The design of a seedling growing system for small-scale urban farmers in Soweto

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Seedling growing system

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Department of Industrial design

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ACKNOWLEDGMENTS

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ABSTRACT

This document is a study on the design of seedling growing system for small-scale urban farming. The design and research is based on the problem that farmers struggle with growing seedlings as a result of lack of resources and technology that is specific to their needs. Using participatory design methods a product was designed that is both fully functioning and is suited to the participants. The designs process explored how to incorporate all design considerations such as modularity, portability, protection against pests and extreme weather and easy watering into one complete, well-functioning system. The design and research was consistently undertaken with the active involvement of participants throughout the process. This refers to the research methodology of Participatory Action Research where designers design with participants rather than designing for participants. This study formed part of the broader Izindaba Zokudla project which aims at uncovering issues surrounding small-scale urban farming in Soweto through discussions and conversations with actively involved participants.

KEY WORDS:

Participatory design, Small-scale urban farming, Agriculture, Seedlings, Industrial Design, Soweto

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CHAPTER 1

INTRODUCTION

1.1 THE STUDY

1.1.2 Background and Context

The biggest event that effected contemporary agriculture into what is commonly experienced today was the Green Revolution that took place during the 1970s (Smillie 1991:105). The Green Revolution was an era of mass development in farming and included the extensive use of fertilisers and insecticides. Additionally with a focus on science, genetic modification brought about an increase of monoculture farming and hence a decline in biodiversity (Smillie 1991:105). Due to the seeds becoming more dependent on fertilisers, pesticides and better land quality, costs to farm with these seeds increased and became too expensive and out of reach for smaller farmers in developing countries (Smillie 1991:105). Subsistence farming previously enhanced food security but due to small-scale farmers not being able to farm with the expensive, genetically manipulated seeds, there was a major decline in subsistence farming. This decline results in food insecurity and poverty became a prevailing issue (Smillie 1991:107).

The problem area on which this study is based is that of challenges faced by small-scale urban farmers in Soweto attempting to produce seedlings for their farms. Inconsistency in seedling growth contributes to the issue of food insecurity which is one of the reasons why these farmers have started these small-scale urban farms in the first place. Food insecurity is a major contributing factor to the problem area explored by this research response. It must be noted that it is difficult to measure food insecurity and that there are varying models that different researchers have followed. In its simplest form, to be food insecure is to go hungry for more than three days a week (McLachlen & Thorne 2009:5). Another way is to identify if a household is food insecure is when a household has to spend more than 40% if its income on the purchase of food (Shisanya, SO & Hendricks, S 2011:509). In South Africa there is not a shortage of production of food as the commercial agriculture sector is well developed and successful. However, it is other factors such as economic stagnation, inflation on cost of food, unemployment and climatic factors that influence the food security rate in South Africa (Shisanya & Hendricks 2011:511).

Research into food insecurity has suggested that urban agriculture is a mechanism used most by the poor or food insecure to cope with their circumstances (Cloete, Lenka, Marais, Venter 2009:8). Urban agriculture, or community gardens as referred to by Shisanya & Hendricks

(2011:512), is a practice whereby households are provided with better access to affordable, nutritious and diversified local foods at lower cost. Milla McLachlan and Janine Thorne (2009:15) explain how subsistence farming contributes to food security in South Africa, in rural and urban context, through contributing to the livelihoods of households.

The research takes place in the context of Soweto, South Africa. Cloete et al (2009:9) conducted a study on food security in South Africa and found that Soweto is an area within South Africa that experiences food insecurity with community members spending more than 40% of their household income on food expenses. This suggests that there is an opportunity for *small-scale urban agriculture* (SCUA). Fortunately this form of agriculture is already being practiced in Soweto but lacks proper development or resources for it to become an effective solution to food insecurity as well as develop a local economy within Soweto. Figure 1 and 2 show the typical setting of a small-scale farm in Soweto and some of the problems farmers experience with resources.

There are numerous problems surrounding SCUA in Soweto, especially quality of resources, which allows for opportunities in technological development that will improve the experience. This study unpacks the challenges of growing seedlings in the community gardens within Soweto

Figure 1: Farm on school property in Tladi, Soweto.2014. Photograph by author

Figure 2: Current way of growing seedlings in tires. 2014. Photograph by author

with the goal to improve and develop SCUA through the design of some sort of technology.

1.1.2 Motivation and Significance of study

The motivation of this study stems from research undertaken on how produce is accessed in the context of South Africa and, more specifically, Soweto. The supply of food in urban cities in South Africa is considered adequate but not everyone has equal access to food, in addition, much food is lacking nutrition (McLachlan & Thorne 2009:9). The most pertinent motivation for this study is to use design to create a form of technology or product that will help farmers grow better quality seedlings faster and more easily. In turn this will help with the other issues surrounding SCUA in Soweto.

The significance of this study evolves from the motivation. The opportunities in SCUA have already been highlighted but there is very little information or case studies to show how these opportunities can be turned into real rewards. This study aims to serve as a case study demonstrating how design for a specific community can help in the sustainable development of an agricultural process. This study will also provide insight as to how to design a product that needs to work well on its own but also fit into existing systems whilst possibly creating new ones that bring change to the current food system.

1.2. PROBLEM STATEMENT AND RESEARCH QUESTION

Although small-scale urban farms are seen as a possible solution to food insecurity experienced in South Africa and more specifically in the context of Soweto, it is a practice of agriculture that is reasonably underdeveloped, lacking technological advancements, basic tools and resources that will help evolve small-scale urban farming into a successful solution towards food insecurity (McLachlan & Thorne 2009:15). Ian Smillie (1991:91) believes that the development of 'intermediate technology' is the correct way in empowering SCUF and that the technology should be suited to the context in which it was being used (Smillie 1991:91). His view on 'intermediate technology' is still very relevant especially to this problem area. Most of the tools and technology used by farmers in Soweto are not suited to the specific needs of SCUF possibly hindering the farming process and intensifying labour.

The central research question for this study**: "How can a fully functioning seedling growing system be designed to be suited for small-scale urban farmers?**

1.2.1 Aims and objectives

The aim of this study is to create a fully functioning seedling growing system that is specifically suited to small-scale urban farms in Soweto. The product focuses on the entire process from growing seedlings to the transplanting stage. The objectives of the study include making the product low-maintenance, durable, sustainable and to improve the farming process through this product. It is important to combine these objectives in a cohesive manner to produce a well-functioning and aesthetically pleasing end product. To make this product best suited to the end user it needs to be easily accessible and affordable.

CHAPTER 2

LITERITURE REVIEW

The aim of this literature review is to give the study a good foundation before conducting research and data collection. This is done by exploring small-scale urban farming and how it will influence the study and its outcome. Understanding the basics of growing seedlings and exploring and analysing precedent products will establish a framework and design criteria for the end product. Participatory design is the main design theory for this study with Participatory technology development as a sub-theory that focuses on participatory design in terms of agriculture.

2.1 SMALL-SCALE URBAN FARMING

Small-scale urban farming is not an entirely new phenomenon. Urban agriculture was commonly practised in pre-modern cities but the modernisation of countries led to the idea of separating the different uses of urban land and diverting agriculture to rural areas (Cloete, Lenka, Marais & Venter 2009:10). Due to a rise of food insecurity in South Africa, small-scale urban agriculture has become relevant again and is described as a 'mechanism used by the poor in order to cope' (Cloete et al 2009:8). However, the idea of the potential of urban agriculture as a contributor towards food security and economic development is still largely unexplored (McLachlan & Thorne 2009:11).

In South Africa, small-scale urban agriculture has been practiced in many urban areas such as Cape Town, Durban and Johannesburg, the city in which this study is based. In research undertaken by Cloete et al. (2009:9) it was noted that urban agriculture is already well established in Cape Town more so than Johannesburg, South Africa's most populace city. This highlights the significance of this study and how small-scale urban agriculture is a phenomenon that has scope for development and improvement, possibly through product design. The reasoning behind the differing stages of development within South African cities is due to the significantly different environments within the country. It is therefore necessary to design for the specific needs of the context in which this research project takes place (Cloete et al 2009: 10).

Although UA has proven to be a promising prospect, there are significant contributing factors to SCUA that have at times hindered its development (McLachlan & Thorne 2009:14). There are ongoing debates on policies around land reform in South Africa that effect the development of small-scale urban farms such as the government not clearly allocating land in urban areas for agriculture (McLachlan & Thorne 2009:14, Cloete et al 2009:11). These farmers encounter common problems such as pests and a lack of water supply as well as poor quality of soil on the land that is available to them (Cloete et al 2009:34). When designing for small-scale urban farmer in South Africa, there are challenges designers face and need to consider. These include ways to maintain and enhance food production while protecting the ecosystem; the cultural differences and needs of the community; resources available to urban farmers, all of which play a role in determining the end product (McLachlan & Thorne 2009:20). Improving food security is not the only benefit of SSUF. Stephen Shisanya and Sheryl Hendriks (2011:512) look at SSUF and how it positively influences certain aspects and skills specific to the farmer and their community.

