MULTIFUNCTIONAL FURNITURE FOR UNDERPRIVILEGED COMMUNITIES: A MILESTONE IN SUSTAINABLE DEVELOPMENT

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MULTIFUNCTIONAL FURNITURE FOR UNDERPRIVILEGED COMMUNITIES:
A MILESTONE IN SUSTAINABLE DEVELOPMENT

A Thesis
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of
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by
Farah Nasser

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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>LIST OF FIGURES</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>vii</td>
</tr>
<tr>
<td>LIST OF ABBREVIATIONS</td>
<td>xi</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>xii</td>
</tr>
<tr>
<td>CHAPTER 1. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>1.1 Statement of the Problem</td>
<td>1</td>
</tr>
<tr>
<td>1.3 Research Question</td>
<td>2</td>
</tr>
<tr>
<td>1.4 Scope</td>
<td>2</td>
</tr>
<tr>
<td>1.5 Significance of the Problem</td>
<td>4</td>
</tr>
<tr>
<td>1.6 Definitions</td>
<td>4</td>
</tr>
<tr>
<td>1.7 Assumptions</td>
<td>5</td>
</tr>
<tr>
<td>1.9 Delimitations</td>
<td>7</td>
</tr>
<tr>
<td>1.10 Chapter Summary</td>
<td>7</td>
</tr>
<tr>
<td>CHAPTER 2. LITERATURE REVIEW</td>
<td>9</td>
</tr>
<tr>
<td>2.1 Psychological Approach: Improving Livelihood Conditions for People in Underprivileged Communities</td>
<td>12</td>
</tr>
<tr>
<td>2.1.1 Community Involvement</td>
<td>15</td>
</tr>
<tr>
<td>2.2 Furniture Design</td>
<td>19</td>
</tr>
</tbody>
</table>
2.2.1 Programming for Furniture ................................................................. 19

2.2.2 Furniture Design Methodology ........................................................... 20

2.3 Multifunctional Space-Saving Furniture .................................................. 24

2.3.1 Historical Context ................................................................................. 25

2.4 Sustainability ............................................................................................ 29

2.4.1 Materials ............................................................................................... 29

CHAPTER 3. METHODOLOGY ........................................................................ 44

3.1 Framework ............................................................................................... 44

3.2 Perspective ................................................................................................ 45

3.3 Sample Approach ..................................................................................... 45

3.4 Data ........................................................................................................... 46

CHAPTER 4. PRESENTATION OF DATA & FINDINGS .................................. 48

4.1 Interviews .................................................................................................. 48

4.2 Existing Conditions .................................................................................. 52

4.3 Furniture Prototype and Features ............................................................. 61

4.3.1 Specifications ....................................................................................... 61

4.3.2 Design Prototype .................................................................................. 61

4.4 Manufacturing Processes ........................................................................ 63

4.5 Furniture Prototype in Existing Floor Plans ............................................ 65

CHAPTER 5. CONCLUSIONS, DISCUSSION & RECOMMENDATIONS ....... 72

5.1 Case Study: Jordan .................................................................................. 72

5.1.1 Features ................................................................................................ 73

5.2 Recommendations .................................................................................... 76
5.3 Conclusion .............................................................................................................. 78

LIST OF REFERENCES ................................................................................................. 79

APPENDICES

Appendix A: .................................................................................................................. 87

Appendix B: ..................................................................................................................... 91

Appendix C: ..................................................................................................................... 94

Appendix D: ..................................................................................................................... 95
LIST OF TABLES

Table 4.1 Wood Material Schedule ................................................................. 62
Table A.2 Conversion Table ............................................................................ 94
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 2.1 Housing and Family Well-being</td>
<td>13</td>
</tr>
<tr>
<td>Figure 2.2 Brick Making in Mutare, Zimbabwe</td>
<td>17</td>
</tr>
<tr>
<td>Figure 2.3 Programming has six distinct steps that are sequential</td>
<td>20</td>
</tr>
<tr>
<td>Figure 2.4 Anthropometrics: Body Measurements</td>
<td>23</td>
</tr>
<tr>
<td>Figure 2.5 Wooden Chest</td>
<td>25</td>
</tr>
<tr>
<td>Figure 2.6 Drop Arm Sofa</td>
<td>26</td>
</tr>
<tr>
<td>Figure 2.7 Military Camp Day-bed</td>
<td>26</td>
</tr>
<tr>
<td>Figure 2.8 Murphy Bed—plan view</td>
<td>27</td>
</tr>
<tr>
<td>Figure 2.9 Murphy Bed—perspective view</td>
<td>28</td>
</tr>
<tr>
<td>Figure 2.10 Hybrid Poplar</td>
<td>32</td>
</tr>
<tr>
<td>Figure 2.11 Community Reforestation Project - Bamiyan, Afghanistan</td>
<td>33</td>
</tr>
<tr>
<td>Figure 2.12 Growth Pattern of Poplar Trees in British Columbia</td>
<td>34</td>
</tr>
<tr>
<td>Figure 2.13 15-Year-Old Kawa Poplar Tree in New Zealand</td>
<td>35</td>
</tr>
<tr>
<td>Figure 2.14 Door and Dresser Made Out of Poplar Wood</td>
<td>36</td>
</tr>
<tr>
<td>Figure 2.15 Poplar Working Properties</td>
<td>37</td>
</tr>
<tr>
<td>Figure 2.16 Example Grades</td>
<td>37</td>
</tr>
<tr>
<td>Figure 2.17 Nail Size Chart</td>
<td>39</td>
</tr>
<tr>
<td>Figure 2.18 Narrow Butt Hinges</td>
<td>40</td>
</tr>
</tbody>
</table>
Figure 2.19 Hardware VELCRO Hook & Loop ......................................................... 40

Figure 2.20 Wood Adhesive ...................................................................................... 41

Figure 2.21 Wipe- on Polyurethane Wood Finish .................................................... 41

Figure 2.22 Sanded Plywood .................................................................................... 42

Figure 2.23 Medium Density Fiberboard (MDF) Core ............................................. 43

Figure 4.1 Space-Usage Needs .................................................................................. 52

Figure 4.2 Home #1 Floor Plan .............................................................................. 53

Figure 4.3 Home #1 Perspective 3D Rendering ....................................................... 53

Figure 4.4 Home #2 Floor Plan ................................................................................ 54

Figure 4.5 Home #2 Perspective 3D Rendering ....................................................... 54

Figure 4.6 Home #3 Floor Plan ................................................................................ 55

Figure 4.7 Home #3 Perspective 3D Rendering ....................................................... 55

Figure 4.8 Home #4 Floor Plan ................................................................................ 56

Figure 4.9 Home #4 Perspective 3D Rendering ....................................................... 56

Figure 4.10 Home #5 Floor Plan .............................................................................. 57

Figure 4.11 Home #5 Perspective 3D Rendering ....................................................... 57

Figure 4.12 Home #6 Floor Plan .............................................................................. 58

Figure 4.13 Home #6 Perspective 3D Rendering ....................................................... 58

Figure 4.14 Sleeping/ Tabular Unit Plan View .......................................................... 59

Figure 4.15 Sleeping/Tabular Unit Section Cut ........................................................ 60

Figure 4.16 Storage/Seating Unit ............................................................................. 60

Figure 4.17 House # 1 with the Space Buster ......................................................... 65

Figure 4.18 House # 2 with the Space Buster ......................................................... 66
Figure 4.19 House # 3 with the Space Buster .......................................................... 67
Figure 4.20 House # 4 with the Space Buster .......................................................... 68
Figure 4.21 House # 5 with the Space Buster .......................................................... 69
Figure 4.22 House # 6 with the Space Buster .......................................................... 70
Figure 4.23 House # 4 – Table by Day, Beds by night .......................................... 71
Figure 5.1 Renderings of the Different Uses and Applications.................................. 73
Figure 5.2 Storage Unit (vertical/ horizontal)/Seating (bench/ tall stool)............... 74
Figure 5.3 Tabular Unit - Dining Table................................................................. 74
Figure 5.4 Sleeping Unit......................................................................................... 75
Figure 5.5 Tabular Unit - Coffee Table................................................................. 75
Appendix Figures

Figure A.1 Women’s Focus Group ................................................................. 87
Figure A.2 Bathtub Used for Storage ............................................................. 88
Figure A.3 Bedroom in Existing Home .......................................................... 89
Figure A.4 Kitchen in Existing Home ............................................................ 89
Figure A.5 Shelving Unit in Existing Home .................................................... 90
Figure A.6 Furniture Specification Cut-sheet (Front) ....................................... 92
Figure A.7 Furniture Specification Cut-sheet (Back) ....................................... 93
LIST OF ABBREVIATIONS

GEP: Global Engineering Program
BIM: Building Information Modeling
UNDP: United Nations Development Program
NGO: Non-Governmental Organization
MDF: Medium Density Fiberboard
MC: Moisture Content
ABSTRACT


Overcrowded living space is a contributing factor to the social and economic problems in impoverished areas such as Jabal Al-Natheef refugee camp in Jordan. Addressing such a convoluted problem requires long-term planning and availability of resources. However, initiation of small projects to target pain points, employing technologies such as Building Information Modeling (BIM) to design solutions, and empowering the people to implement them could alleviate the impact of poverty. Giving the stakeholders the ability to build and reproduce the designed solutions will help communities grow by allowing individuals to provide for themselves. This will also create jobs and sets the stage for sustainable development.

