Science and Mathematics Education Centre

Impact of School Gardens on United Arab Emirates Science Students' Learning Environment Perceptions, Attitudes, Aspirations and Knowledge

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DECLARATION

To the best of my knowledge and belief, this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

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Signature:

Date: 9 July, 2020

ABSTRACT

There is a long history of gardens being used as educational tools in schools, however, only a limited number of studies have investigated the impacts of school gardens on student outcomes. To date, no studies have been carried out in school gardens in countries with extreme climates such as the UAE and, therefore, this study fills a gap in the research. The overarching aim of the study was two-fold. First, to investigate whether the use of a school garden, during science classes, made a difference to students' perceptions of the learning environment, attitudes towards their science classes, aspirations towards future gardening and towards healthier eating, and their knowledge of healthy eating and nutrition. Second, to examine whether students' perceptions of the learning environment created in school gardens was related to these outcomes.

The school chosen for the study was a Cycle 2 school (comprising students in Grades 6 to 9), located in an inner-city area of Abu Dhabi. This quantitative study included a sample of 307 students in 19 classes for the pre-test administration and 368 students in the same 19 classes for the post-test. This provided a total of 268 matched pairs of responses (students who responded to all of the perception surveys and the knowledge tests for both the pre-test and the post-test).

Given the dearth of instruments available to address the research objectives, the first step (Research Objective #1) was to develop and provide support for the reliability and validity of three perception surveys: one to assess students' perceptions of the unique learning environment created in the garden setting; one to assess students' attitudes; and one to assess students' aspirations towards gardening and healthier eating. To provide support for the validity and reliability of these surveys, analyses of data collected from both the pre-test (N=441 students) and post-test (N=336 students) was used to examine the factor structure, Eigenvalues and internal consistency reliability. In all cases, analyses led to a slightly refined version of the instruments, the results for which provided strong support for the validity and reliability of each survey when used with this sample.

The second step (Research Objective #2) was to examine whether the use of a school garden during science lessons led to improvements in students' perceptions of their learning environment, attitudes, aspirations, and knowledge of healthy eating. The data collected from students before the use of the gardens and again eight months later were analysed using one-way multivariate analysis of variance (MANOVA) and effect sizes. The findings revealed that, after participating in the gardens, there were statistically significant differences ($p<.05$) in students' learning environment perceptions for four of the scales, with students scoring more favourably on all four scales after the introduction of the school garden. Students' scores were also statistically significantly greater for their aspirations towards future gardening ($p<.05$, effect size=.11 standard deviations) and for their knowledge of healthy eating and nutrition ($p<.01$, effect size=.68 standard deviations). However, contrary to expectations, the pre–post results indicated that the differences in student attitudes towards science classes (enjoyment and task value), and aspirations towards healthier eating, were non-significant.

The third step (Research Objective #3) sought to examine whether relationships exist between the learning environment created with the use of school gardens and students' attitudes to science, aspirations to gardens and healthier eating, and knowledge of healthy eating. To address this research objective, simple correlation (r) and multiple regression (R) analyses were used. The results indicated that there were statistically significant and positive associations between students' learning environment perceptions and their attitudes towards science learning ($p<.01$) and aspirations towards healthier eating and future gardening ($p<.05$). There was also a statistically significant ($p<.01$) and positive relationship between the learning environment created with the use of school gardens and students' knowledge healthy eating. These findings suggested that the learning environment created during science classes with the use of gardens had a positive influence on both affective and cognitive outcomes of students.

The findings from this study include three major outcomes. First, the study has added three validated surveys to the field of learning environment and school garden research. Second, the findings of the study provide evidence that school gardens could be helpful in improving students' perceptions of their learning environment, aspirations towards future gardening, and knowledge of healthy eating and nutrition. Third, the findings provide evidence of positive associations between the learning environment and

student attitudes, aspirations towards healthier eating and to the future keeping of gardens, as well as improved knowledge of healthy eating and nutrition. With so little research focusing on school gardens, the outcomes of this study extend this field and pave the way for future research on school gardens. The findings are likely to be of significance to a range of stakeholders, as they provide evidence to support the benefits of school gardens on student outcomes in Abu Dhabi. The findings could also benefit policy developers, school administrators, and teachers, as they provide information about the positive effects of the learning environments on student outcomes and how learning environment factors are improved when the use of on-site school gardens is integrated into the science curriculum and classroom lessons.