They describe these benefits as:

- Access to fresh, nutritious foods
- The promotion of physical fitness
- Gaining knowledge and expertise in growing plants
- The development of shared decision making skills
- Problem solving and negotiation skills amongst farmers
- Building a sense of community

2.2 SEEDLINGS

Understanding the seedling growing process is vital to a well-designed product that will meet the needs of the users and provide optimum conditions needed for seedlings. This section looks at what conditions and resources seedlings need in order to grow successfully as well as what steps and tasks farmers need to perform.

The seedling growing process starts with choosing seeds and ends with transplanting the seedlings into the main garden bed (Fritz & Zlesak 2009:1). When planting seedlings it is suggested that seedling trays should be used to divide seedlings up individually to prevent the damaging of their roots (Fritz & Zlesak 2009:1). Using clear plastic domes on top of seedling trays helps in aiding the correct conditions for growing seedlings such as keeping moisture in the soil and creating a greenhouse effect. These lids do need to consider ventilation and need to accommodate the growth of the seedlings (Fritz & Zlesak 2009:1).

Although seedlings can grow in any soil it is suggested that using a combination of vermiculite (a variation of silicate sand) for drainage and peat (an accumulation of organic matter) provides a nutritive substance. This mix does not house natural weed seeds and has the correct texture and porosity for growing seedlings (Fritz & Zlesak 2009:1). Watering seedlings is also vital for them to grow successfully. It is imperative to keep the soil moist, but not too wet and never to let the soil dry out (Owen 1998:1). The next important step in growing seedlings is the transplanting process. It is here that most seedlings die due to transplanting shock or damage to the roots during the process. Removing seedlings from the seedling trays is a delicate process and users should never pick seedling up by stem (Fritz & Zlesak 2009:1). Using some of the soil in which the seedlings germinate during the transplanting process will help prevent transplant shock (Fritz & Zlesak 2009:1).

All of these factors affect the growth rate of seedlings as well as determining the success of a seedling. Some of this information can only be learnt by the users but if the product nudges users, who do not have proper knowledge on how to grow seedlings, they can still grow them.

2.3 PRECEDENT STUDIES

Precedent studies aid the designer with criteria that could improve the design of the product but without reinventing the wheel. Identifying the success and failures of existing products will highlight the gap in markets and help in adapting the product so that it is best suited technically and aesthetically to the user. This section explores examples that deal with innovation in functionality and aesthetics of products that can be related to the field of research.

The Seed Starting Ultimate Growing System by Burpee, seen in figure 3, (A garden is the best alternative therapy 2013) is a seedling grower starter kit that is aimed at residential gardeners. This product is similar to what this study aims to achieve as a complete growing system that can

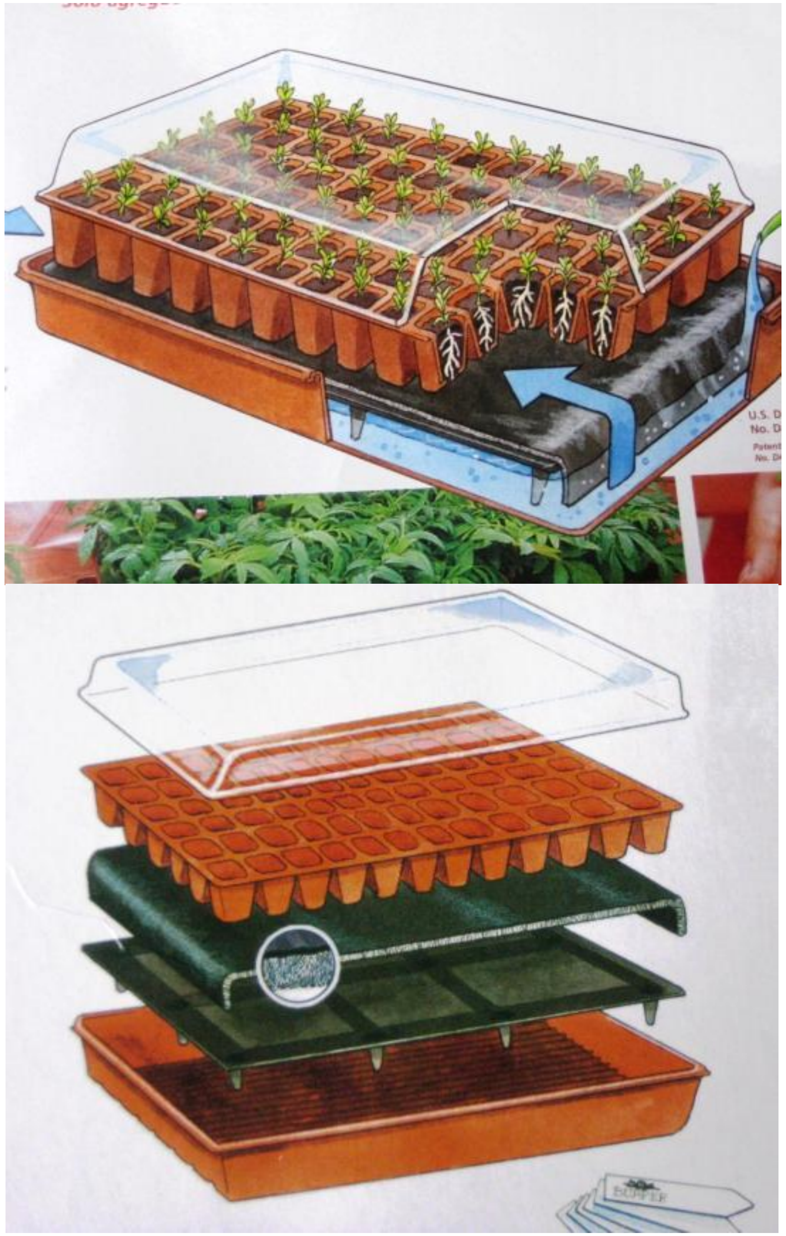


Figure 3: Burpee Seed Starting Ultimate Growing System (A garden is the best alternative

function on its own without too much interference from users. The Burpee ultimate growing system uses a water reservoir and a membrane to keep the soil moist as well as a plastic cover to keep the environment moist and humid (A garden is the best alternative therapy 2013)

When analysing precedents it is helpful to explore products that have a different approach to growing plants and seedlings. Jenny Sabin's Greenhouse and cabinet of future fossils, seen in figure 4, is a design that does exactly that. Her design is unique in the structure she uses and the numerous, colourful greenhouses stacked within the structure (Laylin 2011:1). The structure does not have one solid glass covering but instead creates greenhouses through multiple glass sheets within the structure. The structure is also stabilised through the curves in its shape and made from recycled and recyclable materials. This design presents the possibility of using a similar structure to house multiple seedling growers as well as creating the greenhouse effect in the seedling growers through sheets instead of clear lids attached to the product.

A precedent adopting a more DIY solution is seen in figure 5. Here users have recycled a common 2 litre plastic bottle into a miniature greenhouse to help grow seedlings. Through slightly altering the bottle it has transformed the bottle into a system that creates correct conditions for seedlings to grow. One of the key features of this design is that water is

Figure 5: Jenny Sabin. 2011. Greenhouse and cabinet for future fossils (Laylin 2011)

Figure 4: DIY seedling grower made from plastic bottle (Van Cotthem 2001)

saved through condensation when the bottle collects all the water vapour that is transpired throughout the process. The plastic covering also protects the seedlings from pests and insects. Even though this is a very simple solution, it works well and inspires the incorporation of easy, non-complex solutions into the design of the product for this study.

2.4 PARTICIPATORY DESIGN

This study follows a participatory research design. Participatory design also serves as a design theory that is a significant contributing factor to this literature review. This subheading discusses participatory design in terms of how it has changed the way designers, who have used it as their design method, view the design process and how it has changed the final outcome of projects and products. Participatory technology development is a sub-category to participatory design and gives better insight into the way participatory design effects agriculture.

Participatory design was first made popular or successfully practiced in Scandinavia in the early 1970s (Robertson & Simonsen 2012:4). Sanders, Brandt and Binder (2010:1) describe participatory design as a design approach in which users and other stakeholders work with designers throughout the design process. One of the main views centered around participatory design is that there should be an “active involvement of those who would use these new technologies”, although there have been different interpretations of this view (Robertson & Simonsen 2012:4). Studies undertaken on participatory design from its initial success in Scandinavia suggest that this theory and practice can vary and differ depending on the context of each study.