This project is based on a field study initiated by Purdue University Global Engineering Program in collaboration with the School of Technology. This project illustrates the need and capability of multifunctional furniture design features in order to maximize space usage and improve the livelihood conditions of people living in underprivileged communities. The author designed a furniture piece which serves as a tabular unit, storage and seating units, as well as sleeping units based on the need and
time of day. The design criteria should achieve easy-to-implement and aesthetically-pleasing modular pieces of furniture. To facilitate a manufacturing process led by the locals, furniture design specifications, prototype diagrams, and clear graphics were produced. Options for raw material were described based on market availability and source of imported wood. Moreover, a potential forestation program that takes advantage of the fast growing poplar trees was examined to create a local timber industry in the long-term. The designs addressed common requirements of many families who had been interviewed in Jabal Al-Natheef. Floor plans of six of these families’ homes were presented with 3-D rendering perspectives using AutoCAD, Google Sketchup, and Revit modeling software. This thesis addressed one specific problem in the overcrowded and poorly facilitated environment of Jabal Al-Natheef; however, there were many other challenges that required urgent attention. Hence, there was room for many more similar efforts as per the recommendations for further studies and future research projects.
CHAPTER 1. INTRODUCTION

1.1 Statement of the Problem

Poverty stricken communities make up a great part of the world today. In Poverty facts and stats, Shah, A. (2013) mentioned that out of 2.2 billion children in the world under the age of five, 1 billion live in poverty, and UNICEF estimates that 22,000 children per day are dying due to poverty in deprived and neglected villages. Moreover, 640 million of those children are without adequate shelter, and many of those who have shelter are deprived ample utilities and facilities in overcrowded accommodations.

The major initiator for this research was the author’s involvement with the Global Engineering Program (GEP) at Purdue University. GEP’s mission is to bring together students from different disciplines to work in collaboration with Non-Governmental Organizations (NGO) worldwide in order to help make a difference in less fortunate communities. In fall of 2011 a representative from Ruwwad, an NGO in Jabal Al Natheef, Jordan, visited Purdue University to propose a project idea and recruit someone from GEP for the study. The specific purpose of this research was to answer the question, “can sustainably developed multifunctional furniture benefit underprivileged communities?” This project surveyed the needs of people with very few resources and living in overcrowded spaces. Since this was an issue that affected many people around the world,
obtaining an understanding of the necessities that they lacked, while keeping the concept of sustainable development in mind, was imperative.

1.3 Research Question

How can sustainably developed multifunctional furniture benefit underprivileged communities?

1.4 Scope

The objective of this thesis was to create a design for feasible and sustainable multi-functional furniture that can transform a living space based on the need and time of the day. However, the scope of work on such a project went beyond planning and designing different aspects of concern. Dealing with such a convoluted environment whose elements were poverty, overcrowded living space, and lack of available material and financial resources, required innovative work methods in order to lead the project in the right direction. Sustainable furniture design might increase the efficacy of living space utilization, while likely giving the people a sense of self-worth to encourage them to build the furniture themselves with the limited resources available. And as a result, poverty stricken areas could hopefully prosper in a better living environment.

The initial stage of conducting such work was to study the environment and people at hand. According to the Online Merriam-Webster’s dictionary, the environment was defined as “The circumstances, objects, or conditions by which one is surrounded,” and “The aggregate of social and cultural conditions that influence the life of an individual or community” (Environment - Definition and More from the Free Merriam-
So, the step of studying the elements comprising the environment gave a clear indication and, therefore, more concise definition of the problem. This was essential, since underprivileged communities had special considerations stemming from the social and cultural circumstances, the limitations, and the constraints that must be taken into account during the course of the project. In such locations, it was inconclusive to work on solving the technical issues without bearing in mind the implications of social and economic situation present.

For that reason, a multidisciplinary approach was an essential way of securing the linkages between all project components. To eliminate deficient end results, taking the opinions of people in underprivileged communities helped develop the project based on their targeted needs and created a link between the people and their providers. Involving the community in the process would clarify their requests, and proposed solutions that yield greater impact could be studied accordingly.

Several factors needed to be accounted for prior to the design phase.

- The materials chosen must be readily available and durable enough to withstand wear and tear, as well as local weather conditions.
- Cost was a major determining factor; implementation of the final product should fit the low budget of the consumer, and should be reproducible and assembled locally to stimulate the local economy.
- Surplus production of these pieces could be marked for export to neighboring countries that suffer from similar living conditions.
- Aim to concoct aesthetically pleasing pieces.
1.5 Significance of the Problem

The design of feasible, multi-functional furniture could be utilized in small living spaces in underprivileged communities worldwide. This will be used in the communities to reduce, and hopefully eliminate, tribulations resulting from poor living conditions. Not only does the furniture help the living conditions in these poverty stricken environments, but it also might help to empower these communities. The designs would be easy to implement. Someone with little or no background in construction would be presented with clear step-by-step graphics and directions of how to assemble the pieces. The adopted approach in this project might be applicable to any impoverished community. Not only would it provide design blueprints, but it could help build local expertise in any part of the developing countries. Building and selling this advantageous, useful, widely used furniture could create job opportunities and can turn into a community effort. As Lao Tzu stated in the Chinese proverb, “Give a man a fish and you feed him for a day. Teach a man to fish and you feed him for a lifetime.” Encouraging the people to provide for and benefit from each other was one step closer to a better society. It could create an economic model of supply and demand of products and services that stimulates the local economies.

1.6 Definitions

BIM: Building Information Modeling is an innovative technology used to better manage projects in the AEC industries. It has a very high average of cost return, therefore giving users high economic benefit. In addition to the economic profit, it avoids a lot of down time that result from issues arising due to system conflicts. This down
time that’s avoided is very significant when looking at the project as a whole. (Azhar, Hein, and Sketo, 2010).

Cradle – to – Cradle: “The cradle-to-cradle approach to design was developed by William McDonough, a notable architect in sustainable buildings, and chemist Michael Braungart in 2002. It is a method used to minimize the environmental impact of products by employing sustainable production, operation, and disposal practices and aims to incorporate social responsibility into product development” (Cradle-to-Cradle, 2012, para. 1).

Sustainable Harvesting: “A method of harvesting or using a resource so that the resource is not depleted or permanently damaged” (Sustainable - Definition and More from the Free Merriam-Webster Dictionary, n.d.).

UNDP: “Since 1966, the United Nations Development Program (UNDP) has been partnering with people at all levels of society to help build nations that can withstand crisis and drive and sustain the kind of growth that improves the quality of life for everyone. UNDP works in four main areas: poverty reduction and achieving the Millennium Development Goals (MDGs); democratic governance; crisis prevention and recovery; environment and sustainable development” (Overview | UNDP, n.d.).

1.7 Assumptions

The assumptions for the project include the following:
• The volunteers interviewed during the author’s visit to Jordan answered the questions truthfully.

• The author anticipated that people of Jabal Al-Natheef would be cooperative in allowing them into their homes to make observations.

• The author anticipated a wide range of answers when asking people what they believe that they needed.

• The homes visited in Jabal Al-Natheef are closely indicative of the physical conditions of homes in similar underprivileged communities.

• The furniture manufacturing production will prefer to utilize the most economical locally available wood based resources.

1.8 Limitations

The design attribute of this study was limited to the author’s observations during the site visit to Jabal Al-Natheef, Jordan in March of 2012. The limitations for the project included:

• Analyzing the exact needs of people in underprivileged communities
  - Conducted at least 5 interviews with people living in Jabal Al Natheef refugee camp
  - Gathered in focus groups with adults and youth to discuss space problems faced in the home
  - Combined the ideas that were brought forward in the focus groups and interviews to create a possible solution

• Rendered furniture units by hand to present ideas to the clients
• Presented preliminary sketches to the funders at ARAMEX in Amman, Jordan for approval

• Use of BIM software to model the final product
  - AutoCAD
  - Revit Architecture
  - Google SketchUp

1.9 Delimitations

The delimitations for the project included:

• Due to the limited resources of wood available in Jordan currently, the use of imported wood from neighboring states might be imperative in the initial project stage.

• Building a life scale model of the proposed furniture piece—this could only be done once the funds are provided by ARAMEX.

• Observation of product use after it was designed and manufactured.

• Restriction of insertion of furniture into actual physical environment due to circumstantial changes after the data was collected.

1.10 Chapter Summary

The intention behind these efforts was to improve interior space usage, and therefore, in doing so, possibly create healthier, more prosperous environments in underprivileged communities. Providing new furniture design ideas that could be
customized for the individual needs would optimize space utilization. The designs would also generate local job opportunities to build, sell, and service the products. By leading the community to be engaged in catering for its own needs, this aspiration to reach a more comprehensive goal for improving the livelihood condition of these people could be achieved. The need for jobs and practical, creative, cost effective, environmentally friendly, and aesthetically pleasing designs for improving common spaces could benefit countless communities with such necessities. Therefore, this project was a case study that can be propagated to other impoverished communities throughout the region.
CHAPTER 2. LITERATURE REVIEW

The outcome of the escalating cost of living, deeply rooted poverty, and the hunger epidemic strike many parts of the world today. People living in underprivileged communities face the world with a different perspective. A Human Development Report published by the United Nations Development Program (UNDP) stated that three out of four people were living on less than US$1 a day in rural areas. Rural areas are parts of a country that are not urban. For the purpose of this thesis, anything outside of the traffic of a city was considered rural. In order to seemingly improve their economic status, poor people moved from rural to urban areas. As a result, a vast majority of the world’s urban cities had slum-like subsections due to their dense population of poor people and lack of upkeep from the government. Slums leave the inhabitants without clean water, sanitation, suitable shelter, and safety. (2012 World Hunger and Poverty Facts and Statistics by World Hunger Education Service, n.d.)

