moving parts can be found attached to the sides of the chassis, which provide the articulated movement of the individual bed frames.



Fig 9.3 Up & Drop concealed wheel system

The legs contain a retractable wheel mechanism, which provides mobility when the need to transport the module arises. The stability of the module is kept in mind during moves, so the wheels can only be engaged with the user's intervention and presence. When the user lets go, the wheels disengage and retract. The module is then propped down on the legs, which would provide the rigidity and stability to keep it upright and functional. The Up & Drop system illustrates how a retractable wheel system could work. The system can be installed and concealed in the existing leg design to maintain the overall aesthetic of the unit.





Fig 9.4 Illustration of Dynamic Systems

There are three conceptualized dynamic systems that govern the movement of the bed frames, desk and the seating. The system uses a series of pivot points and rails to articulate the necessary motion of each of the parts.

The desk uses a pivot point on a rail that's attached to the bed frame allowing it to slide down and rotate into position, the support bar is fixed in place to

ensure the correct angle and height of the desk whilst it rotates. Whilst stowed, the desk can lock into the closed position, however when in active use, the motion of the desk should be linked to the motion of the bed frame to stabilize the desk without any user intervention.



Fig 9.5 Desk Motion

The bed frame uses an h-rail system to fold down and up, where each side of the frame has a pivot point attached to either the straight or the curved part of the h-rail, moving in unison to achieve the desired articulation. The motion should be dependent on the user's engagement of the touchpoint on the lip of the outer casing. What that entails is that the bed is locked in position and only releases through conscious user engagement.

Additionally, legs attached to the sides of the bedframe are connected to a pivot point that releases when the bed starts to move, gravity acts on the leg to keep it perpendicular to the ground. Once the leg reaches the final position it can lock into place and release once the bed is lifted up again.



Fig 9.6 Bed Motion

The seating and support bar work together to create a scissor system, where the motion of one impacts the motion of the other. This system contains three rails and three pivot points on each side. Two rails are placed on the bed frame, with the top rail connected to a pivot point on the support bar and the bottom rail to a pivot point on the seating frame. There is also a rail attached to each side of the seating which channels a pivot point on the support bar. The system should be able to lock into place when lifted up and stowed until the user can engage it to lower it and vice versa.



Fig 9.7 Couch Motion

8.5 Evaluation

To determine if the final product is a viable intervention and meets the requirements of the brief it will be evaluated on spatial efficiency, adoption of boundaries, adaptability to multi-user needs and the cost for intervention.

Elemental was comparatively evaluated alongside other intervention options available. The contenders were: a standard furniture set, convertible furniture and dynamic spaces.

			Standard Furniture	Convertible Furniture	Dynamic Spaces	Elemental
	x1	Spatial Efficiency	Low (1)	Medium (2)	High (3)	High (3)
±	x1	Boundaries	Low (1)	Medium (2)	High (3)	Medium (2)
eig	x1	Independence	Medium (2)	Low (1)	High (3)	High (3)
Š	x1	Cost	Medium (2)	Low (3)	High (1)	Medium (2)
	x1	Permenence	Medium (2)	Low (3)	High (1)	Low (3)
		Weighted Total	8	11	11	13
		Score (%)	53.3	73.3	73.3	86.7

Fig	10.1	Comparativ	e Evaluation

8.5.1 Spatial Efficiency

Elemental is quite space efficient when compared to a standard furniture sets as it doesn't require a large single footprint for all the furniture in the set. Standard furniture is always present taking up space whether it's being used or not, but by compacting a bed, a sofa and a desk into one unit, Elemental can free up a significant amount of room.

When compared to Dynamic Spaces such as the six in one New York apartment (fig 3.1), Elemental's spatial efficiency drops. Dynamic Spaces integrate furniture into the walls practically having almost no wasted space,

where as with Elemental, even in it's most compact form, it still takes up some space with no added functional value.

Convertible furniture is quite similar to Elemental in terms of spatial efficiency, however, Elemental has a competitive advantage in that it combines a third function into the module as opposed to standard sofa bed which only pack two functions and that it can compact itself into a non-use unit which takes up even less space.

8.5.2 Boundaries and Divisiveness

This is to gauge the level of functional separation that a solution can provide. Boundaries are important to separate different uses and establish a level of privacy as well as establish a sphere of influence, which can adhere to different functional needs.

Current standard furniture sets, when placed in an open space provide almost no boundaries or divisiveness between the functions, however, the layout of the space can hugely influence the degree of division even though the furniture itself provides no division.

Convertible furniture provides a high level of division for functionalities. It can transform the characteristics of the space when it transforms itself. However, with convertible furniture, the space can be either one function or the other, the boundary isn't set to create a borderline between two separate spaces but to completely alternate between two different functionalities.

Dynamic spaces take it a step further by providing both a boundary between two functional spaces as well as a boundary to alternate functionality. They achieve this with integrated transformable furniture, and a mobile wall system to give users privacy of use as well as communicate spatial separation when the need arises.

