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Sustainable Hub for Education and Demonstration

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The Sustainable Hub for Education and Demonstration

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Abstract

The Sustainable Hub for Education and Demonstration

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In our lives we are routinely confronted with images of climate change, resource depletion, and environmental degradation. The Sustainable Hub for Education and Demonstration (SHED) reflects my personal commitment to action in confronting this seemingly overwhelming problem. The structure embodies the practice of green building and makes connections among education, resource conservation, service learning, and community action. As a demonstration of resource conservation, the SHED was designed to be recycled, reused, or repurposed at the end of its service life. The materials of the structure will be reincarnated in another use cycle and no deposits will be made to a landfill. Educational and service learning goals of the SHED were achieved by the involvement of students from UW Tacoma and Clover Park Technical College. The participating students learned the advantages of green building and sustainable development while volunteering more than 1600 hours of time. Additionally, the

SHED has made a contribution to community action for sustainable development by being the first structure in Tacoma to use industrial hemp as a building material. Earth Day, April 23, 2016, marked a day that brought together students, community members, and industry professionals to install the hemp-lime wall of the SHED in the UW Tacoma Giving Garden. The SHED is small, but has large and lasting implications. It will remain in place and serve as a venue for sustainability education for generations to come.

Keywords: Green building, education, sustainable development, community.

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DEDICATION

For my children, Michael, Gabriel, and sweet Daniela

Chapter 1. INTRODUCTION

Individuals, working together, can achieve amazing results. Service learning can bring about positive change in a community. Combining the beneficial effects of green building, sustainable development, and community building, with the transforming attributes of service learning, has the potential of instilling positive change in society. Additionally, the hands-on interaction of building a green structure can help people understand sustainability in a way that affects their hearts, hands, and minds with an indelible impression. These theoretical concepts are the methodology and motivation for the Sustainable Hub for Education and Demonstration (SHED) project. The SHED is a green built structure designed as an educational venue for students and the community to learn about green building and sustainable development.

Russian scientist Mikhail Lomonosov developed the Law of Mass Conservation stating that "*for any system closed to all transfers of matter and energy, the mass of the system must remain constant over time."* This implies that mass can neither be created nor destroyed, it can only change forms (Pomper, 1962). If the mass of the world is a closed or finite system, it would make sense that the natural resources of the world are also a limited commodity. The challenge then becomes developing methods by which people can live within the carrying capacity of the world and wisely use its natural resources. At the present time, if everyone had the consumption habits of the average American citizen, there would be a need for the resource equivalent of almost five planets (Connett, 2013, p. 3). The analysis of consumption, waste, conservation, sustainability of natural resources, and how those subjects apply to the built environment are the catalyst for this project.

Buildings need to protect the occupants from elements like weather, water intrusion, and ultraviolet light, while holding heat and preserving air quality (ASHRAE, 2009). They must

withstand physical, chemical, and biological elements while maintaining the longevity of the structure (Lstiburek, 2009). Moreover, buildings must be designed for long term costs as well as initial construction costs (O'Brien and Smith, 2008). Thus, while the idea of a house may be easy to visualize, the adoption of a systems approach which yields a pleasant living environment that is broadly accessible to diverse groups, and environmentally responsible, can be a bit more challenging.

This project rationale focuses on the conceptual framework of green building and resource conservation combined with service learning to produce community action toward sustainable development. With a student design team and the aid of industry professionals to navigate the permits process, the Sustainable Hub for Education and Demonstration (SHED) was brought to life. The SHED, which is located in the University of Washington Tacoma (UW Tacoma) Giving Garden at 21st and Fawcett Street, stores tools and supplies for the garden and has a covered patio area for educational clinics. The project was designed to be inclusive of all ages, income levels, and to educate the community about green building and sustainable development practices. Its amenities include examples of straw bale and hemp-lime construction, together with a vegetated roof and a solar photovoltaic electric system. Additionally, the SHED was the first permitted structure in the state of Washington to include hemp-lime construction.

The objectives of the SHED project were to educate middle school and college students, together with the larger community, about the unintended consequences of construction practices which are steeped in overconsumption and waste. At the same time, they were presented with eco-friendly alternatives to those procedures and introduced to the practical experience of a real world application. Students participating in the building of the SHED learned about green building and the entrepreneurial potential of environmentally friendly business. With an

educational setting and the leverage of ideas, such as service learning in a hands-on application, combined with the endorsement of local businesses, positive community changes have taken place. Ultimately, students have been empowered with information, knowledge, and the skills of green building practices, while performing a social service and bringing positive change to the community.

The design strategy for the SHED was to reduce, reuse, recycle, and re-design, (what I call the 4-R approach), in order to take full advantage of raw materials and keep precious natural resources out of the waste cycle. The footprint and materials were reduced to the minimum for the functional requirements of the structure, and all components were reclaimed with the exception of the concrete and roofing. Recycled and reused products were used, whenever possible.

An outstanding achievement of the SHED was the fact that the design provided for its own deconstruction. Every board, beam, and cubic yard of concrete is able to be reused, recycled, and returned to a closed loop of materials use. This outcome is the result of an intent-driven design that does not allow for the use any co-mingled materials that limit components to one use (McDonough, Braungart, & Clinton, 2013). This system also makes a contribution to resource conservation by reusing the energy invested in the production of building materials. Globally, buildings consume a staggering 41% of total energy consumption ("Green Building Facts | U.S. Green Building Council," n.d.), and by taking a 4-R approach to the building process, the capitalized energy of products will stay in use rather than becoming waste in the landfill.

Because of the interdisciplinary nature of the project and its goals, there is considerable depth and breadth to the following sections of this project rationale. The SHED project amasses

the concepts of sustainable development, education, service learning, community giving, green building, and environmental entrepreneurship in order to examine the potential of positive community change. As such, a thorough analysis of content is necessary to provide the theoretical basis and foundational framework for the project. This 520 square foot SHED is not expected to cure the world's climate problems and be the answer to all building methodology, but it does open the door to the very important discussion of education, resource conservation, and the positive impacts this subject matter can have in the community.

In the following sections, the reader will be informed about issues that brought rise to the concept of sustainable development. The free market system, the environmental issues that have risen out of the overuse of an outdated paradigm, and the ideas to reverse the current environmental trends will be discussed. The methods and procedure for the SHED project will be introduced. Additionally, the project results, together with the analysis of the survey feedback, will be presented. Finally, a summary of how green building, service learning, and the education of sustainable development dovetail to promote community action will be given. This rationale of the SHED project will then provide a model and set the stage for community projects of the future.

Chapter 2. THE ISSUES OF SUSTAINABLE DEVELOPMENT

2.1 Defining Sustainable Development

The globalization of world economies has created huge markets with massive appetites for resources, resulting in the scarcity of natural assets and polluted landscapes (Minter, 2013). The paradigms of extraction, production, and consumption were a testament to innovation and empowerment of an extraordinary time, but the manufacturing practices of the industrial age have been overused and have ultimately led to an era of environmental degradation, natural resource depletion, and global climate change (Gore, 2006). Additionally, global markets have flattened cultural, economic, and environmental diversity (Elkington, 1997). In 1962, Thomas Kuhn pointed out that a change in basic social assumptions that govern our behavior will bring about a paradigm shift (Kuhn, 1962). If the planet, and the people on it are to enjoy a prolonged and prolific existence, they must bring about a change in the social norms concerning natural resources. This will stimulate a shift to the paradigm of environmental stewardship, and leave a softer footprint on the earth.

Sustainable development is often like the poem by John Saxe, *The Blind Men and the Elephant.* After six blind men conclude their examination of an elephant, none of them could agree what it looked like (Saxe, 2010). How humanity establishes a maintainable balance between people, profit, and planet is much the same as describing the elephant in the room while wearing a blindfold. The conversation is conducted by very caring and educated individuals, but they all have a different frame and bias that consequently makes for a challenging solution. One thing is certain, however, it will take the combined efforts of everyone in order to find an

acceptable process for sustainable progress. The causes of our current problems are interdisciplinary in nature, and the solutions will need to be interdisciplinary as well.

Just as there are many influences in the conversation, there are several perspectives being used to define sustainable development. In 1987, the World Commission on Environment and Development (WCED) produced a document titled, *Our Common Future,* which brought forward the first and most long standing definition: "sustainable development is that which meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987: 43). While the Bruntland Commission made an excellent effort of broaching the topic and its complexity, the definition was left open ended and a bit vague. The inattention to social, political, and cultural boundaries could quite possibly have been intentional in order to avoid the appearance of rigidity and radicalism, but the result ultimately was lacking in guidelines and structure. Dr. Wesley Schultz, a professor of psychology at CSUSM wanted to establish a social connection between consumption and the environment in the definition of sustainability. His contribution stated, "Sustainability refers to the balance between the rate at which a particular system is depleted and the rate at which it replenishes itself" (Schultz, 2002). This is also brilliant input to the knowledge surrounding sustainable development, but it is still not reflective of the interdisciplinary nature of the subject matter.

For the purposes of this project, I frame sustainability as: *Informed societal action that balances natural capital, human consumption, waste, and environmental costs to conserve needed resources for future generations*. This definition first takes into account the fact that people need to put forth well thought out plans that will minimize the unintended consequences of our actions. Secondly, resources are not infinite, and society must balance its consumption within the ecological production of natural capital. Lastly, the proclamation set forth takes into

consideration that individuals do not live in silos, progress is not an exercise in liquidation, and coming generations are dependent on our actions in the present.

Starting the community conversation of a shift from a philosophy of consumption toward the principle of conservation is the important factor here. In concert with these concepts, the design, location, and methodology of the SHED were planned to attract the public and open this discussion. This new model for construction has the potential of resource conservation with a practical application having environmentally friendly outcomes. The following section discusses the ecological changes brought about by the old paradigm of consumption which inspired a shift toward sustainable development.

2.2 Environmental Concerns

The current rate of development has advanced beyond what the global environment is able to rejuvenate, and these are the conditions the SHED was designed to reveal and challenge. Currently Europe consumes 2.66 times its rate of natural resource production, the United States uses 4.16 times its capacity, and the world population as a whole consumes 1.5 times its sustainable carrying capacity (U.S. Energy Information Administration, April 2003). The simple fact is that the model of overconsumption has become outdated, and needs to be replaced with a model of conservation and preservation. As the global population of the last fifty years has almost doubled from 4 billion to 7 billion, the earth's natural capital is being depleted, and caution is needed to protect the precious remaining reserves (Hawken, Lovins, & Lovins, 1999).

The consequences of anthropogenic activity over the last two hundred and fifty years is becoming increasingly evident. The air is filled with pollutants, the earth's water is being used and discarded without regard to hydrological cycles (Royte, 2009). Soil is exploited at an ever increasing rate in order to satisfy the consumptive habits of a perpetually expanding, global

population that is expected to exceed 11 billion by the year 2100 (Nordhaus, 2013). Additionally, the Intergovernmental Panel on Climate Change (2014) concluded that current socioeconomic progress is causing a rise of emissions and land use change that is resulting in an increase of global temperatures of 1-2 degrees Celsius, subsequently causing a global loss of glacial mass. Furthermore, over 4 million tons (the equivalent weight of forty aircraft carriers) of unaccounted for plastic packaging, or "ghost waste," is deposited into the ocean each year, polluting the seas and making its way into the fish we eat (Humes, 2013, p. 140). We are approaching the tipping point of enormous costs associated with health and safety concerns generated by a consumptive existence (Nordhaus, 2013).

These conditions are being accepted as the cultural construct and the social norm when they are clearly out of bounds. Socio-cultural changes need to be made in order that the ship we are piloting turns away from the collision course to which it is headed and preserves the future for our children and their families. If we are to make changes in our environmental landscape, we must shift the established social norm and change societal thinking from user to steward. Berger and Luckmann (1966) contend that we must first concern ourselves with what people know, or what they accept as reality in their daily lives, before we can make changes to the social structure. When people become aware of environmental changes and see that they have an intimate connection to a life supporting eco-system, they can be empowered to positively impact social norms toward environmentally friendly practices.