In What Are Slums and Why Do They Exist? The United Nations Habitat stresses the need to improve and recover the livelihood conditions of the approximately one billion that reside in slums today. However, in order to do so, governments, international aid agencies, community based organizations, and non-governmental organizations (NGOs) involved in facing the slum challenge must first understand what slums really were and how to approach such environments. “Today, slums have come to include the
vast informal settlements that are quickly becoming the most visible manifestation of urban poverty in developing world cities. Such settlements are known by many different names and are characterized by a variety of tenure arrangements. In all cases, however, the buildings found there vary from the simplest shack to permanent and sometimes surprisingly well-maintained structures, but what most slums share in common is a lack of clean water, electricity, sanitation and other basic services” (UN-Habitat, 2007).

While their day to day struggles might vary, people living in these underprivileged communities’ are mainly concerned with finding the means necessary to survive in this world today. Knowing that these communities existed in many countries in every continent was an indication that it was not a trivial issue. The complexity of this situation lied in its global magnitude; however, there might be many commonalities irrespective of the geographical locations. These communities were victims of economic constraints and scarcity of allotted funds, definition of clear objectives and phased long term policies, and the social and physical limitations associated with every region. (Mullick, 1994). A holistic view of this convoluted multifaceted problem mandated the necessity to break it up into components that were understandable and manageable. While some of these components required involvement at a United Nations or local government level, the role of civil organizations and NGOs should not be undermined. Most governments with a good social security system provided medical care, food subsidies, and education to the needy. However, only very few countries, like Australia whose federal Department of Housing and states’ Housing Commission entitled every needy family to a standard size dwelling composed of enough rooms to house the entire family (Working environment, 2013). So, those government-built dwellings were
scattered throughout all suburbs to avoid social isolation of the needy. While this might be desirable, it was the exception rather than the rule. And, rather than waiting for a comprehensive solution to be devised, smaller scale solutions could be adopted. Hence, the importance of targeted efforts that addressed immediate needs of local impoverished communities. This could be more effective because the work would be based on scenarios that focused the designed solutions on inhabitants’ requirements. Such scenarios should understand the social limitations (competency level of implementers) and the physical limitations (living space boundaries were predefined.) For example, when designing furniture for an explicit circumstance, it was critical to narrow down and, eventually, bridge the gap between the design and implementation phase. Scenario oriented design achieved this by tailoring designs to become well suited to the particular situation present which was a prerequisite for a successful implementation.

Carroll (2007) addressed several factors associated with this concept. “Scenarios are at once concrete and flexible, helping developers manage the fluidity of design situations. Carroll (2007) also stated that “Scenarios can also be abstracted and categorized, helping designers to recognize, capture and reuse generalizations and to address the challenge that technical knowledge often lags the needs of technical design. Finally, scenarios promote work-oriented communication among stakeholders, helping to make design activities more accessible to the great variety of expertise that can contribute to design, and addressing the challenge that external constraints designers and clients face often distract attention from the needs and concerns of the people who will use the technology” (Carroll, Five reasons for scenario-based design, 2007).
Synonymous connotations derived from the word scenario were scheme, plan, concept, and sketch. Therefore, scenario oriented design could be further defined as conceptual planning based on context.

Thus, in order to accomplish this, one must learn and understand the consumer market of the final product before any design could be implemented. Taking into consideration that the areas being explored consist of neglected refugees, it was important to understand their mindset and possible reaction to change. People might fear change or not accept invasion of their privacy. All these factors were imperative. In addition, given that this product will be locally made, people’s involvement would be vital. Recognizing the importance of accurately approaching these communities was directly tied to the success of the work.

2.1 Psychological Approach: Improving Livelihood Conditions for People in Underprivileged Communities

The interactions of people in the real world, whether at home, work or at school, were dependent on their surroundings. This could range from the quality of teachers to the ambiance of the facility. A significantly influencing factor that had been explored was the effect of living conditions on people’s performance. Just as humans were not built the same physically, they also differed in their emotional and psychological profiles.

In the article *Housing and Family Well-being*, Bratt (2002) illustrated three ways in which housing does in fact affect the well-being of a family. The first was the physical attributes of the house, second, the way in which this related to its occupants, and third,
the neighborhood conditions surrounding the house. The concept is clearly illustrated below in figure 2.1.

<table>
<thead>
<tr>
<th>Physical Attributes and Availability of Housing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good quality and safety:</td>
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<tr>
<td>Housing, not homeless</td>
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<table>
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<tr>
<th>Relationship of Housing to Occupant</th>
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<tr>
<td>Not overcrowded</td>
</tr>
<tr>
<td>Affordable</td>
</tr>
<tr>
<td>Opportunities to create positive sense of self and empowerment</td>
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<tr>
<td>Stable and secure</td>
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<td>Tenure option</td>
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<table>
<thead>
<tr>
<th>Neighborhood Conditions</th>
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</thead>
<tbody>
<tr>
<td>Good quality and safe</td>
</tr>
<tr>
<td>Accessibility of housing to employment and education</td>
</tr>
</tbody>
</table>

Figure 2.1 Housing and Family Well-being (Bratt, 2002)

Physical attributes and availability of housing referred to whether or not the people physically had a home. It also explored how high/low the quality of the home was; whether or not it consisted of basic necessities and if it provided a safe living environment for all ages. The next property focused on the relationship of the house to its occupants. Factors include how crowded the interior spaces and whether or not the cost of living was affordable (i.e., electricity, water, etc.). Bratt (2002) portrays the
remaining factors by mentioning that housing impacts “families differentially depending on the relationship between the size and cost of the unit, the size and income of the family, the family’s perception of their housing and the relative security the housing provides” (Bratt, 2002, p.6). The last property discussed was the neighborhood conditions, including quality and safety of the neighborhood where the house was located and its accessibility to vital venues.

Similar to Bratt (2002), Robinson and Adams (2008) conducted a study for the Australian Institute of Family Studies on *Housing Stress and the Mental Health and Wellbeing of Families*. The authors used the World Health Organization (WHO) definition of housing implications on family health to lie in the physical structure, safety and intimacy it provided, surrounding urban design and quality of services available, and community and quality of neighborhood relationships. (Robinson & Adams, 2008)

These categories were consistent with Bratt’s model of Housing and Family Wellbeing.

Harker’s studies showed that poor living conditions could lead to a 25% higher risk of experiencing severe illness and disability. This could also have a distressing impact on one’s emotional wellbeing. Dire housing conditions had an impact on inhabitants’ safety. An unsafe environment increased the likelihood of accidents and injury, which were exacerbated greatly in the case of over crowdedness. In Harker’s (2006) study of the impact of bad housing on children’s lives, it was mentioned that “almost half of all childhood accidents are associated with physical conditions in the home” (p.18). Consequently, if the interior design and the furnishings of a home were not well thought out, they could be extremely dangerous, particularly in teeming spaces. Bratt (2002) addressed this idea with a similar approach by saying that “the evidence
makes it clear that housing affects perception of one’s self, contributes to or relieves stress, and affects health” (p.8).

In the study, Visual Effects of Interior Design in Actual-Size Living Rooms on Physiological Responses, Tsunetsugu, Miyazaki, and Sato (2005) noted that “differences in the designs of living rooms cause different physiological responses. It is essential to consider the physiological effects of the visual surroundings when designing housing environments, with information from psychological investigations as supporting evidence” (p. 6).

One of the most prominent and significant features in a room was the furniture. The scale relative to the room, the choice based on the intended use, and the placement of pieces could make a difference in the way people perform and feel within an environment. “Furniture selection and placement can complement or detract from these feelings and needs. For example, some pieces that are large scaled can seem to overpower a person, and storage units that require too much stretching or are difficult to operate can be frustrating for the user” (Kilmer & Kilmer, 1992, p. 491).

2.1.1 Community Involvement

A fundamental method for helping underprivileged societies thrive was by teaching them to support and provide for themselves. It was not always effective to simply give people what they need, however, working with them to build and create results ensured that they would be able to provide for themselves and cater to their own needs. (Mid term evaluation report, 2011).
2.1.1.1 Participatory Empowerment Project Examples

Practical Action Community Empowerment Project in Zimbabwe

‘Practical Action’ Community Empowerment Projects defied poverty in developing countries. “The right idea, however small, can change lives” was their motto. They were engaged in over 100 active projects with 943,000 beneficiaries. They took existing issues and assist in creating solutions or help improve already implemented solutions (Who we are, n.d.).