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ACRONYMS

ADEC	Abu Dhabi Education Council
ADEK	Abu Dhabi Department of Education and Knowledge
AGHEN	Aspirations to Gardening and Healthy Eating and Nutrition survey
ANOVA	Analysis of Variance
ATS	Attitude Towards Science scale
CES	Classroom Environment Scale
CLES	Classroom Learning Environment Survey
CUCEI	College and University Classroom Environment Inventory
DAS	Dimensions of Attitude toward Science
FAO	Food and Agricultural Organisation (of the United Nations)
GALE	Gardening and the Learning Environment survey
GATS	Gardening and Attitudes Towards Science survey
ICEQ	Individualised Classroom Environment Questionnaire
LEI	Learning Environment Inventory
MANOVA	Multivariate Analysis of Variance
MCI	My Class Inventory
MOE	Ministry of Education (United Arab Emirates)
OECD	Organisation for Economic Co-Operation and Development
QTI	Questionnaire on Teacher Interaction
SAI	Scientific Attitude Inventory
SALES	Students' Adaptive Learning Engagement Survey
SD	Standard Deviation
SLEI	Science Laboratory Environment Inventory
SPSS	Statistical Package for the Social Sciences
STEM	Science Technology Engineering and Mathematics
TOSRA	Test of Science-Related Attitudes
UAE	United Arab Emirates
USA	United States of America
WIHIC	What Is Happening In this Class

Chapter 1

INTRODUCTION

1.1 Introduction

On-site school gardens can be regarded as useful tools in providing an alternative environmental setting to that of the regular classroom. School gardens allow students to connect with the natural world around them, a world that is seemingly becoming more distant from the confines of the classroom (Egan, 2017). Gardens offer students an environment to learn outside of their classroom, providing a first-hand setting, which Ofsted (2008) purports to be important for increasing interest and understanding of subject content in comparison to learning in the traditional classroom setting. For teachers, the garden is a useful tool to enhance student achievement (Smith & Motsenbocker, 2005) and a range of outcomes such as environmental attitude (Skelly & Zajicek, 1998); concepts in nature (Johnson, 2013; Lohr & Person-Mims, 2005); cognitive development (Klemmer, Waliczek & Zajicek, 2005); nutrition and eating habits (Huys, et al., 2017; Johnson, 2013); achievement in science; and personal development in the areas of physical, cognitive and social/emotional development (Blair, 2009).

Despite much global literature on school gardens, Ozer (2007) suggests that comparatively few empirical studies investigating the impacts of using a school garden exist. This notion was supported by more recent studies including Williams and Dixon (2013) and Berezowitz, Bontrager Yoder, and Schoeller (2015). In their synthesis of past research, Williams and Dixon (2013) reviewed literature related to the impact of garden-based learning on academic outcomes. Although the studies reported in 48 journal articles suggested that garden-based learning had positive impacts on students' grades, knowledge, attitudes, and behaviour, the authors also raised concerns with respect to sampling and validity of data, citing these as major weaknesses in the majority of the studies reviewed. Similarly, in Berezowitz et al.'s (2015) review, which examined associations between school gardens and student academic performance and/or diet, found that, of the 3731 publications found, only 15 fulfilled the final criteria. Although the findings reported in this literature indicated that school-

based garden interventions improved or maintained both academic performance, as well as student nutrition outcomes, the authors concluded that many of the studies lacked scientific rigour, including incomplete methodological descriptions, use of a convenience sample, a lack of a control group, and small cohorts. In fact, most studies that have examined the impacts of gardens on student outcomes have relied on anecdotal data (see for example, Dyment, 2005; Ozer, 2007; Wells et al., 2015).

Dyment (2005) and Wells et al. (2015) suggest that many of the issues relating to reliability of data stem from inadequate planning, and lack of understanding about the roles of implementers in the success of school garden activities, as well as modest sample sizes, lack of pre-intervention baseline data, failure to include a no-garden control or comparison group, and lack of random assignment to experimental and control groups. The findings of these more recent reviews would suggest that Ozer's (2007) call for further research into the topic of school gardens and their impacts on outcomes in health and social behaviour, with a need for both quantitative and qualitative research using multiple approaches, is still relevant today.

The potential of school gardens to improve outcomes in science, coupled with the lack of reliable research that has examined the impact of school gardens on student outcomes were the main drivers in conducting the research reported in this thesis. Given the lack of reliable data, the study reported in this thesis rose to this challenge and has helped to fill some of these overdue gaps in research. Further, the study reported in this thesis fills a void in literature and adds to the studies already available.

The overarching aims of this study were two-fold. The first aim was to investigate whether the use of a school garden, during science classes, improved students' perceptions of the learning environment, attitudes towards their science classes, aspirations towards future gardening and towards healthier eating, and their knowledge of healthy eating and nutrition. The second aim was to examine whether students' perceptions of their learning environment were related to their outcomes (attitudes towards science classes, aspirations towards future gardening and towards healthier eating, and knowledge of healthy eating).