When individuals are instilled with a passion for environmental conservation and preservation, they will use that approach, infuse it within the community, and eventually modify opinions and social norms. Sustainable development is not possible without the involvement of citizens, who express and act on their concerns for environmental conditions in the future

(Nolberto, 2005, p. 21). This is the long term goal that informed the SHED project. The participatory process of individual efforts can have a dramatic effect on policies, procedures, and structures. This can directly influence the decisions of planning officials (Neefjes, 2000). Through personal action and involvement in community projects, community cohesiveness and constituent interests can flourish in civil affairs and have a positive environmental change (Edwards, 2010). Next, is a discussion of economic conditions that have precipitated the aforementioned environmental concerns and the development of green building practices.

2.3 The Free Market System

Adam Smith wrote of the "invisible hand" in *The Wealth of Nations*, arguing that people will act in their own self-interests by making the best possible decisions for themselves in each market exchange (Smith, 1776). The invisible hand then creates a self-governed, non-biased market. However, Smith's theoretical model has now evolved into a self-managing, unconstrained construct (Friedman & Friedman, 1979). Friedman and Friedman contend that the free market is a self-correcting/self-regulating system where transactions reflect the cost of supply and demand for the resources required for production. Governing controls just need to get out of the way and let the process happen. But from the framework of environmental concerns that has not been the result. Rising CO_2, global climate change, and increased waste deposits in shrinking landfills are just a few of the market failures (Humes, 2013). Ultimately, "the unregulated invisible hand sets the prices incorrectly when there are important externalities" in the balance (Nordhaus, 2013).

The free market system has become an established structure with a philosophy for extraction, manipulation, and disposal of natural resources that values money above all

(Elkington, 1997, p. 24). In Susan Strasser's book, *Waste and Want*, she cites several historical instances in which the economy has been either preserved, revived, or bolstered through the marketing and sale of goods that didn't necessarily have the best interests of consumers at heart (Strasser, 1999). Cleanliness, convenience, fashion, status, patriotism, and modernity have all been used as lubricants to keep the market wheels spinning. Even during the great depression when money was particularly scarce, consumers were encouraged to buy new products, because it "keeps the machine working" (Strasser, 1999, p. 203). The machine has grown bigger and stronger but at the expense of ecological integrity and a rising concern for waste. The world of business has become guided by exploitation fueled by liquidation of resources in which natural capital is the wealth which feeds the machine (McDonough & Braungart 2013, p. 26).

Even the basic human need for water has become fashionable, clean, convenient, and expensive (Royte, 2009). In the book, *Bottlemania*, Royte uses the case studies of Nestle's Poland Spring, Coca Cola's Dasani, and Pepsi's Aquafina to argue that the bottled water industry is affecting natural resources by draining aquifers, adding more products to the waste stream, and subjecting consumers to carcinogens such as phthalates and endocrine disruptors. She gives a revealing look at the position of the bottled water industry in the global economy and shows how the foundational resource of water is being abused. The waste stream is being flooded with plastic, the chemical composition of packaging is changing consumer health, and the rudimentary resource of water is extracted from the aquifers at unsustainable rates while being sold at prices that would make oil companies blush (Royte, 2009).

The larger issue here is that the flagrant abuse of a simple resource, such as water, is indicative of the pervasive attitude that the earth's assets are never ending and at our disposal. Consumption and discard goes without notice to the extent that the average American citizen

either wastes or causes to be wasted, 1 million pounds of natural capital per year (Hawken, Lovins, & Lovins, 1999, p. 52). As long as earthly supplies of resources are viewed as cheap, plentiful, and easily exploited, the value of natural capital will continue to be understated, and this again is the message of the SHED at the Giving Garden. It respects the resources employed in the design and demonstrates that the building elements can be reused as an additive component of the economy.

The point of this section is that the present paradigm of economic value is lacking. A market system based on volume of product, as in *Gross National Product* (GNP), values linear throughput and gives no accounting for the externalities of waste, environmental harm, and social progress (Lovins & Cohen, 2011, p. 287). Profit is the top priority for business, and anything that distracts or takes away from that end is eliminated from the scope of operation (Schwartz, 2000, p. 47). To that end, GNP is calculated by the amount of currency being exchanged. If there is no payment, say in the case of either community service or environmental pollution, there is no market recognition, no consequence, and no acknowledgement (Sandel, 2013, p.93).

The missing pieces here are well-being, knowledge, and societal investment combined with the consequences of greenhouse gases and global warming, which together give an accurate accounting of the world economy (Lovins & Cohen, 2011, p. 290). The effort here is not meant to denounce the use of the market economy, but to take a different look at how to work within it, and bring about a positive change. The marketplace can be very efficient and a necessary part of everyone's life, but there are some areas, like environmental degradation, that need to be more fully incorporated into economic calculations.

These ideas are part and parcel of the educational subject matter implicit in building the SHED. The project speaks to preservation, rather than exploitation and conservation before consumption, in an effort to spread the seeds of a smaller environmental footprint. Industrial hemp is one of the materials used in the building assembly and is rapidly renewable, fully recyclable, and sequesters carbon during growth (Allin, 2005). Along with these admirable qualities, the industrial hemp market is emerging as one of the most exciting new cash crops in Washington State, which will combine monetary exchange with social benefit. The straw bale and the vegetated roof components of the SHED are also alternative building techniques that add to an economic base. They are also circular in relation to operational life and the carbon footprint of the building (Calkins, 2009). By implementing intelligent and forward thinking design, we can help to perpetuate monetary exchange while preserving the environment into the afterlife of a product, thereby diminishing extraction as the primary source of remuneration.

2.4 Sustainable Development and Education

Infusing the curriculum of sustainable development into the education system has brought the ideas of inclusion and the structure of power to light and has provided an opportunity for students to examine core problems. MacGregor brought together a team of Washington based educators to form *Curriculum for the Bioregion* (MacGregor, 2011). The program was based at Evergreen State College and started in Washington State to bolster teaching and learning of sustainable development in different counties (MacGregor, 2011). Students were exposed to discussions of learning communities, habitat restoration, environmental justice, and climate change. In Poultney, Vermont, William Throop headed the formation of the Environmental

Liberal Arts program at Green Mountain College (Throop, 2013). The interdisciplinary program was reported to affect campus culture and operations while concurrently advancing the eco-literacy of students by aligning curriculum with the complex nature of sustainable development. Finally, Van Lopik, of the Menominee Nation tribal college, tells of his institution requiring an introductory sustainability class for graduation (Van Lopik, 2013). The class goals were to expose students to environmental, social, and economic systems, and also to critically think about past and present environmental perspectives. The result was an unexpected synergy of students reporting a renewed connection to the spirituality of the Menominee culture. These are just a few of the many reports of the benefits coming from the implementation of sustainable development curriculum, and one can imagine the benefits from the widespread employment of this philosophy.

Additionally, Schwartz interjects that a person's decision making is affected by their subjective experience of possibilities that are created through personal accounts of the world (Schwartz, 2000). The family is our first account of moral framing which is reinforced by the influences of church, state, and schools. All of these institutions combine to form the guidelines of acceptable social behavior and with these parameters, we go through life determining if our actions are socially acceptable. Ultimately, educational institutions help shape actions that are socially acceptable. The behaviors that are detrimental to our future sustainability could be seen in that light if educational institutions were to integrate that knowledge into curriculum.

Amory Lovins from the Rocky Mountain Institute recently finished his latest work titled *Reinventing Fire* (Lovins, 2011). In the book, he describes the transformation of the energy sector to a cleaner and more efficient running model. He asserts that this is one of the most important periods of time for human kind. Energy is being combined with the information age

where social and technological breakthroughs are happening so fast that one discovery is being morphed into another and yet another with no time laps in between. Lovins declares that one of the obstacles of the transformation to the new energy age is culture and knowledge. The fact that the general culture of the world is highly invested in fossil fuels and lacks the knowledge to break free from that particular monkey is inhibiting our ability to achieve energy independence. He further asserts that overcoming these barriers will require change in policy, regulation, innovation, and education. The technology is available; however, "the real barrier is the slow adoption rates, not the inadequate technologies" (Lovins, 2011, p. 247). This is yet another example that implementation of sustainable development, environmental entrepreneurship, and global stewardship in the educational system can help facilitate the changes that have been deemed necessary for entry into the new energy age.

The literature of this segment shows that students are instilled with a stronger sense of place, a better connection to community, and enhanced communication skills with the help of educational institutions. These ideas are the catalyst for the green building and sustainable development curriculum of the SHED project. Upon examining the literature, it becomes evident that the subject matter imbedded in the SHED will be vitally important to the community, and that the project will provide a great service. Additionally, as students are exposed to the new technologies, they will gain an understanding of real world application of those technologies. These are just a few of the outcomes of the transitional process from theoretical to physical, that is facilitated by the educational process, and which gives further weight to the concepts of sustainable development in the scholastic environment. The following piece of the discussion now incorporates education with service learning to produce community action.

2.5 Service Learning and the Community Connection

Service learning is an educational experience designed to serve a community need and provide a deeper understanding of the educational experience for students. It is becoming an increasingly frequent component of educational programs that provides a stronger connection between students, community, and educational institutions (Felton & Clayton, 2011). This connection then enables a stronger community with the transfer of informational needs between the community and institutions, additionally strengthening the educational tie between students and the community. Service learning frames the unique situation where the interdependence of all participants is brought to light and nurtured, while giving each player a different view of the social construct and concurrently cultivating empathy for others.

The educational experience of service-learning students has been greatly enhanced during the school encounter and after graduation. Students engaged in community service consistently performed better than students not engaged in a program. They developed better reasoning, communication, and critical thinking skills, and were more likely to engage in local political issues after graduation. (Felton & Clayton, 2011).

Service learning can be used as an avenue to help students of many different academic levels and a wide variety of personal attributes. In a study conducted by Davis and Chancey (2012), it was shown that involvement in service learning for students who may have normally lost interest in studies, kept their focus on school and actually resulted in a 12% increase in grades. Students reported to be more motivated to maintain their grades, developed personally, and exhibited more desire to do school work than other students during the course of the school year. Similar to the Felton and Clayton (2011) report, Davis and Chancey (2012) found an

increased level of personal growth, leadership, and critical thinking skills. Students experiencing barriers due to gender, race, physical abilities, and other reasons have taken part in service learning projects and experienced success and empowerment. In addition, the synergy of the activity was to develop a sense of belonging, agency, and connectedness to school and community.

In an effort to provide data about the impact of service learning, Leege and Cawthorn (2008) conducted a study that linked educational institutions and the dollar value of contributions to the public. Firstly, they again reported the benefits of service learning as a hands-on experience that encouraged environmental responsibility and increased student interest in community. But they also attached numbers to the popularity of the process with the examination of Campus Compact, a non-profit organization that promotes community service. Out of 1,045 institutional members, 91% of participating colleges and universities offered service learning in the curriculum, and 32% of the student body was enrolled in those class offerings. Results of service learning components at Georgia Southern University showed that 251 students contributed a total of 700 community service hours and when calculated at a standard rate of $18.77 per hour, the total infusion into the municipal area was $13,139 dollars' worth of labor that otherwise would not have occurred. Looking at the total picture of service learning, it is emerging as a benefit to students, educational institutions, people of the community, and the surrounding economy.

This project is no exception. The service learning time contributed by students to the SHED totaled more than 1600 hours over the first 22 weeks of the project. Volunteer time included building design, donation generation, marketing, and grant development. If the same $18.77 were to be applied to the SHED, a total of $30,032 of labor would be infused into the

community through students learning to serve, rather than be served. The project and enthusiasm of students also inspired local business to support the undertaking with contributions of machinery, concrete, framing materials, roofing, siding, hardware, and hemp products in the amount of approximately $30,000. The project and the experience the students were exposed to fulfilled the expectations of service learning by completing the circular loop between community, educational institutions, business community, and the network that occurs throughout the experience. The most interesting fact of the project, however, is that the majority of the time, participants were enjoying themselves so much they didn't even realize that service learning theory was happening. They were just having fun!