Traditionally the process for using participatory design includes the designer, users and other important stakeholders where the interaction and participation between these people would take place in an organised workshop (Hussain, Sanders & Steinert 2012:92). Through Hussain’s et al (2012:93) study in Cambodia on prosthetic limbs, they found that participatory design in developing countries works differently to what has previously been practiced. In their study they found that trying to organise all the participants to work together in one workshop was not practical and that designers and stakeholders should adapt to the environment that the users were part of (Hussain, Sanders & Steinert 2012:92). This concept will be relevant to this study and research as the designer will actively be involved with the participants and will have to find ways to adapt the design process to suit them and for them to educate the designer on what is most important for their needs

2.4.1 Participatory technology development

One of the main objectives of this study is essentially to develop a piece of technology that is suited to small-scale urban farmers in Soweto. This aim does not only concentrate on participatory design as a research methodology but on how participatory research development will influence the outcome of the design and benefit the participants. There is a large gap in the development of technology for 'resource-poor' farmers which is largely due to a concentration in research for agriculture in 'resource-rich' areas (Conroy & Sutherland 2004:1). Previously researchers and academics have tried to take technology that is intended for large-scale agriculture in developed countries and adapt it to developing farms that have not previously benefited from technological development. This approach was not seen as the best solution since the needs of the two contexts differ in the needs of the users. Using participatory design to develop technology to fit the specific needs of the users will be a better suited approach (Conroy & Sutherland 2004:2).

Using participatory technology development as a technique to ensure an effective outcome for a design is something that has been suggested for the development of sustainable technological developments in all areas of agriculture (Heiskanen, Kasanen & Timonen 2005:98). Evaluating technological development has moved away from the focus being on the function and design of the technology to a more user-centred evaluation to determine the success of a design (Heiskanen, Kasanen & Timonen 2005:98). It is essential to understand and consider the context in which technology is developed as well as the needs of the users. Designing a piece of technology is not based on what external participants perceive the problem area to be, but to use the participation of the community and end users to identify what the true problems are and allow them to have a significant input into the design and development of this technology (Heiskanen, Kasanen & Timonen 2005:99). This in turn makes the technological development sustainable as the end product does not become redundant and contributes to the sustainable economic development of the community and context where it takes place.

Using participatory technological development to aid the research component of this study will help identify what the participants classify as a technological development for them instead of what designers might perceive to be a technological development. Understanding the context and resources available to the users and participants will provide a framework used to design a piece of technology that is sustainably suited to their needs.

Through the exploration and understanding of these topics an initial sense of direction has been established for this study as well as highlighting specific themes that the design of the product will have to consider. Participation and participatory technology development as methodology and methods needed for this study and will be further explored in the next chapter. While understanding small-scale urban agriculture and the process of growing seedlings clarified the problem areas experienced in these topics and will aid the designer in finding the best possible solution when experiencing similar problems.

CHAPTER 3

METHODOLOGY

This chapter concentrates on the methodology that was used to conduct the study. The chosen methodology has to be suited to the specific area of study to ensure the correct and most accurate outcome for this study and the end product. This methodology will explore the research paradigm, design research, sample group, data collection and ethical considerations

3.1 RESEARCH PARADIGM

The chosen research paradigm for this study is qualitative research. Qualitative research is a research paradigm where the study is part of an intimate relationship between the researcher and what is being studied (Denzin & Lincoln 2008:14). This research paradigm allows for the 'generation of rich data' and allows the researcher to explore real life behaviour of participants while letting them speak for themselves (Kuper, Levinson & Reeves 2008:404). Since the researcher will be directly working with urban farmers to develop a seedling growing system in a specific context, a qualitative paradigm is most suitable.

3.2 RESEARCH DESIGN

The research design best suited for this study is participatory action research. This study constantly involved the participants and users throughout the design and research process in order to find the best possible solution. Ozanne and Saatcioglu (2008:242) describe the process of participatory action research as involving the participants throughout the research process from problem identification, design, data collection to analysis and application of research findings. The design for this study aims to actively involve the participants in the research process.

3.3 SAMPLE GROUP

Polkinghorne (2005:139) suggests that using qualitative research for a study requires the researcher to choose a sample group that can 'provide substantial contributions to filling out the structure and character of the experience under investigation'. The sample group for this study consists of six farmers who are part of the Region-D Farmers Forum. These farmers practice permaculture agriculture on a farm based on a school property called Sekakalaha Molepo, in Tladi, Soweto. The sample group comprises a mix of men and women with most of them being pensioners. English is not the home language for most of the members but they can communicate and express themselves in English. The sample group has experience in small-scale farming with some members currently attending a course to further their skills and knowledge.

3.4 DATA COLLECTION

According to Polkinghorne (2005:142) the most common method used in qualitative research for collecting data is interviews where the researcher can gain full and detailed accounts from an informant of the experience under study. Due to the nature of this study most of the data collected was done through interviews and focus groups. Most of the interviews done with participants were unstructured or semi-structured to allow for participants to give data that the researcher may not have initially accounted for.

Interviews were conducted in the initial stages of the study. The first interviews conducted were very informal and usually brief. The reason for this was just to inform participants about the nature of the study and get feedback on the current environment of the area of study as well as the most important problem areas, as well as building a relationship with the farmers. Polkinghorne (2005:142) mentions that participants are usually reserved in their answers possibly due to concerns about giving the correct answers or being weary of what they want to reveal. In doing a very informal initial interview explaining the study and the process allows participants to share more information later on. These interviews were done while exploring the farming grounds while the researcher took important notes of what the participants were saying during the conversation.

After a deeper understanding of the problems was in place, the study had a clearer direction and more formal and structured interviews were undertaken. These were conducted in a group setting as time was a contributing factor during field visits. The first group interviews were aimed at finding personal experiences with growing seedlings as well as what specific problems participants on the farm experienced. Clear visual questionnaires were also used to receive feedback on existing products related to growing seedlings. This feedback was used to discuss and sketch initial ideation with participants while analysing these images in the questionnaires.

Observations were constantly made throughout the study. Observations usually took place after the interviews with participants to give a secondary source of data for the researcher of the experiences described by the participants (Polkinghorne 2005:143). These observations were made by the researcher through taking notes and photographs that could visualise the environment and the problems participants were experiencing. The visual observations also allowed the researcher to identify problems that were not necessarily covered in interviews.

These interviews, focus groups and observations formed part of the initial data collected. The next step in the process was to analyse this data and use it as criteria for the design. The analysis of this data was done through highlighting common themes and analysing the most important problem areas as well as interpreting the needs and wants of participants. After this concept ideation and first prototypes of the design could be developed. An important form of data collection in this participatory action research study was allowing the involvement of the participant. Field testing and feedback on prototype and concept ideation was the undertaken.

3.6 ETHICAL CONSIDERATIONS

It is important for researchers to consider ethics during a qualitative study to allow the data to correctly present the viewpoints of participants (Polkinghorne 2005:144). The primary concern of ethics is the participants. The conditions of the study, concerning confidentiality and consent, were explained to the participants. The researcher had to inform participants of the process and progress of the study and be completely transparent in the findings of the study through sharing the information with those who would use the findings. See attached annexure A.

CHAPTER 4

FINDINGS & DESIGN

This study uses participatory methods for not only the background research phase but as well as the design research phase of the project. It is therefore important to discuss and explain the findings of the research in conjunction with the design process as they go hand in hand. Initial findings were conducted through interviews and observations which then led to user feedback. The user feedback was used to refine the design, prototype testing and implementation of the final prototype before finalisation. The findings and design of the product will be discussed in terms of the different phases that took place throughout the process.

4.1 PHASE 1: INITIAL RESEARCH

Before any form of design could take place it was important to establish a good background understanding of the daily practices of farmers and their personal experiences. Through this initial phase a better understanding of problem could be gathered in the findings of the interviews which would start to set basic design constraints for the next phase of the process.

4.1.1 Interviews and observations

The first observation was done during the monthly Region-D Farmers Forum (RDFF) in Soweto on the 13th of August 2014. The RDFF is a newly established local organisation aimed at aiding small-scale urban farmers in the community with knowledge and certain resources. From this meeting it was observed that approximately 15 farmers attended the meeting with the majority of the farmers being over the age of 50 and pensioners, for them farming is considered as their primary form of income.

Students were then allocated individual farms where specific studies would take place. The site this study would concentrate on is a farm situated on adult school premises of Sekakalaha Molepo, in Tladi, Soweto which was established in 2012. The first interview that took place on the site was in the form of a focus group with 6 participants on 13 August 2014 although only 3 farmers, P1, P2 and P3 spoke. The focus group discussed daily practice at the farm and aimed to gain insight into the specific challenges regarding the seedling growing process. Through initial observation the farmers appeared to be hard working and enthusiastic about taking part in the participatory design process.

Figure 7: First focus group. 2014. Photograph by author

Figure 6: Form of protection against pests. 2014. Photograph by author

The farmers explained that seedlings are currently grown in seedling trays inside car tyres or basins next to the vegetable gardens shown in fig 2 (P1, P2). Alternatively, seeding beds are used whereby seedlings are planted

directly into the ground (P3). These make-shift growers are then closed with or covered with potato sacks or shade netting (P3). The farmers expressed that the main challenge faced in growing seedlings is protecting the seedlings from pests, insects and birds. P2 explained that these pests "like the seedlings when they are still young" (Focus group 1 P2:57).