In the ‘Practical Action’ Midterm Evaluation Report for Promoting Examples of Participatory Local Empowerment Urban Planning in Zimbabwe, Africa, “delivery of urban services such as waste management, shelter, water and sanitation are the responsibilities of the governing local authority.” Lack of provisioning of these basic services had led to poor living conditions in many councils. Practical action with financial support from the European Union on a 4 year project titled PEOPLE UP aimed at increasing participation of residents in urban governance (Mid term evaluation report, 2011).

The project yielded multiple socio economic impacts. Brick molding and knowledge on business management were skills taught to the community throughout the duration of the project. “The project also brought improved participation in governance as the capacity gained from trainings allowed them to participate in both the software issues and hardware components of urban services delivery. For example the communities produced their own bricks to build better structures, produced their plans and queried rates levels which were just dictated to them and also demanded good
services from the local authority. All the participants of active brick moulding enterprises had been provided with an opportunity and a chance to earn at least $150.00 a month” (p.3). The interaction among people when they attended developmental meetings has improved relationships despite their different political affiliation. Although progress towards increasing income and employment opportunities from the services residents providing to their own communities was going slower than expected, however, long term prospects to derive income were likely to be sustainable. Figure 2.2 shows the residents in Mutare, Zimbabwe learning to produce their own bricks.

*Figure 2.2 Brick Making in Mutare, Zimbabwe*  
(Mid term evaluation report, 2011)
Indonesia National Program for Community Empowerment in Rural Areas

Community empowerment projects vary in size and scope. The National Program for Community Empowerment (PNPM's) is scoped to reduce poverty and improve local-level governance in rural areas of Indonesia. The World Bank committed US$231.19 million for the United Nation to manage and execute this project. (ID National Program for Community Empowerment in Rural Areas, 2008).

The scope of the project included:

- “Delivered two types of block grants to Rural districts and villages
  - Supported investment proposals made by villages and selected by consensus in an inter village meeting
  - Supported the participatory planning process and ensured proper technical inputs into implementation.

- Facilitation and training, this component consisted of salary and operational costs for the sub district technical and social facilitators. The component financed trainers, workshops, relevant materials, and quality reviews.

- Implementation support, technical assistance and project administration

- Project management and the technology needed for this purpose” (ID National Program for Community Empowerment in Rural Areas, 2008).

A Directorate General of Village Community Empowerment, within Ministry of Home Affairs was established to help this wide scale project and in the distribution of 15-20 national and international scholarships.
There were empowerment programs set up officially through governments (Armah, 2011). For example, the Strategies to Empower People (STEP) Program was created by the Louisiana Legislature in 2003 to provide job training and support services to work-eligible residents who were dependent on state funds for basic needs. “Poverty reduces productivity and economic output, raises crime, and cost associated with it, and increases health expenditures” stated Holzer, Schanzenbach, Duncan and Ludwig (2007, para. 6). By assessing the efficacy of such programs and knowing that not all underprivileged communities were supported by government programs, it should be a primary goal to ensure that non-governmental refugee camps were not neglected.

2.2 Furniture Design

“Furniture is one of man's most prized possessions. He sits on it, sleeps on it, eats on it, and perhaps most importantly, puts his most valuable belongings into it” (Eckelman, 2003). Furniture was also an essential part of an interior space that affected the actions and behavior of humans. It was imperative to understand the preferences, activities and needs of the user before designing or choosing furniture for a space.

2.2.1 Programming for Furniture

Before a designer can decide what furniture to apply to a space, the environment and people needed to be evaluated. The methodology used in the planning stage was known as programming interior spaces. “A program generally takes a form of a written or graphic document in which background information, analysis of facts, evaluation, goals, and conclusions relevant to the problem solution are documented and presented in a clear,
organized manner, facilitating communication between user and designer. The program establishes the basic goals and objectives for the designer during the design phase” (Kilmer & Kilmer, 1992 p. 178).

Figure 2.3 Programming has six distinct steps that are sequential (Kilmer & Kilmer, 1992, p. 180)

“When a large amount of information must be programmed, a model or paradigm generally consists of six basic steps: establishing goals, gathering and analyzing facts, specifying needs, evaluating the program, organizing, and presenting conclusions relevant to the problem situation” (figure 2.3) (Kilmer & Kilmer, 1992, p. 180). The author had to understand the convoluted environment and then designs could be applied accordingly.

2.2.2 Furniture Design Methodology

There were several separate, yet closely related areas of design which should be considered in the creation of a new furniture piece. According to the Eckelman’s furniture design theory (Eckelman, 2003) and furniture design methodology developed
and thought at Wood Research Laboratory, Purdue University, good furniture design should address different design areas listed below:

**Aesthetic design** - is the most dominating and important area of furniture design. It is the artistic development of a structural form that is appealing to consumers and which will culturally enrich their lives.

**Functional design** - is the planning of the structure so that it will perform its intended function in as efficient manner as possible. Functional design concepts ordinarily receive much less attention. Yet, in many cases, the correct functional design of a piece of furniture is even more important than either the esthetic or engineering design (Eckelman 2003).

**Engineering design** - is the planning of the structure so that it can safely resist the loads imposed upon it in service. Skilled craftsmen can intuitively create furniture that is structurally sound, however, furniture designer can use the engineering principles to create strong and durable furniture piece.

**Design for manufacturing** - furniture should be designed with understanding of manufacturing capabilities and options which should be relevant to the level of industrial development. Designer should choose a manufacturing path that is straight forward and practical (Design for Manufacturing (DFM) Guidelines - Engineers Edge, 2013)

**Design for the environment** - products are designed and produced with the effort to reduced environmental impact. Designer should address how products are being developed, produced, where materials used for the production will be outsourced, what are the environmental consequences of their production and use, and how they are
disposed of at the end of their life cycle, could they have a second life or could they be recycled etc.

**Anthropometric/ Ergonomic design** - Anthropometrics are the measurement of the size and proportion of the human body. An example can be seen in figure 2.4.
Figure 2.4 Anthropometrics: Body Measurements
(Kilmer & Kilmer, 1992, p. 190)
Kilmer & Kilmer (1992) define ergonomics as the study of the relationships between human beings and their function in the environment. It is the application of anthropometrics for optimum human/environment relationships.

The goal and a challenge of a good design was to address all design types simultaneously in order to obtain ultimate outcome - the furniture product which would be aesthetically pleasing, user-friendly, durable, easy to manufacture, will support the user and would be environmentally responsible.

2.3 Multifunctional Space-Saving Furniture

Refugees endured the hardships of being displaced, and sometimes permanently moved, from their home countries. In addition, many refugees today were permanently bound to live in camps that might or might not be supported by the government. Non-governmental or “unofficial” refugee camps usually receive no attention in the form of family planning and guidance or community development. (Chassay & Campbell, 2007). Over the years, the population grew significantly transforming the environment into a slum-like region. With little to no money, families ended up settling in very small dwellings. Their inability to afford new houses or expand the existing one, the next generation family often shared same living space; thus, exacerbating what was originally a convoluted problem. Overcrowded homes could result not only from the number of family members, but also from mismanaged space as well. This problem had a solution; multifunctional furniture. Furniture could be designed in a way to serve multiple purposes. This space saving concept has been around for many years, however, it was not until recently that the importance and convenience of multifunctional furniture was
recognized, particularly due to the increase of urban lifestyle which is associated with limited living surface area. (Kilmer & Kilmer, 1992, p. 491)

2.3.1 Historical Context

Figure 2.5 shows a wooden chest. Once the chest is closed, the piece can also be used as a daybed. This concept dates back to the late Gothic era.

Figure 2.5 Wooden Chest
Independent sketch based on similar photo (Daybed in history part 2, n.d.)

Figure 2.6 was known as the ‘drop arm’ sofa. The model here shows a couch with adjustable sides. When the sides are lowered, the sofa transforms into a daybed. This innovation dates back to the early 17th century in England.
The military camp day-bed, shown in Figure 2.7, is a box-like chest that stores a fold away bed. This was used in the United States during its civil war.

According to U.S. Patent Office records, Thomas Jefferson was the inventor of the first Hideaway Bed ever patented in the United States. Although the original design
plans no longer exist, the bed is believed to have been elevated to the ceiling by pulleys and ropes, and secured in place when not in use.

The Murphy Bed was another improvement to the furniture design world. The piece was invented by American William Lawrence Murphy in 1900. The space-saving Murphy bed pivoted on the doorjamb of a dressing closet and then lowered into a sleeping position. It folded back upright and hid in the closet until next use. In 1908 Murphy patented his “In-a-door” bed (Bellis, 2012). The floor plan appears in figure 2.8 and a sketch of the perspective view in figure 2.9.

![Figure 2.8 Murphy Bed—plan view](image)
Independent sketch based on similar photo (History-a man named murphy, 2004)
As time went on, it was no longer merely the big furniture items that were being utilized in multiple ways. Inventors like Odo Klose improved two single purpose pieces into one—for multi-use. His creation was a chair and a step-ladder in one. “The arrangement has a base frame and a backrest which is pivotally mounted on the base frame and adapted to be folded from a backrest position to a step-ladder position and vice versa for respective use as the top rung of the step-ladder when it is in a horizontal position and as the backrest of a chair when it is in the backrest position” (Klose, 1981, para. 1).

With respect to the previous examples, it was apparent that furniture fulfilling more than one function has been present for some time and may therefore continue to prosper.
2.4 **Sustainability**

There were several existing companies that acknowledged the sustainable way for designing their products- Green Design being one of them. Their philosophy was to achieve a sustainable relationship with the environment. It consisted of two major categories.