2.6 Environmental Entrepreneurship

Environmental entrepreneurship is a recent concept that creates an avenue for emerging startups, community, and the environment to exist in the business world together (Cohen and Winn 2007). It has been defined in the past by emphasizing the different parameters of economy, social community, value, profit, and environmental protection (Dean and McMullen 2007). However, for the purposes of this project, environmental entrepreneurship is defined here as *seeking out, promoting, measuring, and acting on opportunities for the sustainable development of commerce, community, and ecology*. Identifiers have emerged with names such as environmental entrepreneur, sustainable entrepreneur, eco-entrepreneur, ecopreneur, and sometimes social entrepreneur, but the constant is that they remain champions for the ecosystem while pursuing profits**.** Environmental entrepreneurship has begun to change the social construct and bridge the gap between industry and environment while influencing policy makers for the

future (Gibbs, 2009). Ultimately, it is the imperfections in neoclassical economics that provide space for the creative innovation of the environmental entrepreneur (Cohen & Winn, 2007).

Environmental entrepreneurship is democratic by nature, accessible to everyone, and as Isaak points out, green commerce is healthier, more economical, and more resource efficient (Isaak, 2002). The environmental entrepreneur will develop an idea, lobby for its adoption, cultivate the concept, and fulfill a market need. This is the "creative destruction" that supplies innovation and overcomes outdated operations to yield market transformation (Schumpeter, 1934). Conversely, businesses that are not green ultimately denigrate community health and decrease the longevity of humankind. Solutions are attainable using present technologies, but resolution is a matter of using political incentive and private creativity to find an agreeable result (Isaak, 2002).

The implementation of green business practices has the potential to be an example of efficiency, stewardship, and profitability to the corporate world (Schaper, 2002). Environmental entrepreneurship then acts to pull green practices into industry through efficiencies and cost savings, rather than to push or induce market entry by stimulus or governmental regulation. With the pull of market incentives being the propulsion of green industry, these practices are a value added piece on the corporate ledger books and greening the businesses is viewed as a generative asset rather than a siphoning requirement (Schaper, 2002). Gibbs, another prominent author on the subject, interjects that the environmental answer is a blend of personal, social, environmental, and financial considerations infused with the business and political decision-making process (Gibbs, 2009).

Support for environmental entrepreneurship and the recognition of its potential will bring solutions that correct the consequences of past marketplace actions. The ideas can be

accomplished through the strategic use of market and social enterprise, and transitional facilitation by academic institutions. The flow and process of business enterprise is well established and entrenched in the global market structure. However, the needed change is an infusion of environmental and social awareness that will establish the connection between commerce and community while guiding business management to the path of global transition through local action. These lessons of sustainable development, materials conservation, and environmental entrepreneurship can be introduced to students in projects such as the SHED. Participants of the project will gain an appreciation for limited natural resources and niche markets in the area of environmental restoration.

Education and academic facilitation in the community setting can change the viewpoints of participants and show them profitable vocations that respect the environment. Ultimately, individual pursuits can influence community action and bring about change in the social norm of environmental consumption. Therein lies the potential for the creative destruction of an exhausted methodology that belongs to the fading paradigm of consumption and waste (Schumpeter, 1934). Participants in the SHED project will then become the driving force behind a small instance of creative destruction, which will reach others and help to perpetuate the momentum of turning construction practices toward green building.

2.7 The rise of Green Building

Green building has been growing since Elkington's book, *Cannibals with Forks*, where he introduced his ideas of sustainable development and the triple bottom line of economic, social, and environmental dimensions to enterprise (Elkington, 1997). Hawken interjected with a monetary value of natural resources in his book, *Natural Capital*, warning that societal

consumption is overshadowing natural reproduction rates and measures are needed to stay within an ecological balance (Hawken, Lovins, & Lovins, 1999). Johnston and Gibson also added to the conversation with a building guide entitled, *Green From the Ground Up,* showing the attributes of energy efficiency and comfort associated with the new found environmentally friendly building method (Johnston and Gibson, 2008). The latest voices in the discussion are those saying that sustainable development is not impossible, it is within our grasp, and we need only to make the choice to be resolved in our commitment. It is also being said that there is entrepreneurial potential in this venture (Gore, 2009; Inslee, 2008).

This section will be devoted to the five most established systems connected to energy efficiency, green building, and sustainable design. Energy Star, LEED, National Green Building Standard, The Living Building Challenge, and The Passive House Standard have all achieved international notoriety and are leaders in their prospective sectors of the green building market. The following will give a brief introduction to each of the five standards and set the stage for an additional frame of view for the process of green building and sustainable development. Building materials and the process of building can be approached with a methodology that reduces the building footprint, but it is important to examine existing practices first. The point of this quick overview of building protocols is not to sit in judgement of them and poke holes in the good work that has been going on since the early 1990's, but to show how the ideas of the SHED project are filling a need that the prevailing building standards are not geared for and do not address.

2.7.1 *Energy Star*

The Energy Star program was established in 1992, and since its inception, has made great strides in raising awareness of climate protection while helping businesses and individuals reduce their energy consumption (ENERGY STAR, n.d.a). Energy Star has developed a third party rating system for energy efficiency of products including appliances, building products, electronics, heating and cooling equipment, lighting, water heaters, and office equipment. The Energy Star brand has extended itself into the residential new home market helping to reduce the energy footprint with the Thermal Enclosure Checklist, HVAC Systems Checklists, and the Water Management Checklists. The Energy Star label is earned for houses through either a prescribed or performance path to certification, and the same label is available to commercial buildings that score a 75 or higher using the Energy Star Portfolio Manager (ENERGY STAR, n.d.b). The Energy Star brand and label are linked with energy efficiency and used as the measuring stick to evaluate appliances and other products.

2.7.2 *Leadership in Energy and Environmental Design*

The Leadership in Energy and Environmental Design (LEED) building program is a point system protocol developed by the United States Green Building Council (USGBC) and was implemented in March of 2000 (USGBC, n.d.). The USGBC is an international group of builders, corporations, nonprofit organizations, teachers, students, and environmental advocates that was established by the three member team of Rick Fedrizzi, David Gottfried, and Mike Italiano in 1993 (USGBC, n.d.). Their goal was to challenge the building community to construct better structures that complement the environment, enrich communities, and provide healthier places to live and work. The portfolio of tools to accomplish the stated goal includes the LEED

building program, a credentialing system to qualify individuals to administer the program, educational programs that propagate the message of USGBC, advocacy systems that continue the momentum of sustainable development, and chapter organizations that create community solidarity and take action at the local and regional level.

Since the development of the LEED program, more than 3 billion square feet of buildings have been created with the new methodology to the tune of about 2 million square feet of globally certified space each day (Kriss, 2014). LEED buildings have kept 80 million tons of waste from entering landfills, attained lower energy bills in certified structures, lowered water consumption, and reduced storm water runoff for LEED built structures. Furthermore, the building system has created market diversification for those using the program, provided healthier and more attractive environments for tenants, and produced a higher investment return for maverick entrepreneurs using the protocol.

2.7.3 *The Living Building Challenge*

The concept of the Living Building Challenge (LBC) was devised in the mid 1990's by Jason McLennan while he was working on the design of the Epicenter in Bozeman, Montana. While a manager at BNIM Architects, McLennan collaborated with Bob Berkebile to develop the standard and in November of 2006, the program was formally launched (Living Building Challenge, n.d.a). The LBC mission is, "*To encourage the creation of Living Building, Landscapes and Communities in countries around the world while inspiring, educating and motivating a global audience about the need for fundamental and transformative change."* (Living Building Challenge, n.d.b)

The “Challenge” is based on the idea of a flower that has seven categories of performance termed Petals. They are Place, Water, Energy, Health & Happiness, Materials, Equity, and Beauty. Each petal is positioned within a list of twenty imperatives of sustainable development, and the system as a whole is said to blend itself with any type of project, scale, and location of either new or existing construction (Living Building Challenge, n.d.c). The LBC differentiates itself from the other protocols through the use of imperatives that concentrate on subject matter such as Limits to Growth, Net Positive Energy, Biophillic Environment, Red List (having to do with materials), Equitable Investment, Beauty, and Spirit. Ultimately, the “Challenge” is to take a holistic view of the building process.

The most noted accomplishment of the LBC is the Bullitt Center in Seattle, Washington, which is a 50,000 square foot six-story building that sits on the hill in the Central Area of Seattle and serves as the new headquarters for the Bullitt Foundation. The project has a relatively small footprint of 10,000 square feet and uses 26 ground-source heat wells that reach a depth of 400 feet which supplies all the climate control needs of the building. The drinking and irrigation water are supplied by a catchment system that is collected in a cistern and treated to potable standards. The electricity for the building is provided by a 575 panel system that amounts to a 244 kilowatt array. All of the wood products are Forest Stewardship Council certified. The building is filled to capacity with 10 tenants and an educational program with more than 60 visitors per day is maintained (Living Building Challenge, n.d.d). Additionally, it upholds a theme of transparency with a video screen showing real time monitoring of all utility production and consumption. If that were not enough, the Bullitt Center holds the designation of being the greenest commercial building on the planet.

2.7.4 *ICC 700 National Green Building Standard*

The National Green Building Standard (NGBS) is administered through the National Association of Home Builders (NAHB), accredited by the Home Innovation Research Labs (a subsidiary of the NAHB), and is the first residential green building standard to be fully recognized and endorsed by the American National Standards Institute (ANSI), (Home Innovation Research Labs, n.d.a). The Home Innovation Research Labs were previously known as the NAHB Research Center and has been responsible for product testing, industry consulting, and market research, but in 2008 the NGBS was developed. Now in 2016, it is partnering with the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), and the International Code Council to form the third iteration of the standard.

The NGBS is third party verified and is flexible in that the structure can be modified on a consensus basis to fit different regions of the home builders associations and assures high performance in the six areas of Site Design, Resource Efficiency, Water Efficiency, Energy Efficiency, Indoor Environmental Quality, and Building Operation & Maintenance. The NGBS focuses on the three qualities of Healthy Homes, Lower Operating Costs, and Sustainable Lifestyle through a point system (Home Innovation Research Labs, n.d.b). The structure can be awarded either a Bronze, Silver, Gold, or Emerald level of certification and is much less costly than other certifications ($500 for a non-member builder and $200 for the NAHB member).

Between 2008 and 2016, over 70,000 homes have gone through the certification process. The NGBS has been linked with improvements to indoor air quality, proper ventilation, and reduction of mold and contaminants while promoting sustainable development. In addition, it has accomplished all of this by preserving natural resources and encouraging walkable

neighborhoods. The Home Innovation Research Labs provide market, building science, and product research with marketing for new and remodeled homes using the NGBS (Home Innovation Research Labs, n.d.c). They have also formed an alliance with the U.S. Department of Housing and Urban Development (HUD) to help create the Partners for Advancing Technology in Housing (PATH) which is aimed at progressing the ideas of scientific development in residential construction.

2.7.5 *Passive House Standard*

The Passive House Institute US (PHIUS) is a non-profit organization founded in 2007, by Katrin Klingenberg and Mike Kernagis. The organization oversees national and international research, training, certification, and outreach of the Passive House Standard. The five design principles of a Passive House are to employ a continuous insulation barrier, build an airtight envelope, use high-performance windows, install a low-energy balanced heat and moisture recovery system, and manage solar gain to take advantage of the sun's energy (About PHIUS, n.d.a). The methodology of the passive design was first started in the 1970's through funding from the U.S. Department of Energy and the Canadian government. The German Passivehaus Institute was next to develop the ideas in the 1980's, and in 2002, Katrin Klingenberg built one of the first Passive House homes in the U.S.