Seeds are currently bought from supermarkets such as Pick n Pay and Shoprite checkers costing between R11.99 and R13.99. Occasionally, farmers use seeds from plants harvested such as carrots and pumpkins to germinate new seedlings (P2). Some farmers drive all the way to Rosebank to buy their seedlings because they know that they have good quality and a variety of seedlings. There is not a single nursery in Soweto that sells seedlings either. The farmers expressed that if they had improved seedling growing techniques, they would wish to grow seedlings to sell at the local farmers market. P2 explained that many farmers prefer to buy seedlings that are "already done" (Focus group 1 P2: 52) rather than germinating their own. P3 explained that this is because growing seedlings "takes long" (Focus group 1 P3: 54). P1 added that the time taken to grow seedlings depends on the type of vegetable and the process may take between 7 to 10 days.

The first visit to the farm showed that the farmers have used most of the land on the school property and converted the grounds in to planting beds, shown in figure 1. When observing the seedlings it was noted that only a few farmers were growing seedlings, nowhere near what was needed in relation to the amount of land that was being farmed. Upon observation it was noted that farmers currently use unsuccessful DIY methods of protection such as covering seedlings with sticks and shade netting. The issue of pests was brought up during interviews but observations showed the seriousness of the issue. Figure 9 shows how rats have eaten through tyres where farmers have grown seedlings to eat the new vegetable shoots.

4.2 PHASE 2: QUESTIONNAIRES AND IDEATION

In this phase of the process farmers were shown a questionnaire on existing designs concerning seedling growth. Insight from this activity and from the previous phase allowed the ideation phase of the design process to start. Farmers were also asked to give their feedback on ideation concepts.

Figure 9: Pegasus hydroponics food growing system. 2013. (Hydroponics-The best food investment 2013)

Figure 8: Holes rats have created in seedling tires. 2014. Photograph by author

Figure 10: Miniature greenhouse with light.2010. (Lloyd 210)

4.2.1 Questionnaire

During the focus group session, farmers were asked to answer questions regarding precedent studies and products similar to the possible end product of this study as well as precedents regarding different types of seedling trays. The questionnaire can be seen in appendix B. The aim was to gain insight into likes and dislikes of the farmers regarding seedling related products. Although the questionnaires were handed out to 8 participants, only 2 were able to write down their comments.

The findings from these questionnaires showed that one of the biggest issues the participants found with most of the existing products was that they seemed like a lot of effort to maintain. The participants also favoured precedent products that had coverings over the seedlings as they felt that it was good protection against birds, pests and insects. Portability seemed to have influence on the participants. All participants preferred designs that were portable as opposed to those that were not because farmers may want to take seedlings to market to sell as another avenue for income. Findings from the questionnaire on the different types of seedling trays proved to be quite helpful. Farmers have difficulty with transplanting as it is not very easy to get the seedlings out of the tray. Most participants liked the idea of a biodegradable seedling tray that could be transplanted directly into the ground. The biggest concern with biodegradable seedling trays is the limited access and higher cost.

4.2.2 Concept Ideation

The ideation phase of this process was to explore basic design shapes in terms of the design constraints set by the findings in previous phases. The design constraints consisted of:

- Protection from pests, birds and insects
- Create some sort of greenhouse effect
- Protect from extreme weather conditions
- House a seedling tray
- Modularity
- Portability
- Easy and efficient watering

From these basic constraints the ideation phase took place. Most concepts in this phase explored the idea of having a clear plastic cover on a basic container that would house the seedling tray. From precedent studies and feedback from users, the principle of watering seedlings from below through capillary action was the chosen method of watering instead of watering from above. This method does not harm the seedlings when watering and will not over water them either. This principle was considered throughout the ideation phase. Aspects such as direct sunlight were also explored through the shape of the container. The modularity and stacking of these containers was roughly explored.

4.2.3 User Feedback

The ideation sketches (Fig 11) were shown to farmers on 20 August at Sekakalaha Molepo so that they could give feedback and inform the next phase of the design process. From this feedback it was discovered that the farmers require a product that is portable, modular and protects the seedlings from pests and insects. A new finding from this user feedback was the concern of sufficient ventilation of the container. One of the farmers explained that “a plant needs air to survive, so a seedling grower must be ventilated” (Focus group 2 P2:85). The farmers made clear from this feedback that there are 3 important things a seedling needs to grow, water air and sunlight. This finding added a few more basic constraints to the design.

The farmers preferred the concept of a manually operated product. A main concern raised was that of affordability and participants were concerned about the complications and cost implications of electric and solar power. The product must be easy to use but not expensive. P1 explained that they would “rather do it manually than something that works automatically but costs a lot of money” (Focus group 2 P1: 142). The farmers also insisted that the product must be easy to assemble, maintain and repair. When asked about concerns regarding theft, the farmers explained that theft is not an issue faced by the farms because of the awareness of the surrounding community.

Figure 11: Framers partaking in questionnaire and giving feedback on sketches. 2014. Photograph by author

Figure 12: Concept sketch showing initial ideation

4.3 PHASE 3: PRINCIPLE PROTOTYPE TESTING AND DESIGN DEVELOPMENT

With the basic design constraints being set in the previous phases, it was time to test the watering principle that was based on one of the precedent studies before the design could develop further. This phase consisted of two prototype tests based on watering the seedlings through capillary action. The results from these tests could then be used in further developing the design.

4.3.1 Prototype test 1

The first round of prototype tests was done on site at Sekakalaha Molepo school farm on 3 September 2014. The aim of this round of testing was to test which factors affected the principle the most to determine the perfect conditions for the watering to work.

This test had three variations of the principle with one prototype as a control, shown in figure 13. The first prototype used two containers that fitted into each other with big enough gaps between the two. This gap would be used to allow for an outer water reservoir. Both inner and outer containers had holes drilled through them to allow for ventilation. Both containers were completely covered to avoid pests from affecting the test. The same set of containers was made for the second variation test. The only difference was that one container used felt as means to absorb

Figure 13: Varition 1 of prototype test 1

Figure 14: Variation 2 of prototype test 1

water from the outer reservoir while the other used hessian fabric. This was to test which fabric would induce capillary action the best. Figure 13 and 14 show the first two variations of the test.

The third variation tested an alternative way of watering seedlings, not using the principle of capillary action. One of the biggest issues with watering seedlings from above is that the spray of water is too strong and damages or over waters the seedlings. For this variation of the test only one container was used with a lid on top. The lid had multiple holes drilled through it to disperse the water before hitting the seedlings.

The control for this test was purely an open container with no lid. All four tests were left on site for 2weeks. Participants were instructed to observe and take note on the progress of these seedlings.

Figure 16: Variations of first prototype testing. 2014. Photograph by author

4.3.1.1 The results

After two weeks, 17 September 2014, the prototype tests were retrieved from the farm to see the results and get feedback from the farmers. Upon first observation it was clear that the testing was not very successful in terms of growing seedlings. The control and test variation 3 grew more seedlings than test variation 1 and 2. Test 1 and 2 did not grow any seedlings. Analysis of this showed that there was too much moisture in the container and that the condensation over watered the seedlings and encouraged algae growth. The containers were also placed in direct sunlight so the temperatures inside were too high. This meant that the container needed a lot more ventilation and possibly offer some form of shading.

Figure 15: First prototypes being tested in the field. 2014. Photograph by author

The feedback from the participants reflected the same results. Participants suggested that the container needed more ventilation. Participants did say that the water reservoir lasted long and they did not need to refill it more than once a week.

4.3.2 Prototype test 2

The second round of prototype tests also tested the principle of using capillary action to water seedlings but took the results from the first test and altered certain variables and to find the correct balance for the principle to work. Each test used seedling trays made out of coconut husk to test for better absorption of water for the seedlings.

All 6 variations of the test tested the principle of capillary action. The first set consisted of test variation 1 and 2. Here the prototypes used two containers that would fit one into the other with room for the water reservoir. The top of the inner container was covered with clear plastic sheet to protect the seedlings. This plastic cover and inner container had significantly more ventilation than the previous tests. The changed variable between 1 and 2 was the material used to absorb water from the outer to inner container. Hessian cloth and felt cloth were used again.

The second set consisted of test variation 3 and 4. Here the prototypes were made identical variations 1 and 2 except that the clear plastic that covers the inner container was replaced with 30% shade netting. This was

Figure 17: Variations of second prototype tests. 2014. Photograph by author

Figure 18: Two containers that fit into each other used for prototype test 2. 2014. Photograph by author

to test if adding shade to seedlings would improve their growth. In addition shade netting also has good ventilation.

The last set of variations tested if more ventilation to the water reservoir would affect the growth of seedlings and the rate of which the reservoir had to be refilled. The prototypes for this set of testing were the same as variations 1 and 2 with the clear plastic cover on the inner container. The changed variable was that more holes were made in the outer container to ventilate the water reservoir.