- “Reduction of the ‘footprint’ that is left throughout the process of making the new products. This could be done by using low-impact, non-toxic, sustainably-produced or recycled materials that required less energy to convert from raw to finished state” *(Green is more than just a name, 2011).*

- “Design products, buildings and services to function in an environmentally friendly manner are equally important for determining whether it is truly 'green'. The 'green' design “consumes less energy, is engineered for quality and durability so it lasts longer with less maintenance, is engineered for reuse or recycling, and does not lead to physical harm” *(Green is more than just a name, 2011).*

2.4.1 **Materials**

The standard that evaluates how green or sustainable a piece of furniture was greatly dependent on the materials that go into the final product and its manufacturing process. Ensuring that the material was extracted from non-threatened resources, harvested in a conscientious manner, realizing how far it had to travel to get to the final destination, and, most evidently, knowing if the material might cause any harm or side effects to the consumer, are all essential variables that needed to be considered. The
consumer was not the only one who might be negatively affected by the product. Several questions must be asked; did the manufacturing process put the workers in harm’s way? Did it continue to create waste or polluted the environment? And at the end of its use could it be recycled?

Forest Stewardship Council (FSC) certified wood, a renewable resource, was considered universally to be a highly sustainable building material (A smart guide to sustainable furniture & FSC-certified products, 2008).

“Cradle-to-cradle was a method used to minimize the environmental impact of products by employing sustainable production, operation, and disposal practices and aimed to incorporate social responsibility into product development” (Cradle-to-Cradle, 2012, para. 1). Since wood was highly recyclable material, in addition to its other sustainable attributes, the cradle-to-cradle concept could be achieved with proper product development, manufacturing, use and after-use.

2.4.1.1 Material Specifications – Wood Species Selection

Short Term Supply Solutions

The author proposed several options for the material selection process. The first being one that was the responsibility of the NGO or the funders in Jordan. At the time of implementation, resources needed to be discovered and studied in order to decide on the most reasonable resource, based on the needed properties and features (cost effectiveness, strength and durability, light weight, fast growth). In the case that there was no well suited material for the project, importing appropriate material from elsewhere might be the solution. Russia could be a possible provider for the wood resources needed,
however, East African countries were also rich with timber that could be sea freighted through the Red Sea.

**Long term Supply Solutions**

“The highlands of Jordan host forests of oak and pine, as well as pistachio and cinnabar trees. Olive, eucalyptus and cedar trees thrive throughout the highlands and the Jordan Valley” (Geography & Environment, n.d.). Oak and Pine trees were widely known to be heavy duty dense woods good for furniture manufacturing. Although, these trees passed the strength test, they were only scarcely scattered over the 1% of land which was considered forest in Jordan. An initiative has been in progress since 2011 to envelop the country in green. This project was know as the Green Corridor and its goal was to plant millions of native trees to “create a permanent band of greenery from one end of Jordan to another” (RBG, 2011, para. 2). Trees mentioned so far that meet furniture manufacturing specifications were slow growing but, in the long run, offer the potential to provide lumber material locally. Another factor that might make oak and pine less desirable was the fact that their weight typically was considered heavy for impermanent movable furniture.

Jordan can take countries such as Afghanistan or New Zealand as model examples for their natural resource management practices. Afghanistan had a reforestation project called the Global Partnership for Afghanistan (GPFA). This initiative works with rural Afghans to primarily create farm businesses that improved poverty and build sustainable livelihoods for the people. Growing hybrid poplar woodlots in Afghanistan has provided the country with many benefits. The timber produced was used for construction
purposes, as well as for carpentry (furniture). It also served to slow the destruction of diminishing natural forests. (Forestry, 2013)

“This is the kind of project we really need... it will support our communities for many years to come and help us to earn a decent living with no need for outside help” a Jalrez farmer said (Forestry, 2013). Therefore, besides the benefits mentioned, this initiative also served the purpose giving the people a sense of empowerment.
However, the poplar tree grown in plantations that was not currently wide spread in Jordan can offer a viable alternative due to its fast growing nature and its wood properties. It is “A very fast-growing tree, up to 5 to 8 feet per year. Usually planted for very fast shade, or can be harvested in 5 to 7 years” (Tree Details—The Tree Guide, n.d.). Figure 2.12 (courtesy of the Landfill Leachate Remediation Project - Armstrong, British Columbia, Canada demonstrates the trunk diameter growth rate of 1.5 – 3 inches per year. “The realized wood fiber production from 250 trees after completed growth over 5 years is 872 cubic feet or 25 cubic meters including the trunk only, or 50 cubic meters when counting the branches but excluding the root fiber” (Landfill Leachate Remediation Project - Armstrong, BC, 2009).
Figure 2.12 Growth Pattern of Poplar Trees in British Columbia (Landfill Leachate Remediation Project - Armstrong, BC, 2009)

Figure 2.13 & Figure 2.14, courtesy of the New Zealand Farm Forestry Association, Show a 15 year old poplar tree and actual pieces of furniture made out of its timber. It was to be noted that the poplar tree was core to the New Zealand timber export industry to China (Hunter & McIvor, 2008). As shown in Table 2.15, the poplar working properties were rated close to excellent according to Poplar - Industrial Timber & Lumber Company (2012). This, in addition to its fast growing properties and its FSC-certification (Dodge, 2007), led the author to choose poplar. The binding method of nailing and gluing the pieces together were rated very high, something that presents ideal conditions for furniture manufacturing. Both of these properties are exhibited in Figure
2.14 where the door was typically made of glued pieces and the dresser was composed of glued and nailed pieces. Moreover, these furniture items reveal the staining working property in the flexibility to stain the same wood in different styles.

*Figure 2.13* 15-Year-Old Kawa Poplar Tree in New Zealand (Hunter & McIvor, 2008)
Figure 2.14 Door and Dresser Made Out of Poplar Wood
(Hunter & McIvor, 2008)
In Jordan, the existence of poplar trees dates back to the biblical days. The Bible Plants’ site of the Old Dominion University quotes “The Euphrates poplar, *Populus euphratica*, which forms a conspicuous part of the vegetation of the lower Jordan River (Genesis 30:37)” (Plant Site, 2006). Poplar trees can grow up to 160 feet and produces straight grained wood with very few knots. If planted at a commercial scale, it can be a primary source for furniture and cabinet manufacturing. Its shrinkage is minimal and it
has excellent machining and gluing characteristics. Its light weight wood helps it accept nails and screws without the risk of splitting. It can be painted and stained, and from a distance it looks to have the texture of other better known and more expensive woods. (Poplar - Industrial Timber & Lumber Company, 2012). Having mentioned that the Poplus Genus can be grown in Jordan, there is still a need for a sponsored and comprehensive agricultural program aimed at creating forest land to produce commercial quality and quantity of this wood. An industry has to be created in Jordan to cut the trees and transform the trunks into a treated lumber ready to use. This industry has the potential to create jobs for the locals. Also, there needs to be a well-established and regulated process to control the tree cutting and replenishing. It is also necessary to note how the configuration of production and consumption can better suit the global environment and local economy. Choosing the right adhesive process is the key in safeguarding strength and durability. Poplar timber is characterized to be an excellent wood for gluing, which is a prerequisite for durable furniture. Poplar can be finishes with polyurethane to extend its durability in high humidity conditions. “Polyurethane is widely revered as one of the most durable yet easy-to-apply protective wood finishes. Polyurethanes are now available in both oil-based and water-based, and there are differences in the way in which both are applied (wipe on or brush on). However, for many projects that will see a lot of wear and tear, few finishes are as appropriate as applying polyurethane for the final touch” (Baylor, 2013). Poplar wood is also known to do very well with paint and stain. It accepts stain evenly and absorbs the paint which makes it retain a good finish for a long time as compared to other furniture or cabinet wood. Painting with light colors will help to reflect the light within the tight overcrowded
houses. This will help reduce lighting requirements or at least put less strain on eye muscles while inside the house. Both adhesive and nails or screws can be used to join the wood. (Examples shown in figures 2.17, 2.18, and 2.19 and details shown on furniture spec sheet in Appendix B)

Figure 2.17 Nail Size Chart
(Nail Size Chart, 2012)
2D-4D Nails used in construction
Figure 2.18 Narrow Butt Hinges
(Narrow Butt Hinges - Solid Brass, 2012)

Figure 2.19 Hardware VELCRO Hook & Loop
(Industrial Strength Velcro Brand Fasteners, 2013)
Figure 2.20 Wood Adhesive (Titebond Original Wood Glue, 2011).

Figure 2.21 Wipe- on Polyurethane Wood Finish (Interior Clear Protective Finishes, 2013)
In the case of plate type construction (where bigger panels of materials are incorporated into a design) use of engineered or wood composite materials will be beneficial (Engineered Wood, 2006). The most suitable composite material for furniture construction would be plywood (furniture or construction grade); medium density fiberboard (figure 2.23) (this material will be easy to work with but it is fairly heavy for movable furniture); laminated plywood or particleboard and hardboard (shown in figure 2.22) (Kennedy, 2011). Engineering material would have to be outsourced from more developed markets or possibly imported. Nevertheless, because of the simplicity of production from composite material, availability of such material resources should be explored by producers and benchmarked based on material properties and cost (Engineered Wood, 2006).