This chapter introduces the study. Section 1.2 provides an overview of the study location, Abu Dhabi, including a geographical overview and an outline of education and education reform. Section 1.3 outlines the impetus for the study, including the concepts of health and nutrition, and of greenhouses and gardens in schools in Abu Dhabi where the study took place. The research objectives of this study are introduced in Section 1.4. In Section 1.5, the theoretical framework of the study is described, while the significance of the study is outlined in Section 1.6. An overall description of the chapters contained in this thesis is provided in Section 1.7.

1.2 Context of the Study

This section provides a contextual overview of the location site of this study, including information about the city of Abu Dhabi. Section 1.2.1 introduces the Emirate of Abu Dhabi with a brief geographical description and statistical overview. Section 1.2.2 provides a brief history of the education systems in place in Abu Dhabi, while Section 1.2.3 describes some of the changes of the education reform processes taking place in the Emirate of Abu Dhabi since 2008.

1.2.1 Introduction to Abu Dhabi

The research reported in this thesis took place in the city of Abu Dhabi, United Arab Emirates. Abu Dhabi is an island city located on the south-eastern side of the Arabian Peninsula, in the Abu Dhabi Emirate of The United Arab Emirates (UAE). Abu Dhabi is the capital of the UAE, and is also the largest Emirate of the UAE in terms of physical size and population. According to the World Population Review (2018), Abu Dhabi city's total population is 2.78 million, with a 4.8 percent annual growth rate. The population of Abu Dhabi can be divided into three main resident compositions—citizens of the UAE residing in Abu Dhabi, expatriate residents living in Abu Dhabi, and non-residents of Abu Dhabi (such as short term visitors). There is no official figure available of non-residents, and this creates difficulty in calculating the exact population of Abu Dhabi.

Abu Dhabi is located along the Tropic of Cancer, and is classified climatically as having a hot desert climate. In fact, most of the Emirate is comprised of desert sands

and barren plains, and summer time temperatures can each extremes of heat with virtually no rainfall throughout the year. According to statistics provided from the National Centre for Meteorology in Abu Dhabi, average annual temperatures peak at 42.9 degrees Celsius in August, with an annual precipitation of less than 58 mm, placing it amongst the driest cities on the planet. Given the lack of precipitation, annual sunshine rates are very high with the city bathed in sunshine on most days of the year. Although the sunshine is beneficial for plant growth, the lack of significant rainfall and natural water sources makes the Emirate barren of any major natural plant growth, and most visible vegetation grows as a result of human intervention such as from irrigation and the use of greenhouses. The main source of fresh water in the Emirate is from desalinised sea water. These last two facts are important considerations in the context of this study, in relation to the lack of student exposure to vegetation in their natural environment.

1.2.2 Brief History of Education in the United Arab Emirates

Just as the UAE is a relatively new nation, a true system of education is also a relatively new concept in the UAE. Prior to the early 1970s, there were very few formal schools, and by federation in 1971, The Emirates Center for Strategic Studies and Research (2004) reports that there were 74 schools in the country. In fact, prior to federation, modern education as recognised in the western world, was virtually non-existent in the UAE (Godwin, 2006).

With the establishment of the seven Emirates of the UAE, and the development of formal government posts in 1971, constitutional guidelines were proposed in the development and expansion of formal education across the nation, and with the rapid expansion of the oil and gas industries and growing wealth, much was invested in the development of education systems, so that by the year 2000 more than 1100 schools had been established across the country (The Emirates Center for Strategic Studies and Research, 2004). Having worked in the Abu Dhabi education system in higher management and curriculum development for more than 11 years, direct experience and anecdotal evidence collected by the author during this time indicates that the education system was developed to closely resemble systems in western countries, with input from British, American, Canadian, Australian and other western country

curricula. In the author's experience, most of the teachers working in the public education system in schools across Abu Dhabi, were recruited from nearby Arabic speaking countries (including Jordan, Syria, Egypt as well as UAE nationals and other Arabian Gulf countries). However, with the introduction of English as the language of instruction in many subjects from 2014, many teachers have since been recruited from a range of English speaking western countries (including South Africa, Australia, New Zealand, United Kingdom, United States of America, and others).