4.3.2.1 The results

The results from this round of testing showed significantly improvement. The containers were placed in direct sunlight for at least 6 hours of the day. Within 5 days of planting the seeds, some tests already started to show sprouts breaking through the surface. This development started a lot sooner than the previous round of test which in 2 weeks produced no seedlings.

The containers with shade netting as covers showed the most promise. Of the variations, this grew the fastest. Testing hessian cloth and felt cloth also showed better results than the previous round of testing. Felt cloth stayed the wettest for longest. Hessian cloth was less effective with capillary action. The set of containers with more ventilation added to the water reservoir dried out the fastest. The reservoir had to be refilled

Figure 19: Prototype showing the different types of material used. 2014. Photograph by author

Figure 20: Results after 5 days for prototype test 2

more frequently than the other tests as well as both the cloths used in this set drying up faster than others.

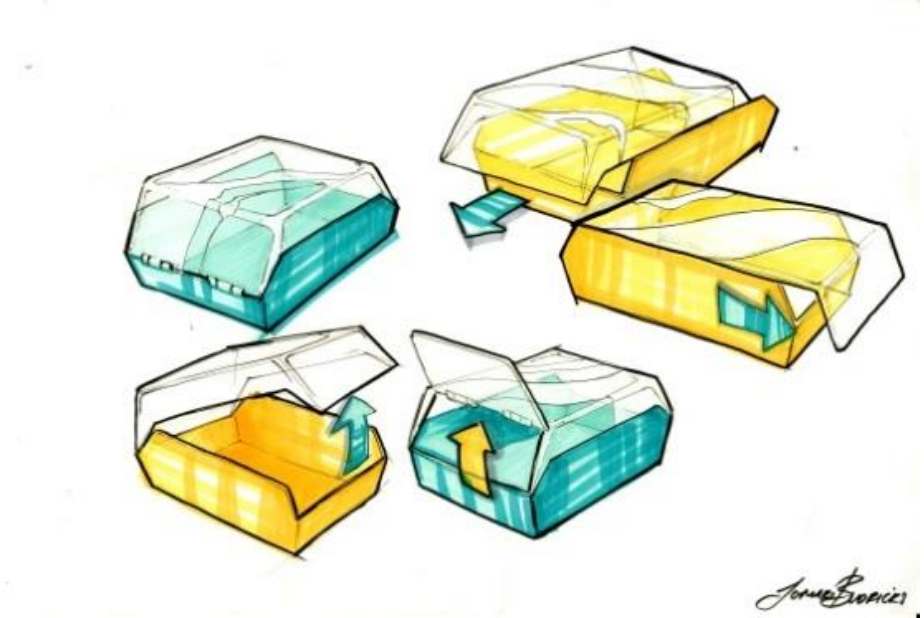
From this round of tests it can be concluded that shade netting provides the best results in terms of offering shade and ventilation. The principle of watering seedlings from underneath through capillary action works best using felt as the medium to absorb the water.

4.3.3 Design development

During the design development phase of the design process considerations such as materials and manufacturing processes started to affect the outcome of the design. Shape and form of the design started to develop to create a more aesthetically pleasing design. A stand for the product, to allow for modularity, was also explored through the design development phase.

Functional aspects such as access to the seedling tray while in the container through the use of a draw was explored as well as different possible ways to open the top clear lid of the container. The concept of using shade netting in conjunction with a clear plastic lid was considered to be the ideal solution at the time. The container had to be deep enough to house the seedling tray with a water reservoir. The idea of separating the water reservoir from the main container was considered as it would be difficult to transport the containers with water in them.

Figure 21: Concept sketch showing exploration of opening the container. 2014



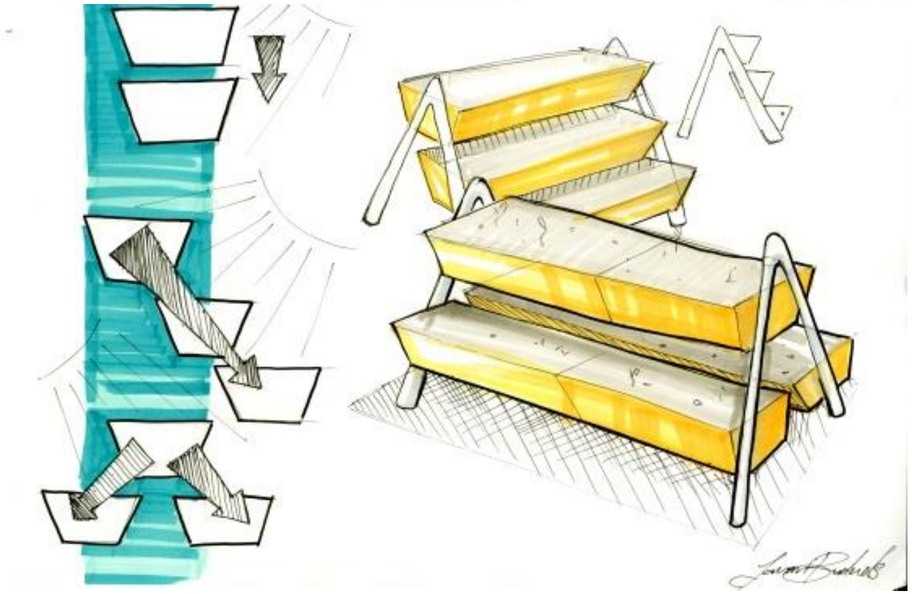
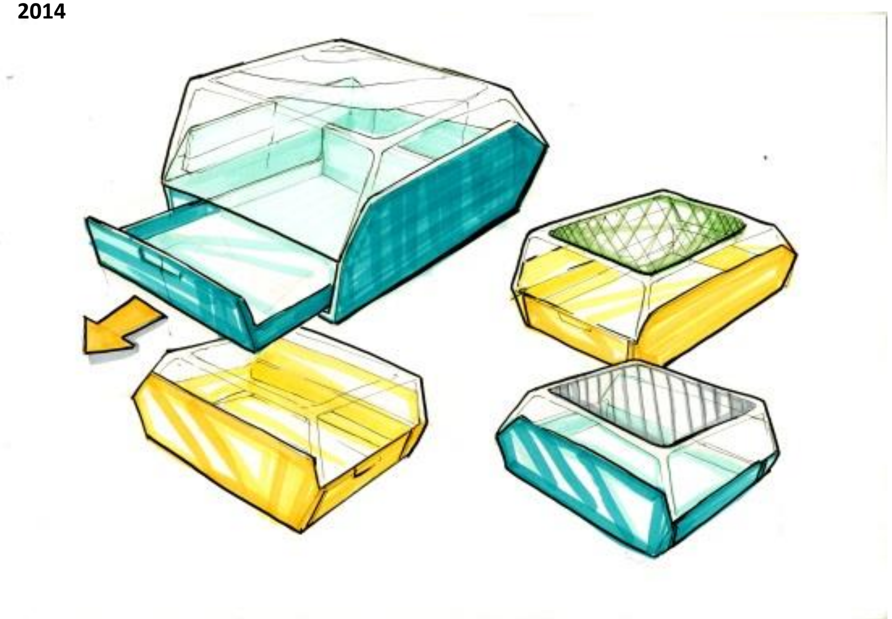


Figure 22: Concept sketch showing exploration of the design of the stand. 2014.

Figure 23: Concept sketch showing how a drawer could be incorporated into container. 2014



The basic design constraints for the stand, on which the containers would stack, were also established through the design development phase. The containers should be stacked in a diagonal step arrangement to allow for all containers to be exposed to sunlight. The assembly of the stand was initially explored trying to find an easy and cost effective way of assembling the stand.

Although there had been some considerable development in the design since the previous phases, there were still issues concerning the design direction. The container and stand working together as a system was not fully resolved. Initially plastic injection moulding was being considered as the form of manufacture of the container. This process would prove to be too expensive for a small batch of products for this study. Vacuum forming was decided upon as the better form of manufacture suited to the container. Using a clear plastic for the cover was also problematic since clear plastic degrades badly in the sun, even with UV stabilisers. Replacing the plastic cover completely with the shade netting would therefore be best suited to the design.

4.4 PHASE 4: REFINEMENT AND USER FEEDBACK

Reflecting back on the feedback and progress of the previous phases it was clear that the design needed to be refined into a simpler product and a fully integrated system. The refined design and a scaled prototype were then taken to participants to get their feedback before finalising the design.

4.4.1 Design refinement

From the previous phase it became apparent that the design developed into a complex and possibly expensive product. There were issues surrounding the manufacturing processes that were being considered as well getting the stand and container to work as a system.