*Figure 2.22 Sanded Plywood*
(Sanded Plywood, 2013)
Figure 2.23 Medium Density Fiberboard (MDF) Core  
(Plywood Core Types, 2011)
CHAPTER 3. METHODOLOGY

The author’s trip to the slums of Jordan determined that a qualitative research approach was most appropriate. The goal was to observe the people in this underprivileged community and come up with results that could improve their living conditions; through the implementation of multifunctional space saving furniture. The observations were recorded in words and in due course translated into a three-dimensional model of the furniture piece designed.

3.1 Framework

A mixed method approach was used to conduct this research. Initially, case study was the most suitable framework for this research. Case studies analyze what happened with a situation at a certain time and place. Although the case study approach covered a broad spectrum, it was essential to include the findings from observation of the culture at hand, also known as ethnography. Combining these two research frameworks resulted in an ethno-case study. This provided the ingredients for a scenario oriented design that promotes “work-oriented communication among stakeholders, helping to make design activities address the actual needs as perceived by the end user” (Creswell, 2008).
3.2 **Perspective**

When dealing with such a challenging environment, ground presence was essential. Remote investigation and analysis was necessary in the initial phase but not sufficient for developing appreciation of the exact needs. To merely study a culture or community from a distance leaves various gaps in the research. Contact with the community and its environment was fundamental to create an understanding of the situation in order to gain an in depth knowledge of the efforts that yielded the greatest impact. In return, this contact also allowed the author to gain the residents’ trust in order to move forward with any changes.

3.3 **Sample Approach**

Participatory approach through site visit was paramount (Field visits: Developing a participatory approach, 2012). Residents’ awareness needed to be evoked for the importance of change in their environment and to provide them with an opportunity to express what they need most for their surroundings. No solutions were to be imposed upon the community. Solutions should have evolved from within, as the people were most knowledgeable about their needs and about the feasibility of any proposed ideas.

For that reason, regular meetings, surveys and interviews were conducted throughout the course of the project. The study then followed a dynamic trend, since goals and preferences for what transformations needed to be made were anticipated to change for the residents. We were working with the people, not strictly for them.
The Global Engineering Program at Purdue University had ties with a Non-Governmental Organization—Ruwwad at Jabal Al-Natheef, Jordan. Ruwwad was located in the heart of the city, and provided a facility where the refugees were encouraged to go interact and learn. Several times a week people from the neighborhood gather in focus groups in order to discuss issues arising in the community or simply to socialize. The author became involved in several of these focus groups. Given that the people were approached in a familiar, comfortable environment and were spoken to in their native language, Arabic, they did not feel as though they were under the microscope. Consequently, several volunteers from the focus groups allowed for visits into their homes. Throughout the remainder of the trip, the author was immersed in the culture, observing interaction of people to the interior environment of their homes.

3.4 Data

Given that interviews were conducted within the focus groups and at people’s homes, IRB (Institution Review Board) approval was required in order to use or publish the findings.

The author was invited into the homes of six different families. Due to the duration of each interview as well as the time it took to take space dimensions and do a home inspection, the author was only able to visit six homes during the field visit. These homes were chosen at random. Several families were not comfortable being surveyed, while others were very cooperative. One-on-one interviews were conducted with the head of the household, or another adult who was available to answer the author’s questionnaire. The condition of each home differed; however, on average, and after
analyzing the inhabitant to square foot ratio, they were fairly similar. Data was also collected through extended discussion in women and youth focus groups.
CHAPTER 4. PRESENTATION OF DATA & FINDINGS

Chapter 4 discusses the analysis results and data collected from the literature review and the author’s visit to Jabal Al-Natheef, Jordan in March of 2012. It also evaluates the current living conditions in underprivileged communities based on the assumptions that were made under current limitations and constraints. The analysis is then focused on Jabal Al-Natheef refugee camp, the case study at hand.

4.1 Interviews

Many people were approached for interviews and site visits, six families have accepted to participate in the survey and data collection. Knowing the culture of the Middle Eastern countries, families’ privacy is a social requirement as well as a religious line that must not be crossed. No pressure was applied because it is imperative for the scenario oriented design to promote a collaborative working relationship. The end result sought required that users feel relaxed to present their problems as they perceive them. Also, having spoken to many people who were not comfortable or were not available for site visits, it was realized that the vast majority have common concerns.
Jabal Al Natheef Residents Questionnaire

Interview # 1 (figure 4.1 & 4.2)

1. Have you lived in this home in Jabal Al Natheef your whole life?
   Yes
2. How many family members reside in your home?
   32 (extended family live with us)
3. What are their ages?
   They range from 3 months (my youngest daughter) to my husband who is 48 years old
4. What piece of furniture would you like to see in your home that does not exist already/
   does not fit in the space?
   We would like to have a dining table/work space for the kitchen or beds so the kids don’t have to sleep on the floor.
5. Would you be willing to work in constructing furniture?
   No, I have to be a stay-at-home mom. My teenagers would be willing to work to help support the family. We could definitely use the money.

Interview # 2 (figure 4.3 & 4.4)

1. Have you lived in this home in Jabal Al Natheef your whole life?
   Yes, this house was my grandfathers
2. How many family members reside in your home?
   Only 2. My mother and I
3. What are their ages?
   I am 30 years old. My mother is an old lady
4. What piece of furniture would you like to see in your home that does not exist already/
   does not fit in the space?
   My mother is getting old. She is having a very hard time getting up off the ground since that is where we sleep (on a mattress). I have a disability. My leg got amputated when I was younger. I also have a lot of trouble getting in and out of bed since the place I sleep is not elevated. It is just a mattress on the ground. We would also like it if we had a dining table. Also storage. Things seem to get cluttered around here.
5. Would you be willing to work in constructing furniture?
   No, I wouldn’t be able to since I have a disability. I can barely walk and my mother cannot either.
Interview # 3 (figure 4.5 & 4.6)

1. Have you lived in this home in Jabal Al Natheef your whole life?  
   Yes.
2. How many family members reside in your home?  
   Six in my family. We have 3 daughters and a son
3. What are their ages?  
   My kids are still in elementary and middle school.
4. What piece of furniture would you like to see in your home that does not exist already/ does not fit in the space?  
   Beds for the kids. Currently they have to sleep on the couch and floor. Since my husband got sick he needs to sleep on the bed where the kids used to sleep.
5. Would you be willing to work in constructing furniture?  
   No, I have to stay home to take care of my sick husband

Interview # 4 (figure 4.7 & 4.8)

1. Have you lived in this home in Jabal Al Natheef your whole life?  
   Yes.
2. How many family members reside in your home?  
   Three of us live here. My husband passed away a few years ago. It’s just me and my two sons.
3. What are their ages?  
   One is eighteen and the other is twenty
4. What piece of furniture would you like to see in your home that does not exist already/ does not fit in the space?  
   Storage and a dining table or coffee table. Something the boys can use as a desk and we can use to eat on. Storage space is a big issue for us.
5. Would you be willing to work in constructing furniture?  
   Yes, and my boys can help too. We could use the money.
Interview # 5 (figure 4.9 & 4.10)

1. Have you lived in this home in Jabal Al Natheef your whole life?
   Yes.
2. How many family members reside in your home?
   Seven in my family. We have two daughters and three sons.
3. What are their ages?
   They range from ages three to twelve
4. What piece of furniture would you like to see in your home that does not exist already/does not fit in the space?
   Beds for the kids. Dining table and chairs.
   Would you be willing to work in constructing furniture?
   No, I have to stay home to take care of my kids. My husband doesn’t have a job currently. He is in need of one.

Interview # 6

1. Have you lived in this home in Jabal Al Natheef your whole life?
   Yes.
2. How many family members reside in your home?
   Four of us live here. I have two daughters and my mother lives here too.
3. What are their ages?
   My daughters are ages four and seven.
4. What piece of furniture would you like to see in your home that does not exist already/does not fit in the space?
   We need chairs and a table. We usually eat on the floor. We also need more storage.
5. Would you be willing to work in constructing furniture?
   Yes.

The results of the interviews were collected, analyzed and were illustrated in the graph below (figure 4.1). This pie chart showed the percentages of each furniture category, based on the need of the people in Jabal Al Natheef. The highest percentage was the need for dining with 31% of the people in need for such a unit. It was followed by the need for sleeping units at 23%. Storage and seating came in a tie at 15%. Coffee
table and countertop also tied at 8%. Although this number was fairly low, it didn’t change the fact that it was a lacked need.