Since its inception, the PHIUS has trained more than 1,700 industry professionals including engineers, architects, and energy raters and certified more than 120 structures. It is now annually hosting the largest passive house conference in North America (About PHIUS, n.d.a). The PHIUS has also made efforts of entering the affordable housing arena by partnering

with Habitat for Humanity, Rocky Mountain Institute, the U.S. Department of Energy, Carnegie Mellon University, and the University of Oregon.

PHIUS is a third party designed and rated system that is heavily dependent on performance rather than points and is specifically designed for the climate zone of each individual project. Each passive building is designed with the combination of help from a PHIUS accredited designer and the use of construction modeling software which is developed and supported by the Residential Energy Services Network (About PHIUS, n.d.b). The structure is designed specifically for annual heating and cooling demand and peak heating and cooling loads for energy consumption per square foot of conditioned floor area. The energy usage of the project is determined through the combination of energy modeling, National Renewable Energy Laboratory (NREL) information, and the International Energy Conservation Code. All fenestrations of doors, windows, etc. are extremely efficient and air tight, and heat recovery systems are included in the designs.

The Passive House design is pointed at one specific idea of reducing the carbon footprint of housing, and every component of the process is planned to that end. The program strives for results, and the rigorous performance standards and inspections insure the outcomes. The PHIUS has been the recipient of numerous awards for building design, building components, and building performance. The Passive House standard is one of the most energy efficient protocols, and its popularity and brand recognition are gaining momentum every year. The certified structures carry the distinction of being U.S. Department of Energy Zero-Energy Ready Homes (About PHIUS, n.d.c).

2.7.6 *Analysis of Protocols*

There are many opponents and supporters of the green building standards. Owen, in his book, *Green Metropolis,* is very critical of LEED saying that it is nothing more than a system of building point totals, and the designers are nothing more than "LEED brain" in their thinking (Owen, 2009, p. 234). On the flip side of the coin in the book, *Getting Green Done,* Schendler sings the praises of the USGBC and the LEED system by saying "LEED has done wonderful things for the movement…" and "It is the number-one reason that green building hasn't festered in a small, dark, radical corner" (Schendler, 2009, p. 178).

While all of the previously introduced building systems have been instrumental in breaking down barriers to green building and bringing awareness to the ideas of energy and resource conservation, it is difficult to see how the end of operational use is designed into the protocols. All the building protocols will recycle and use recycled material, employ reused material in various applications, and are conscientious about natural resources. Energy Star is probably the single largest contributor to the growth of energy conservation in the U.S. However, the one idea that remains understated is that of "end of use" and designing for the next use. Component parts need to be designed to feed the reuse cycle and maintain the autonomy of constituent materials, so no additional processing is necessary for the process to take place.

The deconstruction practice then becomes a "leave no trace" practice that would restore the building site to pristine condition. The following is an analysis of the approach taken toward natural resources and the building materials used in the SHED project, which provides more clarity to the theoretical underpinnings of the project.

2.8 The Importance of Materials Conservation

Buildings in aggregate consume 40% of global materials, account for 14% of all potable water consumption, and use 41% of total energy consumption. Additionally, in the U.S., they consume 73% of the electricity and produce 38 % of America's CO_2 emissions ("Green Building Facts | U.S. Green Building Council," n.d.). The construction industry has an impact on the environment, both locally and globally, which gives rise to the potential of conservation in this area. The reduction of impacts, however, may be partially answered in the following 4-R Procedure (Re-cycle, Re-use, Reduce, and Re-design).

2.8.1 *Re-cycle*

Recycling is a practice considered both virtuous and sustainable (Kurugöl & Tekin, 2013; Seftiuc & Vasiliu, 2011). The action of identifying and separating materials shows a great respect for scarcity of resources, while entrepreneurial profits have been found in the discards of others (Minter, 2013). As it turns out, there are multiple benefits in sorting through the trash. Recycling scrap materials, using building materials containing recycled scrap, and the dismantling of old structures all have potential for income and landfill avoidance (E.F., 2002).

At the Romanian "Gheorghe Asachi" Technical University of Isai, Seftiuc and Vasiliu conducted a study of the potential for recycling demolition debris and found that 40% to 50 % of the observed material was brick and mortar, 20% to 30% was wood, and 20% to 30% was mixed solid waste such as metal, plaster, glass, insulation, and electrical items (Seftiuc & Vasiliu, 2011). The claim was that materials recovery could help reduce solid waste landfill deposits, control landfill fees, and reclaimed resources could ultimately be used as the feed stock for

newly made building materials. Additionally, in Turkey at Mimar Sinan Fine Arts University, the department of architecture found that waste sorted by agricultural, construction, industrial, and domestic could be recycled into products such as particle board, aggregate padding, reused metals, and reused glass (Kurugöl & Tekin, 2013). The contention was that a large amount of waste products were available, and after reviewing the literature of market prices and the personal accounts of researchers, value was discovered in everyday waste (Humes, 2013; Minter, 2013; Connett,2013).

The studies from Romania and Turkey were conducted in different academic genres, and the results were very much in parallel. The bigger significance of these works, however, was not that similar results of value and recovery were found, but that market value for recycled material was found independent from each other and half a world away from the United States. This suggests that there is global potential for monetary value from discarded items, and the compounded leverage of entrepreneurial involvement will keep these articles out of the waste stream.

While the SHED is small and the potential for recycled product is somewhat minor in the grand scheme of the construction industry, much of the product it is built from has either been recycled or recovered, and the structure is fully recyclable at end of use. The concrete used for the foundation and the horizontal walking surfaces has great potential to be recycled for aggregate in other structures. Additionally, a bit of artistic fun was had when recycled wine bottles were used as “light tunnels” in the hemp lime wall. The use of multi-colored bottles helps bring light to an otherwise dark structure and accomplishes the objective with an esthetic presentation. The most significant of the recycled products, however, is the TAGRO growing medium used for the vegetated roof. It is soil made from the solid waste sewage collected from

the local community, treated, blended with soil and sawdust, and then marketed back to the community as topsoil and fertilizer products. TAGRO has seen a growing market for several years and is bringing a clean sustainable solution to a waste problem of particular notoriety.

2.8.2 *Re-use*

Since the development of green building protocols, the deconstruction and reuse of building materials has gained attention (Manuel, 2003). Historically, construction and demolition (C&D) waste has generated thirty times more volume than that of municipal solid waste (MSW), and in 2006 the EPA reported C&D waste to be 7.6 billion tons while MSW was 2.5 million tons (Calkins, 2008, p. 33). With landfill space diminishing and tipping fees increasing, this information points to the fact that there is huge potential for the inclusion of deconstruction practices in the building industry. Not only can reused building materials aid in the construction of new buildings, but the environmental impacts of producing virgin materials is mitigated and the labor intensive processes of deconstruction can be an added component of local economies (Manuel, 2003).

As mentioned earlier, the recovered items have value, and in fact the practice has developed into an industry of its own. An article in the *Environment* journal, published in 2002, highlights the work of a company named Deconstruction Inc. located in Portland Oregon (E.f., 2002). This information would not be terribly significant if it weren't for the fact that they are still in business with eighteen employees. Habitat for Humanity is another entity selling reusable goods as a way to save materials from the waste stream and provide employment for their program personnel (Chiras, 2003). These are only two examples, but they are illustrations of the

growing popularity and the expanding need for a secondary market of building materials still having usable life that can be kept out of the waste stream.

Re-use can be problematic because of the need for uniformity and availability in new structures. Fortunately for the SHED, however, it is quite small and needs are limited. This project has been blessed in that the framing components were supplied by formerly used and/or recaptured materials that have been sent back to lumber yards. The lumber needs of the project were donated by local lumber yards, and in fact, the SHED was built from the waste coming off construction sites in the Pierce County area. Because of sheer strength requirements needed for the walls and roof, it was necessary for those sections to be procured from new materials. In total, approximately 15% of the material on the project was new, and the balance were repurposed components kept out of the waste cycle.

2.8.3 *Reduce*

Reduction has the biggest impact and is the most difficult to achieve in our fast paced world where raw materials are acquired in such great quantities, and products are manufactured in seconds rather than weeks or months. In this setting is easy to have the perception that natural resources are inexpensive, plentiful, and endlessly supplied, but Strasser points out in the book, *Waste and Want,* that since the industrial revolution, marketing and advertising have been the tools of manufacturers to influence consumers, thereby creating more waste (Strasser, 2000). It must be kept in mind though that natural resources are time sensitive, that there are considerable environmental impacts of mining, and ultimately, the cheapest building materials are those that don’t need to be purchased, meaning conservation before fabrication.

Waste reduction has been the focus of one area of building in recent years known as lean construction (Lukowski, 2010). Every part of the construction process is on the cutting table for trimming fat. The internal processes of the company, the building process, scheduling, contractors, suppliers, even the building design is under scrutiny and examined to better eliminate waste and increase potential for profit. An interesting result has been that by trimming fat off the schedule and other parts, the required building materials have been reduced, and environmental impacts have been lessened as well (Song & Liang, 2011). Through lean design, the incidence of cost overruns and delays due to improper design can be eliminated thereby averting the overuse of natural resources and costly deposits to the landfill ("Lean Design Process," 2014).

Reduction of scale can also be added to this segment of the conversation. If developments and projects are condensed, the demand for material is lessened and a smaller environmental footprint is achieved. Since the advent of the industrial revolution and the progress of technology, advances in design and planning of buildings has changed dramatically (McLennan, 2007). Structures have gone from slender "L" or "H" shaped buildings, that take advantage of sun light and solar gain, to square or rectangle or other large shapes that required artificial lighting and space heating.

Reduction is central in the design of the SHED building. Because the project is a storage shed, the footprint lends itself to brevity. Additionally, it is a rectangular structure that minimizes the amount of waste and fall off from cut pieces. However, the most significant aspect of reduction contributable to the SHED is the community in which it resides and its relationship to the people it serves. The structure is positioned on the UWT campus at the northeast corner of 21st & Fawcett Avenue which is noteworthy because of the activity around the site. Students pass

by on a daily basis, 21st street is a freeway access point, and Fawcett Avenue is a main thoroughfare for north and south bound traffic. At this unique location, the SHED is prime to be viewed and visited, and the Giving Garden allows the attraction of providing individuals with personal planting spots. These characteristics of the SHED deliver a concentrated and pointed display of green building practices located in the heart of downtown Tacoma where it affords the use of less transportation by the community. In the case of this project, the prospect of reduction are displayed in the characteristics of the structure rather than the size of the building.

2.8.4 *Re-design*

The idea of re-design is devoted to integrating recycle and reuse into the design process. Two professors at the Misr International University in Cairo, Farahat and Bakry, created the System Development Life Cycle (SDLC), which is a procedure dubbed as a futuristic vision of environmentally responsible and resource efficient building that reduces developmental impact (Farahat & Emad Bakry, 2012). The system is comprised of 10 steps ranging from project initiation and system concept development to implementation of operations and maintenance with each phase feeding into the next and the aggregate concentrating on resource and environmental efficiency. The result of their work is a synergistic design for both new and retrofit construction that is cognizant of social, environmental, and economic issues while using less energy with a smaller footprint (Farahat & Emad Bakry, 2012). The idea is a brilliantly responsible plan for design and reuse that mitigates the effects of planned obsolescence and breaks the linear path of waste.

Intent driven design was fairly quiet until the book, *Cradle to Cradle,* by McDonough and Braungart was published. Their idea has gathered attention, and the thesis of their writing

can be found in many subsequent works (Braungart & McDonough, 2002). Their main argument is that many of the products in today's market are not able to be recycled or reused, because they are "monstrous hybrids" of biological and technical nutrients that can't be separated and reintroduced into the product stream. Ultimately, McDonough and Braungart contend that with the proper design, products could be endlessly used and become feed stock for the next structure in its evolution (Braungart & McDonough, 2002). Products are then part of the upcycle at the end of their useful life, food for the industrial process, and bring a commensurate drop in demand for virgin material that ultimately creates an abundance of natural capital potential (McDonough, Braungart, & Clinton, 2013).