To solve and refine the design from this point the container was refined and designed to be vacuum formed. The shape was therefore simplified and designed to be produced in one simple vacuum form. As a result of

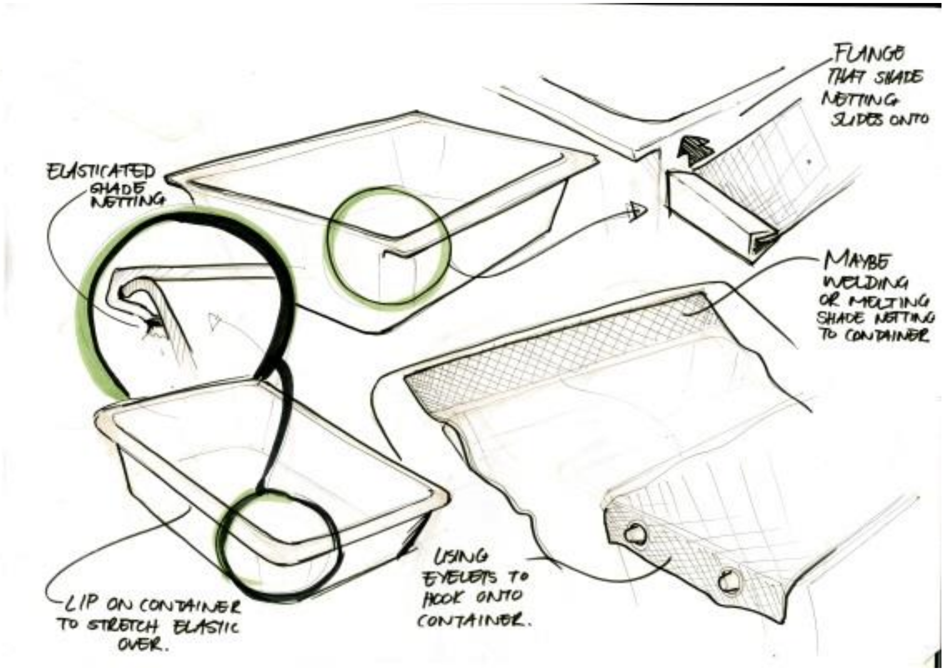


Figure 25: Concept sketch showing exploration of attaching the shade netting

this development the shape of the container had to have a significant draft taper to allow for easy release from the pattern. The container needs to be portable therefore indents on the sides of the container was added to act as handles as well as a platform for the containers to stack on top of each other.

One of the most important functions of the container was to house a seedling tray. The housing aspect of the design has to be universal for any form of seedling tray, whether it is a standard plastic tray, egg cartons or biodegradable trays. An inner island was added to the middle of the

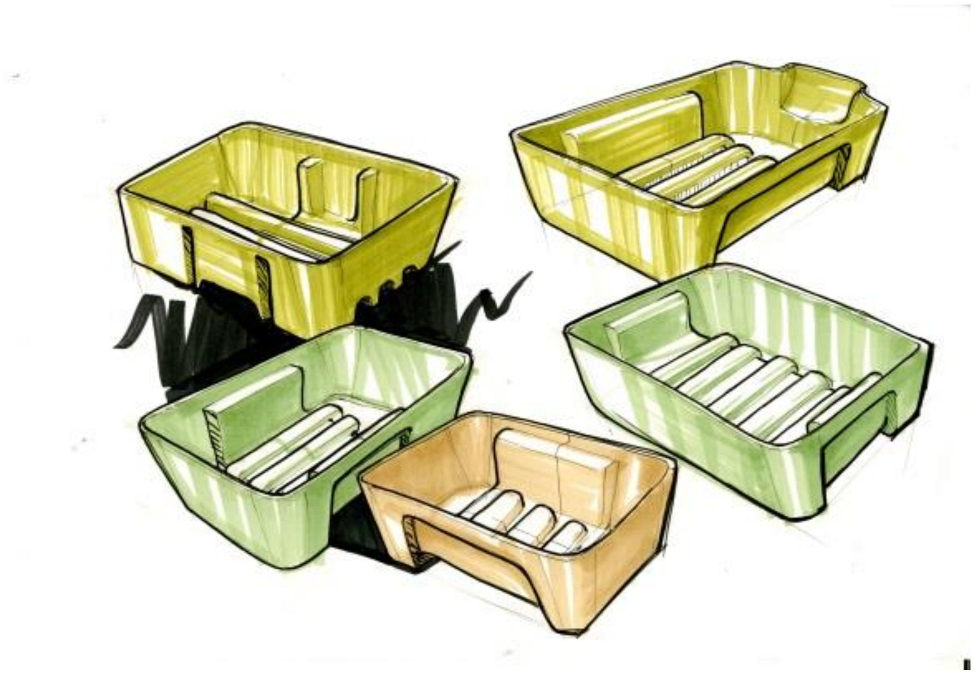


Figure 24: Concept sketch showing the refinement of the container shape

container to elevate the seedling trays out of direct contact with the water reservoir. This island also acts as a platform to drape the absorbent felt cloth.

The shade net covering was explored further in the refinement phase with different ways of attaching the netting. The attachment had to work with the container and could not be too complicated. The netting also required a tight fit to prevent pests, birds and insects from entering the container. The idea of sewing an elastic cord into the netting was explored as a possible solution.

Figure 27: Concept sketch showing the different functions and features of the container

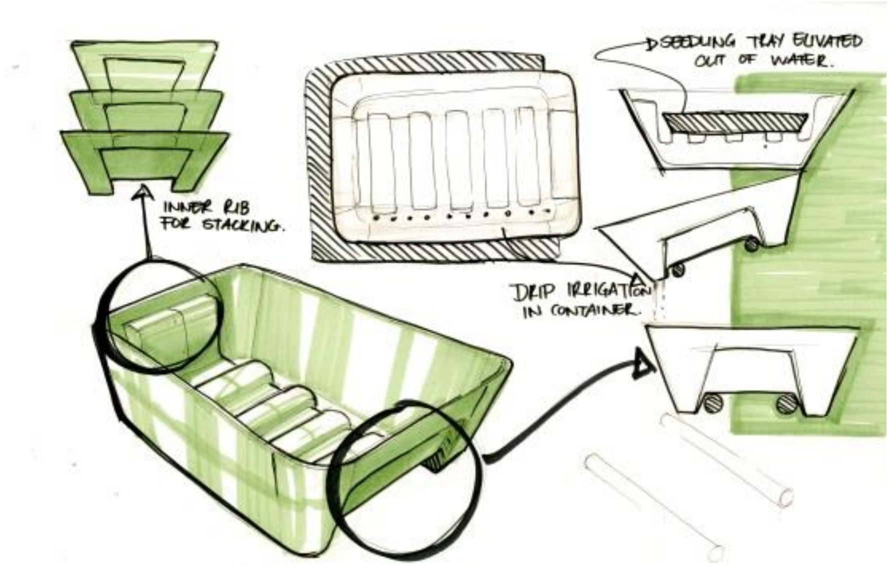


Figure 26: Stand exploration with different materials

The last aspect of the design that was refined was the stand that the containers would stack on. This stand had to work together with the container in a system but be easy to assemble and maintained at the same time. The stand would use a simple A-frame structure with an angled beam to allow the containers to be stacked in a step configuration to have direct exposure to sunlight. Materials such as wood and steel were considered for the stand. The wood would be easy to replace if the part had to break and the steel is smooth which would prevent pests from climbing up the stand.

The idea of using the stand to enhance the watering system was an important development of the design. Due to the nature of how the containers were stacked on the stand it would allow for water to drip from the top container into the next and so on. The top container would act as reservoir that would only need to be filled once a week and would keep the smaller reservoirs in the individual containers at the correct level. The drip rate needed be refined to a rate to ensure the volumes would last the longest whilst sufficiently watering the seedlings.

Figure 28: Scale prototype made out of cardboard. 2014. Photograph by author

4.4.2 Scale prototype

The next step in this phase was to test a scaled prototype in the field and to get feedback from the farmers. The scale prototype was made out of cardboard. The purpose of this prototype was to show users scale and proportions and how each aspect of the container would function. During the process of making the scale prototype it was immediately noticed that the scale of the container was too large. The size was based around a standard size of a plastic seedling tray.

4.4.3 User feedback

The users were showed the scale prototype as well as printed computer renderings of the container and stand assembled together.

The feedback on the container was that the size was too big. It was found that the seedling trays used by the farmers were smaller than the seedling tray than the one used to reference the prototype size. Additionally the taper could be reduced for manufacture, having reduced total width and breadth. It would therefore be easy to scale the container down to the necessary size and the seedling trays were accurately measured to do so.

There was some useful feedback on the design of the stand. Farmers were initially concerned about the size of the stand as they seemed to want to place it indoors. It was explained that the stand had to be placed outdoors during the day to expose seedlings to the sunlight but the individual containers could be kept indoors overnight if needed. There were concerns with the material of the stand. Farmers were concerned with using metal in the stand as it was at higher risk of being stolen to be sold for scrap.