Elemental on the other hand follows a product approach to dynamic spaces; it consolidates transformable furniture and dynamic division of functions, which creates multiple separate functional zones. This approach is a step above standard furniture sets and convertible furniture as they provide a degree of divisiveness, however, the divisions aren't as prominent or clear-cut as in dynamic spaces.

8.5.3 Multi-User Independence

The ability of an intervention to give each user a level of personal independence when in use is important for multiple people occupying a space. It allows for greater self-reliance and better cohesion between the occupying parties.

Standard furniture is adequate at providing an individual user experience, the disjointed functionality means users can go to and use any function independent of the other users, provided that the functionality can accommodate peak usage.

Convertible furniture completely sacrifices user independence for spatial efficiency. Since the furniture can be either one of multiple states, users must rely on each other's needs to be able to use it. It does not provide an alternative for users that want different things at the same time.

Dynamic spaces depend a lot on the layout and the design of the space, however, with a moving wall system and a hard separation of the functions, it provides the convenience and independence of larger multi-room apartment.

What Elemental does is take each of the functionalities and enables them to be used independently or in tandem. It provides a product approach to a dynamic space, giving complete control and personal independence to the users.

8.5.4 Cost of Intervention

Any intervention to a space would incur a cost to both the user and the space. For the user it takes into consideration the financial and logistical cost of implementation. As for the space, the relative permanence of an intervention is vital to gauge as a disproportionate amount of respondents were renters. (80%)

The cost of standard furniture, both financial and relative permanence was set as a benchmark to measure the other intervention solutions. Standard furniture is readily available and it means that it can be found a low price, however, multiple pieces have to be taken into consideration to perform a similar overall function as the other interventions. With convertible furniture, less furniture is needed thus incurring a lower cost on the users. In terms of logistical cost, the small form factor means transportation would be easier. Ease of transportation would also mean a lower permanence as it can be moved out with very little hassle.

Dynamic spaces require tailor-made furniture and mobility systems as every apartment layout can vastly differ. This means, financially, it will be a very expensive intervention solution. Also, dynamic spaces need major construction to be put into place and this makes the solution highly permanent in a space.

With a similar size to convertible furniture, Elemental can be easily transported into and out of living spaces making it have a low permanence. This also translates to low logistics costs for users to bring it into the space. The module itself would be more expensive than convertible furniture as it houses more specialized dynamic systems, and more expensive than standard furniture as it is not readily available. However, it will be significantly much cheaper than the cost of implementing dynamic spaces, as it will not require any construction or custom tailoring to a space.

8.5.5 The Verdict

Overall, Elemental performed well in relation to other competitors. It excelled in spatial efficiency and multi-user independence. Elemental provides an affordable and temporary alternative to dynamic spaces, more functional and adaptive to use than convertible furniture, all in a compact and space conscious module that occupies a fraction of the space any standard furniture would occupy.
9. Conclusion

9.1 Summary

Through the study and exploration of the various aspects of living spaces, issues were uncovered regarding spatial limitations, definition of boundaries and user independence in shared living spaces.

During the course of the research, two root causes were unearthed. One of which was the organization of a space and entailed the order, efficiency and the management of the space. Specifically, Spatial limitations, which became a prominent issue when the spatial area was used as a control and additional occupants incrementally added. With every additional occupancy scenario, a sacrifice of some sort was made to better adapt the space to fit the presence of more occupants.

Second root cause was communication, which involved the integration of the users to the space as well as establishing a level of personal liberty, independence, privacy and defined boundaries. When looking at individual occupants transitioning to share living space with a significant other, the synergistic and symbiotic relationship of the two allows them to live more efficiently, but communication is key. Couples experience a level of interdependence on each other, as they have to adapt to use the same functional elements of the household.

Taking into account all the uncovered insights, the objective was to develop a socio-spatial intervention for couples sharing a living space that would deal with spatial limitations of the space, define personal and functional boundaries, as well as reclaim user liberties and independence.

9.2 Result

The result was the development of Elemental, a modular, ultra-configurable compact living node made for multiple users in mind. The module possesses the ability to define the space it's placed in through its ability to morph and transform to serve different functions and respond to user needs.

What Elemental does is combine the functionality of a bedroom and a living room into one single unit that takes up a fraction of the footprint of any standard furniture set. It also restores a workspace, a functionality that was previously sacrificed in a shared couple's space.

What sets Elemental apart is it's ability to simultaneously operate all it's functions at once giving users a high level of independence when in use. The body of the module acts as a divider between the active functionalities to communicate and set forth boundaries.

Overall, when compared to alternative interventions, Elemental can be seen as an affordable and temporary alternative to dynamic spaces, more functional and adaptive to use than convertible furniture, compacted into a small and space conscious module that occupies a fraction of the space any standard furniture would occupy.

9.3 Further Development

This paper aimed at answering 'why' a product intervention was needed and propose a conceptualized solution, but to properly answer 'how' to make it a reality, further research and development is needed.