![Space-Usage Needs](image)

*Figure 4.1 Space-Usage Needs*

4.2 Existing Conditions

Floor Plans of homes visited were replicated and rendered using BIM software. This method was crucial in the design phase in order to understand the existing space conditions and furniture needs. Total living space area was calculated and noted below the floor plans for all the six homes studied.
Figure 4.2 Home #1 Floor Plan

Figure 4.3 Home #1 Perspective 3D Rendering
Total living space area: 596 sq. ft.
Number of occupants: 32 people
Figure 4.4 Home #2 Floor Plan

Figure 4.5 Home #2 Perspective 3D Rendering
Total living space area: 271 sq. ft.
Number of occupants: 2 people
Figure 4.6 Home #3 Floor Plan

Figure 4.7 Home #3 Perspective 3D Rendering
Total living space area: 265 sq. ft.
Number of occupants: 6 people
Figure 4.8 Home #4 Floor Plan

Figure 4.9 Home #4 Perspective 3D Rendering
Total living space area: 259 sq. ft.
Number of occupants: 3 people
Figure 4.10 Home #5 Floor Plan

Figure 4.11 Home #5 Perspective 3D Rendering
Total living space area: 212 sq. ft.
Number of occupants: 7 people
Figure 4.12 Home #6 Floor Plan

Figure 4.13 Home #6 Perspective 3D Rendering
Total living space area: 170 sq. ft.
Number of occupants: 4 people
Figure 4.14 Sleeping/Tabular Unit Plan View
Figure 4.15 Sleeping/Tabular Unit Section Cut

Figure 4.16 Storage/Seating Unit
4.3 Furniture Prototype and Features

4.3.1 Specifications

Refer to Appendix B for furniture specification cut sheet.

4.3.2 Design Prototype

The previous plans (figures 4.14, 4.15, and 4.16) were the outcome of the study. The author/designer combined the needs of the people from the interviews conducted in Jabal Al Natheef in March 2012. Based on the percentages in figure 4.1 and floor plan square footage average of the homes, a design was produced. The materials schedule (table 4.1) was extracted from Revit Architecture BIM software.
## Table 4.1 Wood Material Schedule

<table>
<thead>
<tr>
<th>Area</th>
<th>Count</th>
<th>Volume</th>
<th>Structural Material</th>
<th>Perimeter</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 SF</td>
<td>1</td>
<td>0 CF</td>
<td>Poplar</td>
<td>36' - 4&quot;</td>
</tr>
<tr>
<td>14 SF</td>
<td>1</td>
<td>1 CF</td>
<td>Poplar</td>
<td>65' - 2 31/32&quot;</td>
</tr>
<tr>
<td>2 SF</td>
<td>1</td>
<td>0 CF</td>
<td>Poplar</td>
<td>36' - 4&quot;</td>
</tr>
<tr>
<td>20 SF</td>
<td>1</td>
<td>1 CF</td>
<td>Poplar</td>
<td>19' - 0&quot;</td>
</tr>
<tr>
<td>5 SF</td>
<td>1</td>
<td>0 CF</td>
<td>Poplar</td>
<td>9' - 0&quot;</td>
</tr>
<tr>
<td>5 SF</td>
<td>1</td>
<td>0 CF</td>
<td>Poplar</td>
<td>9' - 0&quot;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Area</th>
<th>Count</th>
<th>Length</th>
<th>Structural Material</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 SF</td>
<td>1</td>
<td>6' - 2 1/4&quot;</td>
<td>Poplar</td>
<td>0' - 0 3/4&quot;</td>
</tr>
<tr>
<td>4 SF</td>
<td>1</td>
<td>6' - 2 1/4&quot;</td>
<td>Poplar</td>
<td>0' - 0 3/4&quot;</td>
</tr>
<tr>
<td>2 SF</td>
<td>1</td>
<td>3' - 2 1/4&quot;</td>
<td>Poplar</td>
<td>0' - 0 3/4&quot;</td>
</tr>
<tr>
<td>2 SF</td>
<td>1</td>
<td>3' - 2 1/4&quot;</td>
<td>Poplar</td>
<td>0' - 0 3/4&quot;</td>
</tr>
<tr>
<td>3 SF</td>
<td>1</td>
<td>2' - 11 1/4&quot;</td>
<td>Poplar</td>
<td>0' - 0 3/4&quot;</td>
</tr>
<tr>
<td>2 SF</td>
<td>1</td>
<td>1' - 5 1/4&quot;</td>
<td>Poplar</td>
<td>0' - 0 3/4&quot;</td>
</tr>
<tr>
<td>3 SF</td>
<td>1</td>
<td>2' - 11 1/4&quot;</td>
<td>Poplar</td>
<td>0' - 0 3/4&quot;</td>
</tr>
<tr>
<td>2 SF</td>
<td>1</td>
<td>1' - 5 1/4&quot;</td>
<td>Poplar</td>
<td>0' - 0 3/4&quot;</td>
</tr>
</tbody>
</table>
4.4 Manufacturing Processes

A low capital investment, a basic woodworking shop, is considered for production of the proposed Space Buster furniture unit. Production steps and the needed equipment are directly related to the selected and available material resources. Local woodworking shops can be surveyed for adequacy, or can be upgraded with minimal investment. 

(Global Manufacturers - Furniture & Furnishings - Jordan - List, 2013) Partnerships can be explored as well. These options are assumed to be available in a city like Amman whose population is about 3.5 million people (Satellite View and Map of the City of Amman, 2013). However, choosing the most optimal option is beyond the scope of this study.

If solid wood in the form of dried lumber is used (for example poplar boards), the following manufacturing steps should be taken. We are assuming that the material will be of relevant moisture content (between 6 to 15% MC (Advice on Moisture Content for Cabinet Wood & Maintaining Level in Storage, 2013). If not, lumber drying processes would be necessary. Moisture content can be calculated as follows:

\[
\% \text{ MC} = \frac{(\text{weight of wood un-dried}) - (\text{weight of wood kiln-dried}) \times 100}{(\text{weight of wood kiln-dried})}
\]

*Where wood requires 24 hours at 103 °C temperature to be considered kiln-dried*

(Bowyer, 2013).
Manufacturing Process Workflow of Space Buster Furniture

1. The parts (panels) required for the furniture need to be cut in a precise manner. This processing can be difficult to achieve without the proper equipment. These furniture parts would be produced on a jointer, planer, table saw, and band saw.

2. Boards will be glued into panels using a simple butt joint method. Panels made of boards would have to be clamped, and once made, they would have to be surfaced (by planer or sander), then cut into precise dimensions on a table saw or panel saw.

3. If desired, it is also possible to apply finishes before actual assembly.

4. Assemble panels into the frames and cases. Panels will be joined by simple butt joints secured by nails and glue.

5. Increase the strength by considering other kinds of joinery (grooves); however, this extra step will require the use of a router.

6. Pre-drill using a hand drill the needed holes for joinery and hinges.

7. Once parts are prepared, furniture assembly should be quick and simple and a final coat of wipe on polyurethane finish should be applied again.

Production of this type of furniture from engineered/composite materials would require significantly less equipment but this material resource will be more costly and challenging to outsource. (Engineered Siding: Engineered Wood Products, 2013) Final furniture pieces made from composite material will have lower sustainable ratings compared to hard wood, however, could fulfill the immediate needs (Composite Decking VS Wood Decks, 2013).
4.5 Furniture Prototype in Existing Floor Plans

Subsequent to the design phase, the creation was inserted into the floor plan of home #1.

*Figure 4.17 House # 1 with the Space Buster*
Figure 4.18 House #2 with the Space Buster
Figure 4.19 House #3 with the Space Buster
Figure 4.20 House # 4 with the Space Buster
Figure 4.21 House # 5 with the Space Buster
Figure 4.22 House # 6 with the Space Buster
Figure 4.23 House # 4 – Table by Day, Beds by night
Contrast illustrates the difference in function of the same piece

Figure 4.15 illustrates how the Space Buster would function in the setting of a home. On the left it was acting as a tabular unit (coffee table). On the right the design allowed the residents to transform their living room into a bedroom by night. The tabular unit transformed into two sleeping units. The box design of the bed on the right could suit an adult, as well as children. The frame may serve as a boundary for the mattress, which therefore, may be safer for younger children.
CHAPTER 5. CONCLUSIONS, DISCUSSION & RECOMMENDATIONS

Chapter 5 concluded the case study by discussing the found results and presented an established design scheme. The design included detailed plans and 3D renderings of its application. The proposed furniture model was produced while bearing in mind several factors; feasibility, cost, and constructability. Due to the time constraint put on this project, proposed future improvements were also be listed and discussed.

5.1 Case Study: Jordan

Availability of locally grown wood at a commercial level to facilitate the furniture industry does not currently exist in Jordan. However, having The Green Corridor program in place could have potential commercial outcome, in addition to the environmental benefits of having more trees. This began with selecting the right native species of wood. A type that will mature and produce faster would require less effort to maintain, and less water to grow. Since lumber can be produced locally and the skillset of the locals to build their own furniture could be acquired, this set the stage for a sustainable local economy. Consequently, a plan such as this one could allow for implementation of the study to be realized within approximately 5 years, which is the mature age of Poplar trees. In the meantime, wood will need to be imported. Lebanon, a
neighboring country, has rich soils and wet climate can be a source. Another option would be to import timber from Eastern African countries using ship transportation through the Red Sea. As mentioned in the literature reviewed, the Genus species Populus, commonly known as Poplar, was becoming a popular choice in the region due to its fast growth, low maintenance cost, and its strength. To do a full scale study on what it would take to grow this wood (saplings, irrigation water, soil, pest control, fertilizer, protection against cattle, other agricultural considerations) is beyond the scope of this project, however, the reforestation project in Afghanistan mentioned previously (GPFA) was a good example.