In *The Zero Waste Solution*, Paul Connett argues that current waste disposal methods of landfill and incineration are unhealthy for humans and the environment. Additionally, they are driven by consumption and the marketing of ever changing fashion (Connett, 2013). Connett says the only real solution is the transformation to a "zero-waste" economy through the redesign of products and processes. His writing is filled with an abundance of global case studies, community successes, books, journal articles, films, video clips, and environmental conservation organizations that support his findings and give credence to his argument. The importance of Connett's argument is that he strongly advocates for a zero waste solution and also includes a ten component strategy which includes the concepts of separation, collection, reuse, economic development, better product design, education, and politically acceptable outcomes.

Re-design is probably the biggest driving force behind the intention of the SHED project. The purpose of this endeavor was to show the benefits of green building and sustainable development, while at the same time planning for end of operational use. The building is designed so all products can be either re-cycled or re-used in order to stay out of the waste

stream with no net contributions to the landfill. The concrete, glass, and unrecoverable wood products can be recycled, good quality wood can be re-used a third time, and the straw and soil products can be composted with organic matter and provide another growing bed for vegetables. Although the demonstration is on a small scale, the intent will be shown when the SHED needs to move over for another building. Its parts and pieces will be deconstructed, re-used, and stay independent of the waste stream while leaving a pristine plot of land for the next structure.

Chapter 3. THE PROJECT QUESTION

Sustainable development is noble subject matter of its own accord. The ideas of resource conservation and global warming could be discussed and debated for days unending, but that doesn't bring us closer to any kind of conclusion. Additionally, lecturing about the benefits of green building, reuse, and redesign are great theories for academic discussion. But this project is about putting theory into action.

Measurable outcomes are the pathway to change and without action, there is nothing but speculation. Whether the product of our actions is the desired outcomes or something less, it is the steps forward that get us closer to our goal. Oftentimes it is the lessons learned from unintended failures that become the most valuable learning experiences. No one would purposely set out to fail, but there is validity in the action of investigation and discovery that cannot be gained simply through theorization. With this in mind, the following question is posed:

> Is it possible to connect with the community and inspire them to be keenly aware of their relationship to the natural environment through the

construction of a green-built structure that will engage participants with the issues of sustainable development?

The intent here is to capture the hearts, hands, and minds of people with the hope of making a small change and continue that ripple effect throughout the community. It has been my experience, as a construction teacher, that when people are actively involved with the hands-on skill of building, they take a degree of pride that only comes from the intimate knowledge of participation. The expectation is that the individual experience will expand to community awareness, and ultimately, small pieces of social change will emerge. Success will happen somewhere in the nexus of social awareness, optimism, and community activism.

3.1 Engaging the Participants

3.1.1 *Methods Overview*

The intent of this Masters' project was to build a structure that would educate students about the qualities of green building, demonstrate characteristics of sustainable development, and engage the community with the subject matter. The resulting approach was to design, plan, and build a storage structure needed at the University of Washington Tacoma Giving Garden. The project would then employ the assistance of local area professionals, UW Tacoma students, and students in the Construction and Sustainable Building Science programs at Clover Park Technical College.

The focus of the project was to raise awareness for students and community about resource conservation and sustainable development. The SHED was the vehicle that engaged participants and created the opening for the message. The idea was that by engaging the

participant's *hands,* while working on the SHED, their *minds*, by involving the concepts of green building practices, and their *hearts*, by experiencing the benefits of sustainable living, a trend toward positive community change would emerge. Individuals, acting together, can achieve amazing results. With the SHED being the big attraction of the project, the target groups were middle school students and college students from Tacoma and the surrounding area.

3.1.2 *Engaging Middle School Students*

For the middle school students, the project was a two-component program consisting of an after-school outreach and the building of the SHED at the UWT Giving Garden. The purpose of the endeavor was to engage middle school youth with the ideas of green building and sustainability while creating a model of resource preservation and energy conservation. The after-school program would consist of five lectures surrounding the foundational topics of sustainability, green building, energy conservation, renewable energies, and environmental conservation. Throughout the lecture series, the students were tasked to design and build a "green-built" house using Lego bricks.

The first steps towards building a relationship with the middle schools required that I visit the schools, inform the administration of my program, and inquire as to whether students would be interested in the program's subject matter. Once in front of a teacher, it was a process of conveying the worthiness of the program and asking for a group of students to work with. Often, the teachers liked the idea, but they did not have time to fit it into their schedule. Ultimately, Jason Lee and Baker Middle Schools in Tacoma were kind enough to host my program.

As planned, I met with the students once a week for five weeks (Figure 1). For teaching props and student activities I brought solar panels, a small wind turbine, a multimeter to verify

energy production, slide shows, and a box containing craft supplies, glue, colored markers, tape, drawing paper, and of course Lego building bricks. The Legos were used to attract the interest of the students and bring out their imagination to solve the problem of designing their own sustainable structure. The students listened to a fifteen minute lecture on the topic of the day, after which they split up in their groups and designed their green built, sustainable Lego houses.

Figure 1: An after-school green design class

Assessment of their learning was achieved through a survey administered to participants at the conclusion of each five week presentation. The survey examined the relationship between grade level, gender, awareness of green building strategies, and their knowledge of natural resources. Additionally, it queried the students' understanding of renewable energy sources and their interest in working in the green building industry.

3.1.3 *Engaging College Students*

The college students were a much easier group to involve. When I proposed the project of a green built structure to my Sustainable Building Science students, they couldn't wait to get started: there was no asking or selling them on the idea. Building the SHED fit perfectly within the construction and building science curricula, and an ongoing lab day was set for once a week on Thursdays. The students were enthusiastic to be a part of a venture that was going to stand as a part of the local architecture, and a sense of ownership emerged while working through the building process. In terms of a methodology for the college students, it was a matter of having enough materials to keep them moving forward. It was clear and simple: have the materials on site, give them direction on how the structure was to be built, and back out of the way. The college students arrived with resolve, and were there to put the pieces together.

The approach was to use the theoretical base of subject matter covered in the literature review as the educational framework for the building experience. During the build-days the lessons of the construction and building science programs were reiterated and students would hear why the SHED structure was green and sustainable. For the qualitative assessment of college student learning, the original plan was to have college students complete a group interview at the end of every build-day. In practice, a single group survey was conducted at the end of the class quarter term instead. The build days were filled with hard work and harsh weather, and asking students to stay and answer questions at the end of a wet day, proved to be a flawed plan. The survey was designed to assess changes in the participants' attitudes toward "greening" their own lives, preserving the natural environment, building community, and their interest in employment in the green economy.

The core concepts and lessons for both groups were much the same. With that in mind, the survey questions for the middle school and college students noticeably paralleled each other. Granted, there was a wide variance in age between the two groups of respondents. Furthermore, the difference in life experience between the two groups was extensive. However, the objective of the surveys was to investigate changes in attitudes brought about by participation in the SHED project. The survey questions and the responses will be shown in the upcoming analysis section.

3.2 Project Implementation

The first task to begin the project was getting approval from the staff in charge of facilities maintenance and new construction on campus. A plot of land owned by UW Tacoma was granted to be used for the Giving Garden, but before any building was to proceed, the design needed to be approved. Once approved, there was the matter of an architect and engineer to develop a set of plans to submit for permitting. Contributing to this part of the project were: Jonah Jensen, design consultant for BLRB architects, Brett Maddox, structural engineer for PCS Structural Solutions, Laura Holt, design draftsperson from Clover Park Technical College, and myself who communicated the broad scope of project goals.

Figure 2: Conceptual drawing of the SHED, drafted by Laura Holt, CPTC student

The final design elements to be considered after meeting with all the players (architect, engineer, facilities maintenance, new building construction, City of Tacoma permits engineer, Project Earth, and CPTC architectural student) were as follows: the structure needed an inverted "T" foundation, a vegetated roof, water catchment, conventional wood walls, a straw bale wall, an industrial hemp wall, and an independent solar electric system for charging cordless garden tools. It also needed to be big enough to store tools and host educational clinics, wall space to show video during clinics, and a covered area for clinics during bad weather (Figure 2).

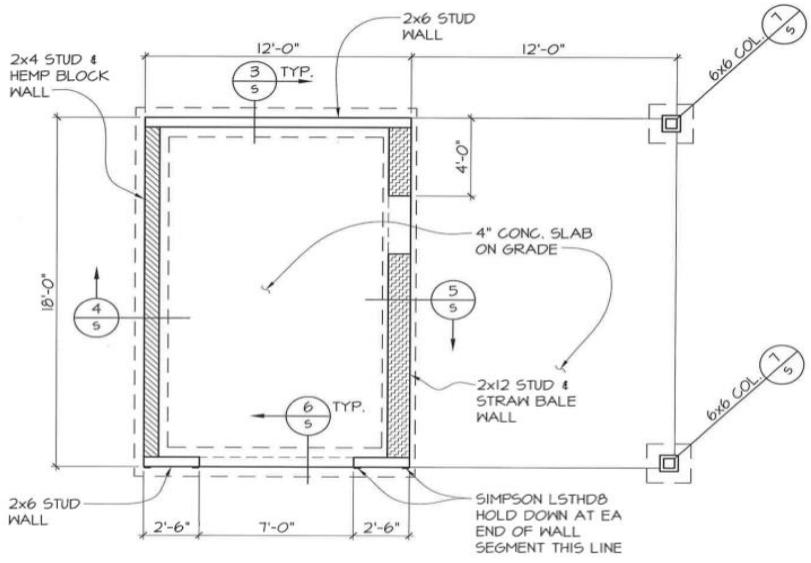

Figure 3: SHED plan provided by Brett Maddox of PCS Structural Solutions

After nine months of coordination and pursuing in-kind donations, the drawings were submitted (Figure 3), a permit was issued, and September 24, 2015, marked the start of construction (Figure 4). A Terramite backhoe was provided through the combined efforts of Star Rentals, Keystone Masonry, and PlanBuild Construction. The labor was provided by the

enthusiastic participation of students in the Construction and Sustainable Building Science programs at Clover Park Technical College.

Figure 4: First day of construction at the SHED.

Because the project started in late September and my projected graduation date was early June, there was very little time to waste, and several of my quarter breaks from teaching at Clover Park were used to keep progress moving forward. Also, the students worked overtime to meet deadlines. In total, the structure took eighteen months to finish: nine months to get a permit and nine months to complete construction. That may seem like a long time for such a small structure, but, there was a considerable amount of project coordination, and the building materials needed to be acquired through donation requests. Consequently, progress was not as quick as one would have hoped. It must be said, however, that the business community was very generous in their contributions in making the endeavor a success, and the project could not have been completed without them. A list of the donors and their respective contributions is provided in Figure 5.

The weekly routine for keeping the project on schedule was a matter of having a variety of activities to keep everyone busy, making sure the needed materials were loaded on the flatbed trailer, and that the needed tools were gathered. In addition, it was necessary to get everyone to the job site, facilitate progress during build-days, clean up the job site, take the trailer back to the shop, and start the process over for the next week.