4.5 PHASE 5: FINAL PROTOTYPE TEST AND USER FEEDBACK

This final phase of the design process consists of a final iteration of the prototype and a last user feedback session. The information collected from this phase will finalise the design in terms of any last forms of refinement.

4.5.1 Final prototype

The final prototype for this phase was made to show users visual and all the functional aspect of the product. Vacuum forming was used to make this prototype which is also the form of manufacture to be used when producing the product. Doing this gave insight into costing and problems that would occur when producing the product.

Figure 23 shows the mould used to vacuum. A female mould, made out of MDF, was used for this prototype. The mould was manufactured at

Figure 29: Mould made out of wood for vacuum forming

Figure 30: Prototype test with shade netting

SoiTech and vacuum formed at SoiTech on the 25th of October 2014. A female mould is best suited for a product of this size as the shrinkage that occurs is away from the mould to allow for the easy release. A sheet of ABS plastic was used to form the container. A basic shade netting covering was also used and included in this prototype. Shade netting is problematic when it comes to joining it to other materials. Due to this aim, elastic band attached with eyelets was used to fasten it to the container.

4.5.2 User feedback

This container along with computer renders of the complete product was shown to the users on the 29th of October 2014. Initially all the functions of the container were explained to participants. A standard seedling tray was placed inside the container to check if the container has been scaled correctly since the last prototype testing. The drainage holes were explained as to how they contribute to the watering system with the stand. Most participants had difficulty understanding this aspect of the design. This was possibly due to the visuals not explaining the watering system thoroughly.

The shade netting was another aspect of the design that had useful feedback from participants. The way the elastic attached the shade netting to the container was problematic as there were areas that could lift up easily and possibly let in pests. It was suggested that the elastic band be sewn in all the way around the shade netting similar to a shower cap.

Participants had issues surrounding the portability of the stand. They suggested that the stand should have wheels on it so they could push the stand to their desired location. It was then explained the complications of adding wheels to the stand which included: cost, weight, maintenance, accessibility however the stand has been designed to be stationary on the farm properties to avoid theft. The containers themselves stack easily without crushing the seedlings and can fit into any other form of trolley

Figure 31: Prototype being tested in field

to transport them.

CHAPTER 5
FINAL DESIGN

This chapter critically explains all aspects of the final design. All research and findings have led up to this point, and this chapter will show how this has influenced the design. Function, aesthetics, manufacture of product and brand identity of the design will also be discussed.

5.1 FUNCTION

The function of the product plays a very important role in making the product viable in the intended context. Participants lack resources and have a low disposable income so the end product needs to function properly for it to justify the cost and value of the product.

The first function, and one of the most important functions of the product, is the watering system. Through research and prototype testing it was evident that there were issues surrounding the way seedlings have been watered, mostly due to lack of watering. It was found that watering seedlings from underneath through capillary action works the best for faster growth of seedlings and without dislodging seeds which is a result from watering from above. This principle was incorporated into the design through creating an island in the middle of the container with ribbing. A felt cloth would drape over the island and the seedling tray would then be placed on top of that. The island in the middle also creates two water reservoirs on either side for the cloth to dip into to absorb the water.

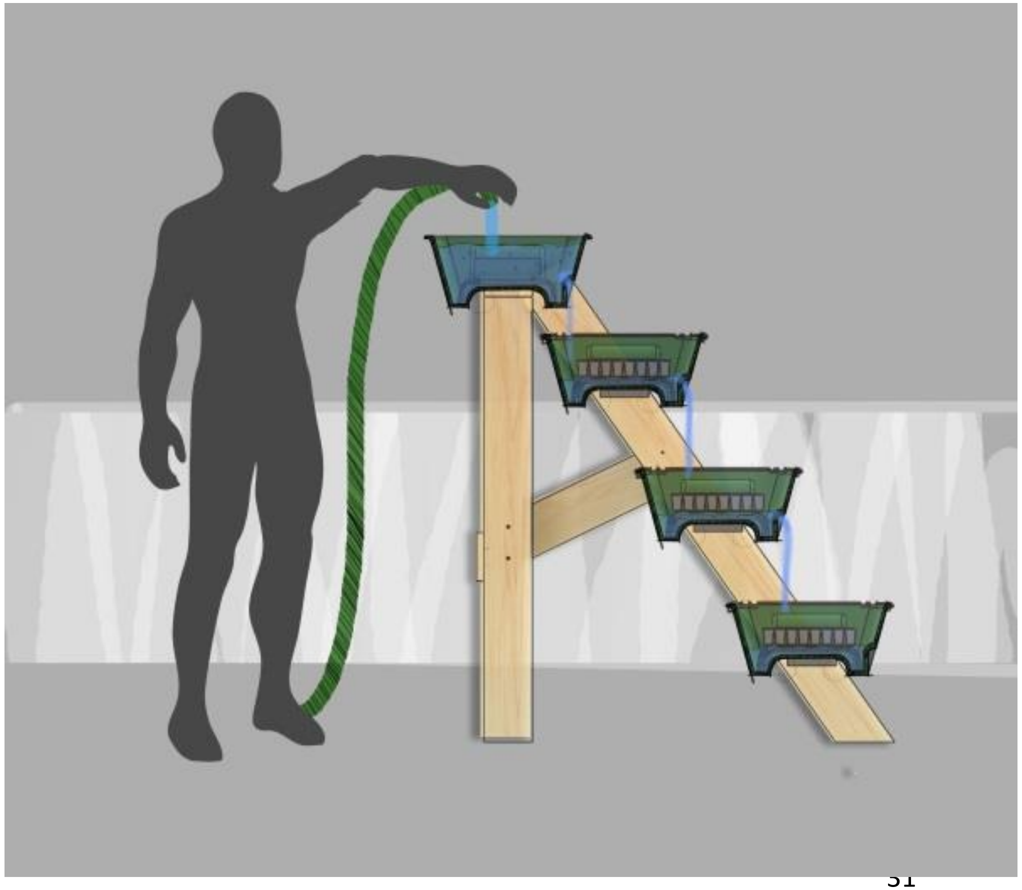


Figure 32: Diagram showing the watering system. 2014

The stand of the product contributes to the watering system of the product. Farmers had issues with watering seedlings regularly, hindering their growth. The stand allows for self-watering of the seedlings by having a large reservoir at the top of the stand that drips into the containers below. Each container has holes drilled in them that allows the water to drip from the one above to the container below. This drip rate is controlled by the size and amount of holes. The drip rate works so that the top reservoir empties out over the period of a week. Farmers therefore only have to fill up the reservoir once a weekly.

There are large ribs included on the side of the container. These act as handles to make it more comfortable to carry the containers. These ribs also help with the stacking of containers. The ribs leave a space between each container when they are stacked so as to not damage the seedlings in each container when transported to market.

The shade netting used on top of the container proved to be the best form of covering during prototype testing to help up the speed of which

Figure 33: Render showing stand and product assembled

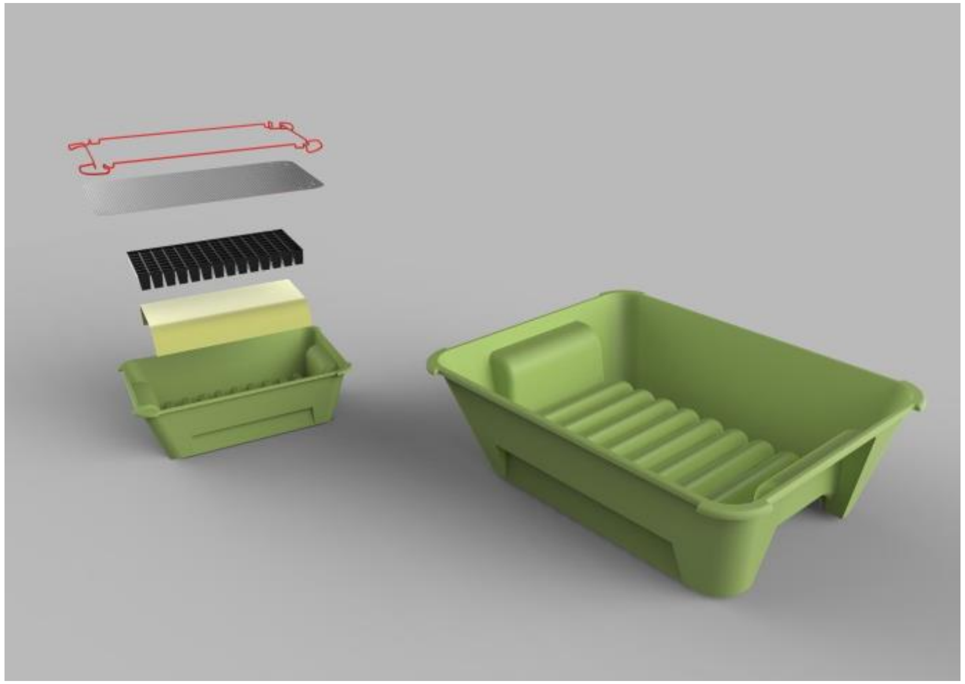


Figure 34: Render showing container and its other components

the seeding grow. The grade or intensity of shade netting should be between 30-40 percent but the flexibility of the system could allow for other grades or the use of plastic with ventilation holes. This shade netting cover is applied through an elastic band sewn in the edge of the shade netting. This netting allows for easy application of the shade netting to the container. The shade netting also allows for sufficient ventilation to the seedlings as well as protection against extreme weather and pests.