5.1.1 Features

Figure 5.1 Renderings of the Different Uses and Applications
Figure 5.2 Storage Unit (vertical/ horizontal)/Seating (bench/ tall stool)

Figure 5.3 Tabular Unit - Dining Table
The furniture piece that was designed as result of this research study is called the “Space Buster”. It is a combination of a box-like feature that acts as a container for two mattresses. The lid of this box serves as a table top when not being used as the frame of bed #2. Stools/benches have been designed in a way to be able to store items inside by opening and closing of one of their faces which acts as a door, and locks once closed. The stools can boost the “box” up to function as a dining table or coffee table, as well as a raised bed.
5.2 Recommendations

Although the scope of this thesis has been fulfilled, there were some recommendations that needed to be put forward. The outcome of this study could potentially benefit the underprivileged community of Jabal Al Natheef if some practical steps were undertaken to move this concept forward into implementation. The thesis and the following recommendations present a model that was applicable to also help impoverished groups worldwide.

- Build furniture model to scale.

- Purdue GEP should present design to ARAMEX who will approve and fund the project. ARAMEX will ensure the design specifications are handed out to the manufacturers. Delivery of the finished furniture products will be handed over to Ruwwad (The NGO at Jabal Al Natheef) to manage the distribution process.

- Present design to Ruwwad, the NGO at Jabal Al Natheef. Ruwwad will have to come up with an implementation and roll out plan to ensure proper distribution of furniture.

- Create workshops to teach people how to make furniture, this will not only serve the purpose of the project but will also teach them a skill that can provide them with job opportunities.

- An in depth training plan would have to be developed.

- Capacity building for the local community
- Advertise for job openings in constructing the pieces. This will be an important step especially if there is a wide adoption of the thesis objective by ARAMEX which will translate into a mass production of furniture items.

- Create a furniture industry as a means to diversify the Jordanian economy and to train and employ low income people. This will serve the project purpose where people in Jabal Al Natheef can build their own furniture and sustain a decent living.

- Propose other thesis and project topics whose aim is to create poplar tree forestland in Jordan. Few studies can be spun off this proposal:
  o Hardwood Tree Improvement and Regeneration Center (HTIRC) in Purdue University’s department of Forestry and Natural Resources research to identify trees and ideal geographical location for plantations that can yield commercial quantity and quality wood to support the furniture industry in Jordan.
  o Leverage Genetic Engineering technology for fast growing trees to survive in Jordanian climate.
  o ARAMEX to increase awareness of the Populus species’ potential in furniture industry. Influence the “Green Corridor” project to include poplar trees in their initiative.
  o ARAMEX to seek Jordanian Department of Agriculture to work with the United Nations on foresting the nation with fast growing wood for better environment and wood industry job creation.
Universities in Jordan can work in collaboration with government departments to develop a plan for a regulated process to ensure continuity and replenishment of forest trees for a sustainable furniture industry.

5.3 Conclusion

This study concludes an effort that was initiated in March 2012. It involved a great deal of coordination between the author and Purdue’s GEP, as well as between the author and various entities in Jordan (in English and Arabic). It also required a volunteer field trip for the author to Jabal Al Natheef, Jordan to spend a week of first hand exposure to the real issues confronting this impoverished refugee camp.

A scenario oriented design approach was used as a guide to identify and cater for the residents’ needs in an underprivileged community. Designing multifunctional furniture pieces that address the need and make more efficient use of floor space was at the heart of this effort. The study was also based on developing the ability of local users of the furniture to provide for themselves. The potential of producing the timber material using poplar as a fast growing tree was identified. Also providing specifications of the furniture and setting up training workshops will effectively make the entire solution locally developable. Researching the possibility of foresting Jordan with poplar trees, and making recommendations for an implementation framework would be a leap on the track towards improving sustainable development in similar underprivileged communities around the world.
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Appendix A:

Visual Documentation

Figure A.1 Women’s Focus Group
Figure A.2 Bathtub Used for Storage
Figure A.3 Bedroom in Existing Home

Figure A.4 Kitchen in Existing Home
Figure A.5 Shelving Unit in Existing Home
Appendix B:

Furniture Specification Cut-sheet
Figure A.6 Furniture Specification Cut-sheet (Front)
Benefits & Features

Furniture is known for incredibly flexible furniture systems.
- Flexible design allows for multi-use
- Can be customized for the individual needs to optimize space utilization
- Designed in environmentally conscious manner

Material
Poplar Wood & Composite Wood

Hardware
- Narrow Butt Hinges - Solid Brass
- Wipe-on Polyurethane Wood Finish
- VELCRO® Brand Hook and Loop STICKY BACK® Tapes
- Franklin Titebond II Premium Wood Glue

Figure A.7 Furniture Specification Cut-sheet (Back)
Appendix C:

System of Measurement

The English System of measurements has been used throughout this project. The Author was obliged to use these units given that they are customary to the software utilized to model the furniture units. In order to convert the units to The International System of Units (SI), the following table can be used.

Table A.2 Conversion Table

<table>
<thead>
<tr>
<th>To convert from</th>
<th>multiply</th>
<th>to get / to convert from</th>
<th>multiply by</th>
<th>to get</th>
</tr>
</thead>
<tbody>
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<td>millimeters, mm</td>
<td>0.0393701</td>
<td>inches, in</td>
</tr>
<tr>
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<td>0.0254</td>
<td>meters, m</td>
<td>39.3701</td>
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</tr>
<tr>
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<td>0.3048</td>
<td>meters, m</td>
<td>3.280840</td>
<td>feet, ft.</td>
</tr>
</tbody>
</table>

(Al-Fuwaires, 2011)
Appendix D:

Human Research Protection Program - Institutional Review Board
To: PATRICK CONNOLLY  
KNOY 323

From: JEANNIE DICLEMENTI, Chair  
Social Science IRB

Date: 02/13/2013

Committee Action: Exemption Granted

IRB Action Date: 02/13/2013

IRB Protocol #: 1301013179

Study Title: Smart Furniture for Underprivileged Communities: A Milestone in Sustainable Development

The Institutional Review Board (IRB) has reviewed the above-referenced study application and has determined that it meets the criteria for exemption under 45 CFR 46.101(b)(4).

If you wish to make changes to this study, please refer to our guidance “Minor Changes Not Requiring Review” located on our website at http://www.irb.purdue.edu/policies.php. For changes requiring IRB review, please submit an Amendment to Approved Study form or Personnel Amendment to Study form, whichever is applicable, located on the forms page of our website www.irb.purdue.edu/forms.php. Please contact our office if you have any questions.

Below is a list of best practices that we request you use when conducting your research. The list contains both general items as well as those specific to the different exemption categories.

General
  • To recruit from Purdue University classrooms, the instructor and all others associated with conduct of the course (e.g., teaching assistants) must not be present during announcement of the research opportunity or any recruitment activity. This may be accomplished by announcing, in advance, that class will either start later than usual or end earlier than usual so this activity may occur. It should be emphasized that attendance at the announcement and recruitment are voluntary and the student’s attendance and enrollment decision will not be shared with those administering the course.
  • If students earn extra credit towards their course grade through participation in a research project conducted by someone other than the course instructor(s), such as in the example above, the students participation should only be shared with the course instructor(s) at the end of the semester. Additionally, instructors who allow extra credit to be earned through participation in research must also provide an opportunity for students to earn comparable extra credit through a non-research activity requiring an amount of time and effort comparable to the research option.
  • When conducting human subjects research at a non-Purdue college/university, investigators are urged to contact that institution’s IRB to determine requirements for conducting research at that institution.
  • When human subjects research will be conducted in schools or places of business, investigators must obtain written permission from an appropriate authority within the organization. If the written permission was not submitted with the study application at the time of IRB review (e.g., the school would not issue the letter without
proof of IRB approval, etc.), the investigator must submit the written permission to the IRB prior to engaging in the research activities (e.g., recruitment, study procedures, etc.). This is an institutional requirement.

Category 1
- When human subjects research will be conducted in schools or places of business, investigators must obtain written permission from an appropriate authority within the organization. If the written permission was not submitted with the study application at the time of IRB review (e.g., the school would not issue the letter without proof of IRB approval, etc.), the investigator must submit the written permission to the IRB prior to engaging in the research activities (e.g., recruitment, study procedures, etc.). This is an institutional requirement.

Categories 2 and 3
- Surveys and questionnaires should indicate
  - only participants 18 years of age and over are eligible to participate in the research; and
  - that participation is voluntary; and
  - that any questions may be skipped; and
  - include the investigator’s name and contact information.
- Investigators should explain to participants the amount of time required to participate. Additionally, they should explain to participants how confidentiality will be maintained or if it will not be maintained.
- When conducting focus group research, investigators cannot guarantee that all participants in the focus group will maintain the confidentiality of other group participants. The investigator should make participants aware of this potential for breach of confidentiality.
- When human subjects research will be conducted in schools or places of business, investigators must obtain written permission from an appropriate authority within the organization. If the written permission was not submitted with the study application at the time of IRB review (e.g., the school would not issue the letter without proof of IRB approval, etc.), the investigator must submit the written permission to the IRB prior to engaging in the research activities (e.g., recruitment, study procedures, etc.). This is an institutional requirement.

Category 6
- Surveys and data collection instruments should note that participation is voluntary.
- Surveys and data collection instruments should note that participants may skip any questions.
- When taste testing foods which are highly allergenic (e.g., peanuts, milk, etc.) investigators should disclose the possibility of a reaction to potential subjects.