Pierce County Master Builders Association	Permit Fees
BLRB Architects	Consulting Architect
PCS Structural Solutions	Engineering
Keystone Masonry	Consulting Contractor
Plan-Build	Consulting Contractor
Star Rentals	Equipment Donation
Valley Construction Supply	Rebar and Hardware
McLendon Hardware	Materials Donation
Miles Sand and Gravel	Concrete Donation
Mortenson Construction	Concrete Donation
BMC Lumber Manager	Lumber Donation
Gray Lumber	Lumber Donation
TAGRO of Tacoma	Roof Soil
ProBuild	SHED Door
Alside Supply Center	Vinyl siding and soffit
CalPortland	Concrete
Madsen Roofing	Roofing materials and installation
Hemp Ace International	Hemp and lime based binder
Northwest Hemp Builders	Hemp wall technical advisor

Figure 5: List of in-kind donations

3.3 Monetary Donations

Having the donors help with the SHED materials was a wonderful gift, but there were parts of the project that would not have been possible without monetary funds. The fundraising

committee established the fund account and generated donations. The committee members were: Thomas Duke, Alumni Relations and Annual Giving Officer; Alecia Kuhl, Fundraising Coordinator and CIVITAS (Urban Studies registered student organization) Officer; Taylor Jones, CIVITAS Officer; and Dr. James Gawel, Associate Professor-Environmental Sciences/IAS and Faculty Sponsor to the SHED project. Thomas Duke was responsible for making sure the funds were placed in the account and also for tracking the running total. Dr. Gawel advised the group on university protocols and helped organize fundraising and planning efforts. Alecia and Taylor worked together to raise general donations from students, staff, faculty and the public through electronic solicitations and collection jars and they designed signage to raise awareness of the project. Alecia first designed posters displaying the SHED and the Giving Garden which informed the student body of the project and the need for donations. A web site was listed on the poster where donations could be deposited electronically. A donor simply entered a credit card number and designated the monies to the SHED. Several entries to Facebook were also made in order to raise enthusiasm and solicit donations. By far, the biggest surprise of the fundraising was the collection jars. Alecia had an amazing idea to put collection jars accumulating spare change for the SHED. There were two locations: one at the on-campus food store where students go for a quick snack between classes, and the other was at the coffee shop (Metro Coffee) that students frequent either on the way to or from class. In total, the jars brought in more than $1,100 in spare change.

Another source of funds for the SHED was a collaboration between Dr. Gawel and myself. He contacted me and said there was grant money available through the Sciences and Mathematics (SAM) divisional fund. SAM is a division of the School of Interdisciplinary Arts and Sciences at UW Tacoma. I was requested to do a write-up about the benefits of industrial

hemp and the use of hemp-lime construction. Dr. Gawel filled in the missing pieces, and sent in the application for review. Approximately three weeks later, the project was awarded $800, and the money was deposited into the SHED fund. The total between the collection jars, the grant award, and online donations came to a sum of $2,750. The public and the college community were very generous in contributing to the project, and it would not have come to fruition without everyone's help.

3.4 Materials and Wall Assemblies

The selection of materials and wall structures for the SHED had mixed influences: some were chosen for me, and some were chosen by me. From the design process, the City of Tacoma permits department required a concrete foundation, and the structural engineer specified the straw bale wall would need to be constructed of 2 inch by 12 inch studs and sheathed with half-inch plywood in order to maintain the shear requirements needed to sustain the structural integrity of the vegetated roof. After the necessities were fulfilled, the hemp-lime wall assembly was selected due to its innovative and novel qualities. Industrial hemp has been getting a lot of attention in Washington, and experimenting with this type of wall was interesting and creative. The final list of material components for the SHED were: concrete, wood construction, straw bale construction, and hemp-lime construction. The following is an analysis of those materials.

3.4.1 *Concrete*

The predominant perception of concrete is that its embodied energy is too high, and it generates pollutants during extraction. Lemay and Lobo (2010) contend, however, even though the initial carbon expenditure may be more than most, when measured against the processes of

aluminum, steel, glass, and bricks, the concrete results in having lower embodied energy and longer usage life, thereby supporting the sustainability of the product. Their research is supported by the U.S. Department of Energy, Portland Cement Association, U.S. Energy Information Administration, and a Life Cycle Inventory on Concrete and Cement completed in Lillehammer, Norway. Although the manufacturing of concrete does contribute to the carbon footprint of structures, when compared to the use of other building materials such as aluminum, steel, and brick, the carbon emissions and invested energy of concrete are less, and the recycle and reuse loop is well established. Additionally, the concrete industry is voluntarily taking action to reduce its greenhouse emissions below the 1990 baseline before the year 2020 (Lemay & Lobo, 2010).

The concrete in the SHED was not considered a spot for compromise. It is literally the foundational structure of the project and is key to the safety of the occupants. There were, however, conservation strategies associated with its use in the SHED. The footprint of the structure was kept to the minimum area required for the tasks of the Giving Garden. The use of concrete is on the order of hundreds of years which contributes to the longevity of the product. Finally, concrete can be recycled several times without being deposited into a landfill. Additionally, in order to insure the recycling objective of the SHED materials, the concrete had no additives used in the mix. Looking at the project materials in total, concrete was the most used product, simply because of engineering and permitting necessities (Figure 6). However, that is an acceptable level of resource use, because these are the components that keep the public safe and the structure durable.

Figure 6: SHED footing being placed by CPTC students

3.4.2 *Wood*

The main building material used in the SHED structure was wood (Figure 7). Conventional wisdom in the sustainability industry is that wood framed structures are undesirable, because they promote clear cutting and monoculture reforestation (Johnston & Gibson, 2008). This point of view has been modified over time, however, as is demonstrated in a study by Knowles, Theodoropoulos, Griffin, & Allen (2011). This study affirms that industry professionals will actually prefer wooden structures as long as the wood is responsibly harvested. While the initial building materials selection is usually a matter of code requirements, costs, and performance parameters, finalization of component selection is done in accordance with ecological philosophies and individual concepts of how sustainability is defined (Knowles et al., 2011, p. 395). Ultimately, the consensus was that wood framed structures or structures that

contained visible wood products were felt to be warmer and more pleasant to inhabit, provided that there was an absence of formaldehyde, and that they were harvested through an environmentally friendly source such as a Forest Stewardship Council or Sustainable Forest Initiative certified supplier (Knowles et al., 2011). Hence, the decision to utilize wood as the framing components of the SHED was made.

In the SHED project, there is a considerable amount of visible wood framing members, but they are not FSC lumber. There was no budget for the first six months of the building process. Consequently there was no money for sustainably harvested lumber. The next alternative that was within the design goals (and the budget) was to search out donations of recycled or reclaimed lumber. As luck would have it, BMC West Lumber supplied all the necessary product with materials that were potentially destined for the landfill. Several bundles called, "farm packs," which had a wide variety of framing, trim, and siding pieces were donated to the project. The bundles had to be sorted, but because manpower was plentiful and funds were lacking, it was a small sacrifice. The donation overage was used in the construction program at Clover Park, and all fall off was recycled to a shredding facility. The important factor here is that recycling and reuse are possible in the construction environment. It may not be as viable in larger commercial applications, but for jobs with flexible time constraints and lower budgets, such as the SHED, this can be a viable alternative.

Figure 7: The primary wood framing of the SHED

3.4.3 *Straw Bale Construction*

In some construction projects, there has been the need for creative license and an alternative to the constraints of traditional building. This craving for artistic expression has created a swing in construction methodology toward more seemingly natural solutions. Some of the resulting assemblies are rammed earth, earth-ship construction, or cobb-style construction made of stacked, earth filled bags with a plaster finish (Wexler, 2009). Swan, Rteil, & Lovegrove (2011) maintain that an increased interest in green building and sustainable development has stimulated a resurgence in building techniques with locally sourced materials and very low embodied energy, such as straw bale construction. Their main point is, while the operational phase of a building is the most costly in terms of energy consumption, the use of

natural straw fiber and earthen structures can help lower the embodied carbon of the construction phase and also reduce the environmental impact of the operational phase.

Mud and straw in construction date back thousands of years, but the use of straw bales has been employed in buildings for about the last one hundred years (Vardy & MacDougall, 2013). The absence of use prior to that is attributed to the lack of structural testing in predictive reactions to loads. Vardy and MacDougall maintained that if straw wall assembly response could be established in weighted conditions, the results would promote bale construction. Their testing included vertical and lateral load analysis of straw bale construction which was stressed to the failing point. Test results concluded that lateral loads caused the walls to fail earlier than vertical loads, and the failing point of the vertical testing was greatly dependent upon the thickness and composition of the exterior finish. Straw is an excellent insulator and sound barrier, but if shear strength is required, the better design would be either timber framed or stud framed walls stuffed with straw bales (Vardy & MacDougall, 2013).

Using this piece of research as a basis, the SHED was built to address these concerns (Figure 8). The engineering requirements for the middle wall containing the straw bale were such that the assembly needed to have 2 inch by 12 inch studs with half-inch plywood sheathing to accommodate the weight and the lateral forces of the vegetated roof. Consequently, the original design of stacked straw bales, secured by mesh, tied with twine, and covered with a stucco cladding, gave way to a more conventional framing. The wall still possesses the high quality insulation and sound reduction characteristics of straw bale construction, but it is achieved with wood framing. Additionally, this wall section performs the function of giving visitors an alternative to the traditional framing of studs and fiberglass insulation. With assemblies like this

on display, prospective builders can consider the technique, do the research, and make informed decisions about building their own homes.

Figure 8: The East straw bale wall after plywood sheathing

3.4.4 *Hemp-Lime Construction*

Nordby and Shea (2013) contend that building standards and legislation do not fully reflect the environmental impacts of the materials used in construction. They performed a case study to investigate the thermal qualities, moisture vapor transmission, and carbon sequestration characteristics of wall assemblies using Rockwool, wood fiber, and hemp-lime construction. The research was significant, because it showed that the environmental impacts of the manufacturing and operational phases of structures are closely linked to materials of the building. The growth of wood fiber sequesters carbon, but there are also ecological consequences associated with harvesting the timber. Conversely, hemp-lime construction acts as a better insulator (R-3 as opposed to the R-1 of wood), allows diffusion of moisture through the wall, and adds to the

carbon capture potential of a structure without the consequences linked to cutting down trees (Nordby & Shea, 2013).

Additional work supporting the hydro-thermal, acoustic characteristics of the hemp-lime mixture was done by Arizzi, Brummer, Sanchez, Cultrone, and Viles (2015). They stated that this combination of materials not only had good moisture, heat, and sound qualities, but could also be used as filler in wall repair, roofs, and masonry block. The study also showed that the hemp hurd (the inner woody part of the plant) had the tendency to absorb moisture and vapor in wet weather, with a greater ability to release moisture in the drier months. Also, this quality could be further enhanced by changes to the lime mixture (Arizzi et al., 2015, p. 9). Moreover, because of the fibrous makeup and ability to adhere readily to other products, the mix showed to be a quick repair material in instances that would otherwise require extensive labor and deconstruction. Regional application, however, was very important. If moisture content of the wall was too high for an extended period of time, microbial activity would occur stimulating mold growth and compromise the indoor environmental health of the building (Arizzi et al., 2015, p. 17).

The conclusions for hemp-lime were very similar to those of straw bale in that they do not show adequate compressive strength to be used as bearing walls. However, they hold excellent characteristics in the management of heat, water, sound, and indoor air quality (Arizzi et al., 2015). Consequently, the results of the research revealed hemp-lime construction to be an outstanding assembly to display in the SHED. Hemp is a viable building product, and the entire west wall was devoted to hemp-lime construction (Figure 9). Additionally, hemp has the unique quality of being a high quality moisture reservoir that will collect excess moisture during wet seasons and release it during dry seasons so as to help control humidity and lessen the instance of

mold and mildew. Furthermore, the literature shows industrial hemp to be an excellent contributor to carbon sequestration without the detrimental effects of clear-cutting forests. Taking this into consideration in combination with the SHED being an environmentally and sustainable structure, the decision to include hemp-lime construction was very simple. Hemp-lime was brought to the building process, because it embodies good building characteristics with a minimal environmental impact.

Figure 9: Joy Beckerman of Hemp Ace Technologies in front of the SHED's hemp-lime wall

The combination of the materials and assemblies previously discussed came together to form the structure of the SHED. The goal of the materials comprised by the SHED is to give a bricolage of traditional and alternative assemblies that will educate and engage the community. The following discussion will give the outcomes of that endeavor.

Chapter 4. ACCOMPLISHMENTS AND OUTCOMES

As I went by a pitch-pine wood the

other day, I saw a few little ones

springing up in a pasture from seeds which

had been blown from the wood…

In a few years, if not disturbed, these

seedlings will alter the face of Nature here.