The function of the stand is not only limited to contributing to the watering system. The stand can hold 3 growing containers which deals

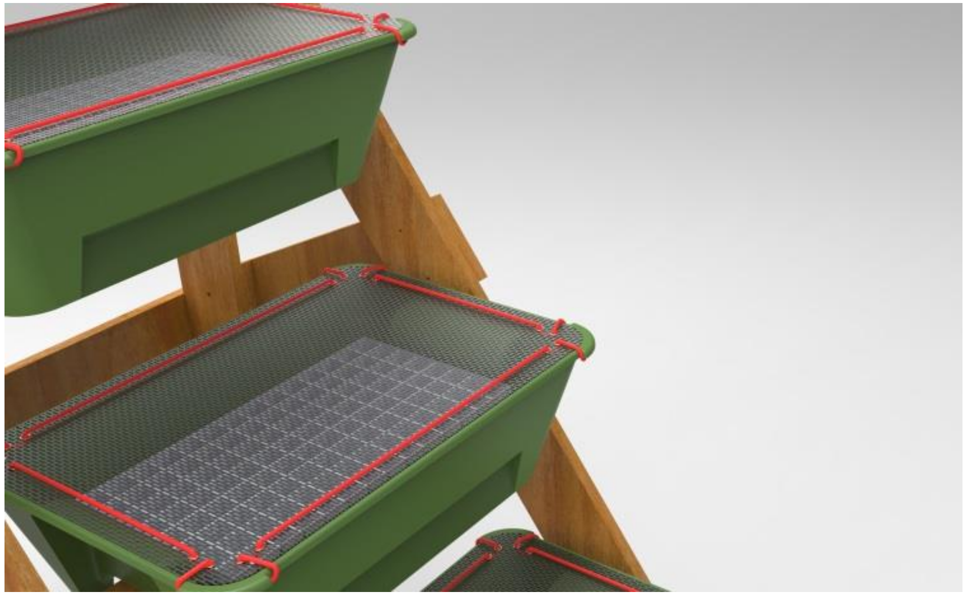


Figure 35:Render showing close up of how shade netting attaches to product

with the aspect of modularity discussed in previous phases of the design. Multiple stands can also be bought and aligned next to each other allowing the product to grow with a farm.

5.2 AESTHETICS

The aesthetics of a product also play a role in adding value to the product. If farmers find more value in a product the more likely they will take care of the product. The aesthetics of the product is mostly brought through the material choice and form giving of the product.

The container used a rectangular shape with large radii on all edges. This gives the container a softer feel. The container uses an earthy colour pallet as it fits within the context of a farm. This colour pallet includes shades of olives and browns. A lighter variation of these colours was used as a darker tone would attract too much sunlight and heat for the seedlings.

Black shade netting was used instead of green as the green would clash with the olive tones of the container but colours could be adjusted based on the market response. A pop of bright colour was added to the elastic of the shade netting. The wood of the stand will be kept natural with the logo burnt on the side of the stand. The natural appearance of the wood also works well with the earthy tones of the container.

Figure 36: Render of final product

5.3 BRAND IDENTITY

The brand identity and name of the end product needed to consider all aspects of the design and create an image of the function of the product through the name. The branding also needed to fit within the context that the product would be used.

Exploration of the product name started with words that were associated with seedlings and with the verb 'grow'. There were considerations of using Zulu versions of words to link it to the end users but the product could also be used by anyone who is interested in the urban farming therefore the language has the be as universal as possible.

'Take Root' was the final chosen name. Looking for synonyms of 'grow' is

Figure 37: Logo for final design

what led to this name. The name also has underlying connotations to the function and purpose of the product. The seedlings use a specific watering system where they are watered through their roots as well as this product helping farmer establish their 'roots' as an urban farmer.

The logo of the product needed to be simple but still incorporate a meaning or indication to what the product does. A simple sans serif font was used to make easy to read. The letter 'e' in 'take' was turned into a visual of a seedling. The word 'root' was placed at the bottom and made brown to symbolise actual roots of seedlings.

5.4 MANUFACTURE

The manufacture of the product was well considered to make the end product as affordable as possible. The container of the end product has been designed for vacuum forming. This form of manufacture can be done locally and is reasonably inexpensive (Thompson 2007:30). Vacuum forming also allows for lower quantities of the product which will be needed initially in the roll out of the product. Most thermoplastics can be vacuum formed but Abs is most common and inexpensive as well as easy to add a UV stabiliser to the material to make the product last longer in the sun (Thompson 2007:432).

The stand will be manufactured out of treated pine timber. This material is relatively inexpensive and does not have the risk of theft that other material such as metal had. Pine timber can also be purchased in standard sizes so it will be easy to replace if the stand had to break.

Standard 22x140x3000mm planks will be used for the stand. The planks of wood are assembled with screws. The planks that go across where the containers stack on use notches to push into the stand. This is done to limit the amount of screws needed to assemble the stand.

The shade netting uses a very simple form of manufacture. It will have an elastic band sewn in around the edges with a colourful piping added over the elastic to protect it and add some colour. The manufacture of it could form part of enterprise development with the opportunity for locals to sew the shade netting themselves as a form of employment.

5.5 COSTING

From the beginning of the study it was identified that the costing of the product needs to be suited to an amount the farmers are willing to spend. The cost of the product was kept low through low cost manufacture processes and inexpensive materials. Figure 32 shows the breakdown of the cost of one entire product (stand, 4 containers, 3 shade netting covers, 3 felt cloths).

Figure 38: Table showing break down of product costing

Start-up costs	
Mould	10 000
Tools and machinery	25 000
Per unit (500)	**70**
Manufacture (per unit)	
Vacuum forming	100
Sewing of shade netting	50
Materials (per unit)	
ABS plastic (R75 x4 containers)	300
Wood	450
Shade netting (R 3x3 covers)	15
Elastic (R3 x3 covers)	9
Cloth (R3 x3 sheets)	9
Assembly and packaging (per unit)	
Assembly of product	50
Packaging	50
total	**1103**

CHAPTER 6
CONCLUSION

6.1 CLOSING STATEMENTS

6.1.1 Summary of the outcome

The motivation of this study stems from the lack of resources available to SCUF especially in the area of seedling growth. Farmers struggle to grow seedlings successfully or in the large quantities needed to enhance the growth of farms. Problems surrounding watering of seedlings and pests on the farms became evident through interviews and observations during research of the study. This lead to the research question of "**how can a fully functioning seedling growing system be designed to be suited for small-scale urban farmers? "**

The function of the product was considered based on how farmers operate on the farms as well as research into how to change certain variables to improve the growth of seedlings. The main functional aspects of the design that was specifically suited to the needs of the farmers were that of the watering system and solving the issue of pests. Implementing a watering system that is low maintenance and helps the product become self-watering solved the problem of farmers not regularly watering seedlings. The shade netting is a simple solution to help with the protection against pests as well as improving the growth rate of seedlings.

The product is perceived as an investment to the farmers as it aids them in developing their yield in produce on the farms as well as offering a secondary form of income through having the option of selling seedlings to other farmers.

Through the use of participatory methods and continuous iterations of the design with participants a final design was established that suited the specific needs of the farmers. The function of the product solved problems surrounding the practice of growing seedlings on farms as well as improving the process to allow for growth of farms. This shows how the sully-functioning end product was designed for small-scale urban farmers.

6.1.2 Recommendations for further study

Due to the time frame of the study, sufficient and thorough testing of product in the field was limited. In an ideal condition the complete product would have been left on the farm for a certain period of time to fully test the functionality of the product. The growth of seedlings also takes between 2-4 weeks to reach the stage of transplanting. Prototype testing was limited to 2 weeks at most due to the time frame of this study.

Recommendations for the final design of the product include looking at improving the portability of the entire product instead of relying on existing forms of trollies. The drip rate of the plastic containers was not fully explored. Although the drip rate was measured for the reservoir to feed other containers it did not factor in drainage for excess water during rainy seasons.

There is opportunity for further research into the manufacture of the product. Although vacuum forming is well suited and reasonably inexpensive, it would possibly struggle with larger quantities if the demand of the product had to increase. There is a certain degree of fettling and secondary machining required after product has been vacuum formed which increases manufacture time. This can be solved through automated processes during and after vacuum forming, similar to how seedling trays are made in bulk. There is opportunity for further research into the materials used in the stand of the product. A material that is more durable but low cost at the same time could possibly be better suited.

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