The simplified properties of the systems involved in the module are outlined, but further specialized research has to be done to determine the different types of mechanical components needed and to develop them to a stage where they can be produced and implemented in the design.

Aside from engineering research, further branding development and strategic business planning has to occur to create a viable product that is ready for the market.

References

- Cross, Nigel. Engineering Design Methods Strategies for Product Design. 4th Edition. 2000.
- Davis, Heather A. *How the sofa changed the world*. 2009. http://www.upenn.edu/pennnews/current/node/4079 (accessed May 2015).
- De Castro, Jessy Belle. *Kenchikukagu Folding Furniture*. 2013. http://www.ippinka.com/blog/kenchikukagu-folding-furniture/ (accessed May 2015).
- Design Council. *The Design Process: What is the Double Diamond?* 2015. http://www.designcouncil.org.uk/news-opinion/design-processwhat-double-diamond (accessed May 2015).
- Dictionary.com. *Element*. 2015. http://dictionary.reference.com/browse/element (accessed May 2015).
- Dirksen, Kirsten. 6 rooms into 1: morphing apartment packs 1100 sq ft into 420. 2012. http://faircompanies.com/videos/view/6-rooms-into-1-morphing-apartment-packs-1100-sq-ft-into-420/ (accessed May 2015).
- Eesti Statistika. *Eesti Statistika Kvartalikiri. 4/12. Quarterly Bulletin of Statistics Estonia.* 2012. http://www.stat.ee/dokumendid/67470 (accessed May 2015).
- Giang, Vivian. *Why Having A Messy Desk Can Be A Good Thing*. 2013. http://www.businessinsider.com/benefits-of-having-a-messy-or-cleandesk-study-university-of-minnesota-2013-8 (accessed May 2015).
- Grcic, Konstantin. *Hack. Vitra at the Orgatec office furniture fair 2014.* 2014. http://www.vitra.com/en-un/magazine/details/orgatec-2014 (accessed May 2015).
- Ikea. Ikea Sofa Beds. 2015. http://www.ikea.com/us/en/catalog/categories/departments/living_ro om/10663/ (accessed May 2015).

- Jäll & Tofta. *Rocky*. 2010. http://www.jaellundtofta.de/eng/content/rocky (accessed May 2015).
- Lester, Stan. An introduction to phenomenological research. 1999. https://www.rgs.org/NR/rdonlyres/F50603E0-41AF-4B15-9C84-BA7E4DE8CB4F/0/Seaweedphenomenologyresearch.pdf (accessed May 2015).
- Logerot, Aïssa. madame est servie. 2009. http://www.aissalogerot.com/#/projects/madame-est-servie/ (accessed May 2015).
- Lott, Tim. Are separate beds the key to a good night's sleep? 2013. http://www.theguardian.com/lifeandstyle/2013/jun/08/separate-beds-key-good-sleep (accessed May 2015).
- Lynch, Kevin. The Image of the City. 1960.
- Maslow, A.H. "A Theory Of Human Motivation." *Psychological Review* 50, 1943.
- Neufert, Ernst Neufert & Peter. *Architects' Data*. 3rd Edition. Blackwell Science, 2000.
- Noticias Arquitectura. *CHK (CONTAINER HOME KIT), LOT-EK*. 2006. http://www.noticiasarquitectura.info/especiales/chk-lot-ek.htm (accessed May 2015).
- Peters, Brandon. *The Importance of Your Sleep Environment*. 2014. http://sleepdisorders.about.com/od/howcanisleepbetter/a/The-Importance-Of-Your-Sleep-Environment.htm (accessed May 2015).
- Pomfret, James. Architect reinvents apartment to solve space crunch. 2010. http://www.reuters.com/article/2010/02/08/us-hongkong-flat-idUSTRE6170V420100208 (accessed May 2015).
- Porterfield, Elaine. *Now Americans Are Going Crazy About Tiny 'Micro' Apartment*. 2013. http://www.businessinsider.com/micro-apartments-2013-6 (accessed May 2015).
- Sevaldson, Birger. "Giga-mapping: Visualisation For Complexity And Systems Thinking In Design." *Helsinki: Nordic Design Research Conference*, 2011.
- Studybed.co.uk. *Studybed*. 2011. http://www.studybed.co.uk/ (accessed May 2015).
- Team Office Talk. *How to Choose the Right Walls for Your Workplace*. 2013. https://teamofficetalk.wordpress.com/2013/02/14/tall-walls-short-walls-or-no-walls-whats-right-for-your-workplace/ (accessed May 2015).
- Up & Drop. Concealed wheeled furniture carrying systems. 2015. http://www.updrop.com.tr/ (accessed May 2015).

• Wagner, Mindy. *Why Mood Boards Matter*. 2008. http://www.webdesignerdepot.com/2008/12/why-mood-boardsmatter/ (accessed May 2015).

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Appendixes

Appendix I



Appendix II



Appendix III





Appendix IV



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