H.D. Thoreau Faith in a Seed

Figure 10: The student builders showing their pride of accomplishment

First and foremost, the theoretical goals set out at the beginning of the SHED project were accomplished. Green building design and resource conservation in combination with service learning and the help of donations from local businesses were melded to raise the awareness of sustainable development in the community. The idea of environmental changes brought about by consumerist behavior and global market forces were conveyed to, and received by participants and inquirers of the SHED project. Moreover, the structure embodies the conceptual framework of the 4-R Procedure (Re-cycle, Re-use, Reduce, and Re-design). The project was an adventurous attempt to reach as many ages and income levels as possible, and it was accomplished without straying from the original intent.

The SHED structure displays all of the design criteria set out at the beginning of the project (Figure 10). It incorporates traditional wood walls with the alternative assemblies of hemp-lime and straw bale construction. The building will be covered with a vegetated roof that collects water to be used for irrigation in the garden area. The SHED also promotes environmental education by providing a covered patio area that acts as an all season teaching venue for issues surrounding environmental conservation. The roof, the straw bale wall, and the photovoltaic system have not been completed to date. But, the ongoing work on these components provide the opportunity to solicit more involvement from students and the community. The theory and construction of the project have come to fruition, and the following discussions will give more details of outcomes from the middle school and college student cohorts.

4.1 Middle School Questionnaire

The curriculum of the after-school program consisted of five weeks filled with the subject matter of green building, sustainable development, renewable energies, carbon footprint, and jobs they might see themselves doing. During the short fifteen minute lectures, I covered topics such as embodied energy, resource conservation, what makes a house green, taking action in their neighborhood, and the different jobs available in the green industry. The students appeared to enjoy themselves especially when I brought in some solar panels and a small wind turbine. They received a hands-on view of photovoltaics and were able to actually see on a multi-meter how solar and wind energy are produced. Additionally, their task was to design and build their own green building with Lego bricks. The Legos were a great incentive for attendance, and a lot of enthusiasm surrounded the construction of their houses. While most of the models were simple designs, the curriculum was reinforced by the requirement of them having to vocally tell me the significance of their green model.

The resulting data has been organized to show the questions in the order asked, and the corresponding responses, with no identifiers to protect student anonymity. There were eighteen participants in the middle school program and the reader will note that most of the questions have more than eighteen responses recorded. This is due to the fact that some respondents gave more than one answer to various questions. There was a small amount of interpretation of responses in order to present an academic report, however, if the reader would like to examine the raw data it is included in appendix A. The questions, responses, and analysis of the middle school program are as follows (Tables 1-5):

4.2 Middle School Questions and Responses

1. What grade are you in?

Grade Level	6th grade	7th grade	8th grade
Number of students	6	9	3

Table 1: Middle school survey question #1

2. What makes a house good for the earth

Category of response	Resource conservation	Energy efficiency	Longevity of structure	Indoor environmental quality
Number of responses	8	6	5	4

Table 2: Middle school survey question#2

3. What can you do to save energy and help the earth at your home?

Category of response	Save energy	Use solar energy	Use less water	Pollute less	Use natural lighting	Reuse products	Ride a bike	Reduce carbon footprint
Number of responses	10	4	2	2	1	1	1	1

Table 3: Middle school survey question #3

4. How could you and your neighborhood help the earth?

Category of response	Pick up garbage and litter	Recycle	Plant gardens	Conserve energy
Number of responses	9	5	3	2

Table 4: Middle school survey question #4

5. If you could pick a “Green” or sustainable job what would it be?

Category of response	Farmer	Construction	Mechanic	Solar tech.	Don’t know	Environmental protection	Doctor	Garbage man
Number of responses	7	3	2	2	2	1	1	1

Table 5: Middle school survey question #5

4.3 Conclusions for Middle School Program

The students clearly picked up on the ideas of energy efficiency, carbon footprint, recycling, reusing products, renewable energies, implementing the ideas into their lives, and even what they might do for a job in the coming years. The use of Lego bricks was a very big hit. Some of the models were wildly creative (Figure 11), but the exercise sparked their imaginations, and also helped to solidify the concepts of sustainability.

Figure 11: One of the first sustainable Lego houses

Not all of my efforts to garner middle school student participation in this project were fruitful, unfortunately. It was difficult to make my way into the school system, and there wasn't any middle school student participation in the actual building of the SHED. There were a number of schools that for one reason or another did not want to participate in the after-school program. In some cases I made several attempts to phone or email teachers to generate interest in my program but received no response. It was part of the plan for the middle school students to participate in the build days. They were invited, however none of them participated. I can only assume that non-participation was a combination of timing, transportation, and coordination of parental supervision; all of which acted as barriers to participation. Nevertheless, I think the SHED itself will pave the way for introducing green building and sustainable development into the curriculum of middle schools in the future.

4.4 College Student Questionnaire

The following are the questions and responses from eleven college students that participated in the building of the SHED (Tables 6-9). The adult respondents were asked to give a direct answer to the questions followed by an explanation of their initial answer. The objective of the survey was to ascertain how participation in the SHED project changed students' behaviors regarding energy and natural resources. Furthermore, respondents were asked if they were planning to enter the green collar workforce.

Here again, the project revolved around green building and resource conservation, while using service learning to build awareness of sustainable development in the community. The survey was simply a vehicle to evaluate how well the plan performed. As stated earlier, there were eleven respondents. However, some students gave multiple reasons to support their initial

answers. If the reader would like to examine the raw data it is included in appendix B. The questions, responses, and analysis of the college student participation are as follows:

4.5 College Questions and Responses

1. As a result of your participation in this program have you made any changes in how you see or use your house?

Category of response	Yes – changed view of house	More confident and willing to do repairs	Observe homes for energy and materials efficiency	Thoughtful of energy use and efficiency	Attentive to indoor air quality	Observant of materials use	Aware of the house as a system
Number of responses	11	6	5	2	1	1	1

Table 6: College survey question #1

All 11 respondents answered yes to the question about the program having an effect on how they view their house (Table 6). As a result of this project, respondents felt more invested in the place in which they live. Responses show that students have been empowered to do work that will make their own homes more efficient. They have also started to look at the design of houses for items such as materials and energy efficiency.

2. As a result of your participation in this program have you made any changes in the way you see and use natural resources?

Category of response	Yes	Always conservative with resources	Good for environment	Important to recycle and reuse	Raised awareness of materials use	Saving money
Number of responses	7	4	6	2	2	1

Table 7: College survey question #2

While seven participants responded that being in the program did have an effect on their use of natural resources (Table 7), the remaining four said they have always been conservation-minded and concerned about the materials they use. The reported motivations behind these answers were varied. The majority responded that conservation was good for the environment and the right thing to do. The minority, however, cited other reasons such as the importance of the closed loop process of reuse and recycling. Others simply stated that as a result of being involved with the project they had become more mindful of conservation. Surprisingly, only one respondent referred to saving money as their motivation for materials conservation.

3. As a result of your participation in this program have you made any changes in how you see or use energy?

Category of response	Yes – Major changes in habits	Yes – Aware and changing habits slowly	Yes – Already energy conservative	No – No changes at this time
Number of responses	6	2	1	2

Table 8: College survey question #3

The vast majority of responses indicated that respondents were either making changes in their lives in order to conserve energy or that conservation was already something they were

doing (Table 8). Respondents reported that they were using heat conservatively, turning off lights, or unplugging electronics to avoid drawing power when not in use. The results showed a slow or no habit change from only 3 of the respondents.

4. As a result of your participation in this program do you think sustainability will play a part in your future employment?

Category of response	Yes	Not likely
Number of responses	10	1

Table 9: College survey question #4

The responses suggest strong interest in sustainability-related employment (Table 9), as indicated by comments such as, "…got a lot out of the program" or "I plan to be a green builder." It appears that the hands-on experience of building the SHED resonated with most of the participants to the point that most respondents wanted to continue the work. Additionally, there was feedback of a visceral nature such as, "I want to do something that matters" or wanting a job that has "…a balance with nature". These comments suggest that participants took into consideration other things than just money when thinking about their future employment.

4.6 Summary of Student Learning

The results show the project achieved its goals of educating young people about sustainable building practices. While the after-school program analysis indicates that participants exhibited awareness of environmental issues, and that knowledge of resource conservation and energy efficiency increased, the work party participants gave a much fuller description of how the concerns of energy and resources were actually applied to their lives following project participation. The questionnaires showed that the educational and hands-on components of the project had an impact on the people that participated. Time will tell if there is actually some kind

of social change that comes about through the actions of this educational project. While the numbers of K-12 participants was not what was hoped for initially, larger numbers would hopefully confirm my results and demonstrate a greater demand for green building and sustainable development education.

There were challenges to the scope of the educational impact of the project and changes to survey administration that altered the volume of feedback. As stated previously, it was difficult to gain access to the middle schools, and that fact certainly had an impact on the amount of information gathered. Additionally, after build-days, students were usually tired and wet from the events of the day and were thinking of a warm dry place rather than completing a questionnaire. Still, even though the number of responses was not large, the outcomes were positive, indicating that the project overall achieved most of its goals.

There was also a tremendous sense of personal pride that came along with sharing the experience with a cohort of volunteers. I continue to receive comments from current and former students who frequent the building site and say how very proud they are of their accomplishments. They also take friends and relatives by the Giving Garden to explain the significance of the project and the building assemblies. Another incredible effect is the foot traffic passing by on a daily basis and the interest that was sparked from the general public. This gave the students the opportunity to expound upon the lessons they had learned through their conversations with the public. Thus, the ripple effect of the lessons learned from the SHED continue. These outcomes are all positive consequences of the SHED project which are quite contrary to the negative environmental outcomes that have become the norm in urban development.

One of the major outcomes of the SHED project was that of service learning. The volunteer labor hours were immense, and the generosity of local business owners was a gift that cannot be replaced. During the fall, winter, and spring quarters of the 2015-2016 academic year, there was an average of 12 students per day, 10 days per quarter (3 quarters) who contributed an average of 6 hours per day which equated to 2160 hours. If the time during quarter breaks was added into the equation, then there were 2360 student volunteer hours in all from Clover Park Technical College. This number multiplied at the hourly rate of $18.75, specified in the literature review, comes to a grand total of $44,250 of labor produced through the power of participatory education, service learning, and personal empowerment.

Chapter 5. CONCLUDING REMARKS

This discussion of the SHED project began with a list of concerns for both the natural and the built environment. The consumption of natural resources is progressing at an ever increasing rate, and structures need to be built in a way that promotes sustainable development. It is important that our buildings not only manage the effects of heat, air, and moisture, but that they also need to do so with respect for the ecosystem. Sustainable development and green building protocols have made great strides towards advancing the cause of environmental responsibility.

A review of the issues concerning green building and sustainable development revealed disconnects between the free market system, consumption, and environmental consequences. Consumption of natural resources in the free market system has led to a rise in atmospheric carbon dioxide, the pollution of soils and consumption of potable water at a rate that outpaces the hydrological cycle. More pointedly, the construction industry globally consumes about 40% of

all materials manufactured. Therefore, building activities embody a large share of world energy resource usage and contribute commensurately to environmental degradation.

Exploration of green building protocols demonstrated that they are respectful of energy usage, resource consumption, and the environmental effects of buildings. LEED, Living Building Challenge, National Green Building Standard, and the Passive House Institute all play a major role in bringing awareness to the subject matter of green building and sustainable development. These protocols have generated attention for energy efficient appliances, resource efficient building practices, quality construction practices, and the quality of the indoor environment. However, there is very little discussion of what happens to a building at the end of use. Is it possible to make a structure that doesn't get deposited into the landfill when its usefulness has ended?

Addressing this question is the basis for the SHED project. It was designed with the green building and sustainable features of straw bale construction, hemp-lime construction, a vegetated roof, and water catchment. But, it was also designed so the entire structure could be either recycled, reclaimed, or repurposed in whole form. Everything from the concrete foundation to the soil on the roof has the potential to be reincarnated and remain in a closed loop use cycle. Obviously, not all structures can be built with this methodology, and surely there is an energy footprint associated with recycling the products that can't be reused. However, it is undeniable that these procedures reduce the demand for extraction of virgin materials, the energy requirements for finished products, and ultimately the environmental effects of consumptive practices.

The conservation strategies demonstrated by the SHED are numerous, but even more significant is the fact students were involved in the project. Multiple age groups of students were

exposed to the concepts of green building and sustainable practices through the development of a curriculum surrounding the SHED project. Middle school students of sixth, seventh, and eighth grade levels were educated about the concepts of embodied energy, carbon footprint, natural resource conservation, and job possibilities in the green collar industry. The truly wonderful part of the middle school program was that the students learned from short lecture time blocks and applied the concepts in a hands-on manner using Lego bricks to build their own green homes. Of course, the structures didn't entirely resemble a house, but the students' imaginations filled in the gaps, and they were able to verbalize the sustainable features of their buildings.

Education of the adult students was a different matter. The students in the Sustainable Building Science program at Clover Park Technical College were already studying green building, so it was not a surprise that they welcomed the opportunity to work on a hands-on project in that genre. The really big surprise was they that loved the project so much that they were willing to work their hearts out in the rain, snow, mud, muck, and the blazing sun. Of course, the barbeque lunches, coffee, and donuts helped sustain positive attitudes as well! The point here is that all of the higher education students saw the worthiness of the project, whether they were from UW Tacoma or Clover Park Technical College, and they were willing to come out and contribute the effort required to finish the SHED.

There was a tremendous amount of service learning associated with the project. The Clover Park students alone contributed over two thousand hours of labor time to the project, and that doesn't begin to account for the time required for organization and planning completed by the design team and myself. Through the construction of the SHED and the caretaking of the adjacent Giving Garden there was a connection made to the surrounding community that inspired individuals to stop and talk about what we were doing. A few of the comments were, "It was so

good to see positive things happening in the neighborhood," and "I could live in a house like that." There was an amazing connection made with the community in large part because the students were not afraid to be generous with their time.

The students' efforts were not entirely altruistic. The majority were involved in the project because they wanted to learn a skill that could either lead to employment or create a market niche in the green industry they could fill. Throughout their involvement in the project, they asked questions like how much could be charged and made comments such as, "We should do this as a business." There was so much enthusiasm for the learned skills that many of the students began talking of businesses in solar energy or tiny homes, while many others said that they would like to start businesses as green remodeling contractors. Entrepreneurship is part of the Sustainable Building Science curriculum at Clover Park, so it is no coincidence that students were thinking about the opportunity to capitalize. Such conversations were a welcome result of their participation.

Another highlight in the list of accomplishments for the SHED project, and an additional source of entrepreneurial fodder, is the fact that it houses the first industrial hemp wall in the City of Tacoma. Earth Day, April 23, 2016, marked a day that brought together students, community members, and industry professionals to install the hemp-lime wall of the SHED at the UW Tacoma Giving Garden. It was an amazing day of cooperation, camaraderie, and collaboration that started at 7 a.m. and didn't end until 9 p.m. Everyone was exhausted and sore, but no one stopped until the wall was complete. At the end of the day UW Tacoma was the first university in the State of Washington to display industrial hemp in a structure using hemp-lime construction. The SHED was also the first structure containing hemp-lime construction to be

permitted in Washington State. It was an amazing accomplishment and a stellar display of the UW Tacoma commitment to interdisciplinary collaboration (Figure 12).

Figure 12: The hemp crew displaying hemp love at the end of Earth Day event

The question I posed at the onset of my project was:

> Is it possible to connect with the community and inspire them to be keenly aware of their relationship to the natural environment through the construction of a green-built structure that will engage participants with the issues of sustainable development?

After conceptualizing, implementing, and analyzing the outcomes of the SHED project, I feel I answered the question with a resounding, YES! The scheme of the SHED project was well

thought out, thorough in scope, and respectful of the participants. The entire project was a matter of mutual respect between teacher and student, and trust that the project was headed for the established goals. Following that, the positive outcomes were a very simple matter. Individuals, working together, can achieve amazing results.

It was my honor and great pleasure to be acquainted with everyone that took part in the SHED project. The intent was to engage the participants and build community around the ideas of green building and sustainable development, and reviewing the feedback the goal was achieved. The adult students are now emerging stewards that will look after our built and natural environment, and the middle school students will be the future leaders who will bring social awareness of the ecosystem. Now that the seeds of knowledge have been planted, the entire cohort that contributed to the SHED are the change agents, and our future is better because of them. I'm not simply hoping for good deeds in the future. I don't hope for social environmental change or wish for people to reduce their consumption habits. I AM COUNTING ON IT! I am counting on it, because my children's future, and the future of every other father's child depends on how we take care of our world today. The SHED project not only built a structure, but also built a community around it. Now the community needs to take action toward a more sustainable future. I am counting on it, and my kids are counting on it. Education is power. As I bring this project to a close and look forward to graduation and the next chapter of my life, I want my children to know that I did everything within my power to make their future a better one. Individuals, working together, can achieve amazing results.

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APPENDIX A MIDDLE SCHOOL RAW DATA

1. What grade are you in?

I am in 8th grade
8th grade
8
7th
6th
I am in 7th grade
6th grade
6th grade
6th grade
6th
6th grade
7th
7th
7th
7th
7
7th
7th

2. What makes a house good for the earth?

A green house with natural stuff
It uses the resources around us
A resourceful house – A house with resourceful electricity
It's sustainable
Not waste much energy
Rock homes – No wasting electricity
Building it to last for centuries
A renewable environmentally safe house
Building to last
Using different kinds of materials
Having renewable energy like solar panels, and building the house to last a long time
Make a greenhouse
So it can recycle cans
No bad fumes built in to the house
We can live in it
A house that is a less electricity house
Energy conservation, solar panels, indoor sunlight

The house is sustainable, replaceable, save energy, has a low carbon footprint, so basically anything beneficial to our earth/community

3. What can you do to save energy and help the earth at your home?

Use more natural sunlight and don't litter
Put solar panels around the house
Ride bikes instead of cars, if you're not using something turn it off
Don't waste energy
Use less water/electricity
Use solar panels
Turn off the lights
No wasting electricity
Have solar panels on the roof
Use solar panels – reuse stuff
No fires
Decrease my carbon footprint, save energy, and be green to my planet
Not eat as much
Turn lights off when I'm not using them
Reducing the amount of water and electricity you use
If you want to save the energy
Use less electronics during the day
Turn off the lights when not using them

4. How could you and your neighborhood help the earth?

Water the nearby plants
By picking up garbage
Plant fruits and vegetables
People could stop vandalizing houses
Neighborhood "Green" watch
Cleaning up litter, conserving energy and recycling
By throwing away more garbage and recycling more
I can help the neighborhood by saving batteries
Have a public recycling crew – walk around the town recycling for the neighborhood
Recycling
Pick up litter and no littering
Make vegetable gardens in our backyards
Pick up trash outside- DON'T LITTER!!!! – throw away your trash
They don't waste energy
Stop littering and pick up trash
No evil people
We could stop littering and be beneficial to our environment
Not littering

5. If you could pick a “Green” or sustainable job what would it be?

IDK at all
A farmer, because I am being green and replenishing and using replenish able sources
Don’t know
A construction worker
Designing green garbage trucks
Doctor/Surgeon
Planter
Farming or gardening
Drywall
Gardener
I will pick to do the grass and the wood
Garbage man
Probably environmental protection so I could work with cool animals
Solar power – mountain climbing
Flower shop
A sun panel house
Build better cars that don’t waste energy and pollute the earth
Working in a plant dome

APPENDIX B COLLEGE RAW DATA

1. As a result of your participation in this program have you made any changes in how you see or use your house?

   "Yes, as well as design changes in future home builds"
   "I am more conservative with my energy usage. I realize the flaws in my own house and also the steps I can take to make it a little more efficient and healthy. I am aware of my house as a system."
   "I see the value of what material is to us to help/aid our environment. It is important to know what is used to create the material that is used in construction. I will use this in building my home."
   "Yes, more aware of mold growth in homes & especially being able to take action by putting mold growth in a minimal presence by cleaning."
   "Living in a house built in the 70's, I have identified different types of energy loss through windows, doors, and insulation."
   "Yes, it has changed the way I look at all buildings even on T.V. I like to see the layout and see if I can figure out the concept they were going for."
   "I'm not worried about doing home repairs. I'm ready to start remodeling my home with confidence."
   "I have a far better understanding of how I can seal up my house to make it more energy efficient. Con: Now I want to move out."
   "Yup, I finally understand why houses are so difficult to build (due to permits)."
   "Yes, I look at how roof lines and building shapes in a different way in how it is put together."
   "Yes, I feel that I have learned enough actually to no longer fear owning a home. I feel that I learned enough to if not fix it myself I can keep a well-informed eye on those I hire to aid me."

2. As a result of your participation in this program have you made any changes in the way you see and use natural resources?

   "Yes, limiting the use of natural resources is a must. Going to things like alternative energy, I-beam instead of lumber, or even OSB instead of plywood. All these are sustainable choices which help the environment."
   "What we use is not always the best choice. Not only for our environment but also for our health in the long term."
   "I've always used resources very well. Others consider a flaw. Other people give priority to saving time but they do nothing and then they complain about being broke"
   "Yes, looking at things that can be recycled to help in making it last longer and using it or other building projects."
   "I always have been a "tree hugger" so I always think about conserving resources. I hope when I get into the Building Science part of the class to learn about more information."

"It has definitely changed the way I see them. I'm still working on the way I use them and have enjoyed learning different ways to use all resources."
"I have become more aware of the resources that can be reused and recycled. I learned a lot about different building materials."
"I try to reuse building materials and be more efficient with the materials on hand."
"Yes, learning to use reduce & recycle is a main thing to learn in a business and using this method is cost effective."
"Yes, I have made changes in my use of resources by reducing my carbon emissions and recycling/repurposing waste materials such as wood."
"Yes, natural resources such as living roofs provide many added values to a home."

3. As a result of your participation in this program have you made any changes in how you see or use energy?

"Yes, I have been reducing my energy use by heating a smaller room rather than the whole house."
"I have not gone into the SBS part of the class yet."
"I haven't made as big of a change as I can but I still plan to do more. But it is nice to talk to my son about these things."
"Yes, the conservation of energy is the priority in building theory."
"I'm more aware of my energy usage, where and also how it is made. Knowing more than "it comes out of the wall" is something more people should be aware of."
"I try to cut down on the use of power as well as unplug unused electronics and chargers."
"My energy consumption is quite low. Our electric bill at the house is 60 dollars per month."
"Not at this time, just keeping an open mind in learning more."
"My drive for an eco-friendly home is far greater. I would love to be "off the grid."
"Yes, learning that electric systems that aren't being used can still be assuming energy are increasing the bill like phone chargers, toasters, microwaves, etc."
"I am more aware of things that can be changed in my own home to prevent energy loss."

4. As a result of your participation in this program do you think sustainability will play a part in your future employment?

"Yes I do, I enjoyed this program and learned a lot. The SHED project was a good learning experience."
"Definitely!"
"I sure do hope so, I look forward to doing something that really matters to me and makes a difference in the world around me."
"Yes, I plan to employ the skills that I have learned throughout this project on every future build that I am a part of."
"I hope it does, I've really got a lot out of this quarter and can't wait for the next one."

"Yes, I intend to be a green builder."
"Looking, and for more of an understanding."
"Most certainly, I am very interested in the energy auditing field."
"Yes, a major part of my employment, having this kind of experience & education I believe can go a long way."
"A big yes. I believe in sustainability which is a part of self-reliance. It is the first step of giving back to nature and to ourselves. It is the first step in finding a balance in nature that was never fully understood."
"Doubt that. As mentioned my money/energy and resource saving measures annoy people and really until society alters its viewpoint or stops ridiculing others who try to live frugally then my prospects of employment will greatly improve."