With increasing numbers of private schools established across the country, the education system has developed in accordance with international standards following the educational reform project which was initiated by the Abu Dhabi Department of Education and Knowledge, ADEK (formerly the Abu Dhabi Education Council-ADEC) in 2008. The aim of the reform process was to implement a unique 'new school model' across all government schools in the emirate of Abu Dhabi (Abu Dhabi Education Council, 2010), with the ultimate goals of whole school improvement, increased student achievement, and better opportunities for students with improved curricula and resourcing, and a change from traditional teaching styles to innovative styles inclusive of cooperative learning strategies, problem solving and inquiry-based learning strategies and others (Abu Dhabi Education Council, 2012). More details about the education reform processes are discussed in the next section, Section 1.2.3. Thus, with the UAE government investing so much money and resources into building a world class education system (Abu Dhabi Education Council, 2012), schools were allocated funds to use in several areas of development, including improving on-site facilities and resources. This was crucial in the establishment (and maintenance) of the greenhouse and garden area in the sample school of this study, and details of this are reported in Section 1.2.5.

At the time of writing this thesis, there were approximately 250 public schools and 185 private schools in Abu Dhabi (Abu Dhabi Department of Education and Knowledge, 2018). The core learning education levels in public schools were divided into three 'cycles'. Cycle 1 includes students from grades 1 to 5, Cycle 2 are grades 6 to 9, and Cycle 3 includes students from grades 10 to 12. Outside of these cycles were the kindergarten and adult education centres which were also administered by ADEK. The science curriculum was taught in English across Cycle 1 and 2 schools, with English

gradually replacing Arabic as the language of instruction across all sciences in subsequent years. In 2018, the UAE Ministry of Education introduced changes to the curriculum structure of most subjects, including science. The hope of the Ministry was to unify subject material across all schools of the UAE in the coming years, but with the continued goals of providing a world class standard of education across the whole of the UAE (Abu Dhabi Department of Education and Knowledge, 2018).

1.2.3 Brief Overview of Education Reform in Abu Dhabi

Since 2008, an ongoing process of educational reform has been taking place in government schools across the Emirate of Abu Dhabi (Abu Dhabi Education Council, 2010). The former Abu Dhabi Education Council (now Department of Education and Knowledge- ADEK), which oversees all of the government schools in Abu Dhabi, has invested in a process of change from a highly traditional system of education, to a system which encourages inquiry based and cooperative learning (Lowe, 2004), with the overarching aim of increasing student achievement and bringing the education system in line with international standards. As such, the education system in Abu Dhabi has transformed rapidly since 2008. Most schools, at the time of this study, were well resourced, and language difficulties were being addressed with improvements in both Arabic and English instruction.

The education reform has opened up opportunities for educators in Abu Dhabi to use alternative strategies to traditional classroom teaching, including cooperative learning and assessment strategies, inquiry based learning strategies, and innovative strategies such as learning conducted in environments outside of the regular classroom, such as in outdoor gardens, to provide students with improved learning opportunities. Learning outside of the classroom environment can encompass a range of methods and sources, and an example of this is the use of outdoor gardens and greenhouses. The use of gardens in schools, therefore was in line with the ideologies and objectives of the educational reform process taking place in Abu Dhabi at the time of the study, and (along with the gaps in reliable research on the effects of gardens on student outcomes, as discussed in Chapter 2), this was an added incentive in the inception and development of this study.

1.3 Impetus for the Study

This section introduces the concepts which provided an impetus for this study, namely the diet and nutrition trends (Section 1.3.1), and the concept of school gardens in Abu Dhabi and gardens in schools (Section 1.3.2), including an overview of how the greenhouse and gardens were established in the sample school.

1.3.1 An Introduction to Human Dietary Changes

Since prehistoric times, and as documented throughout human history, the natural environment has impacted on human life, and agricultural practices have been a major link between the natural environment and human survival (Vasey, 1992). With the ever changing environmental conditions, new and innovative practices have been devised by humans and these are particularly evident in the changing nature of agricultural practices throughout human history (Vasey, 1992). The interactions between humans and the natural environment has helped humans to invent tools for hunting and gathering to meet the basic nutritional needs for survival. From ancient times up to the pre-industrial revolution era, agricultural farming techniques were more widely used across human communities globally and, as a result, people in these pre-modern times had wider access and knowledge of farming techniques and greater access to naturally grown foods, in contrast to modern society (Thrall, Bever & Burdon, 2010).

The increase in human populations and advancements in technology have set the stage for increased urbanization which, in line with industrialisation, created even greater stresses on the world's natural resources (Satterthwaite, McGranahan, & Tacoli, 2010). From traditional societies where food sources were predominantly grown naturally through agriculture, humans increasingly began to manufacture foods using processing techniques, alongside the increased availability of 'fast-foods'. Ukonu (2016) describes this phenomenon as the globalisation of fast foods, particularly in the western world. More and more, people have become exposed to processed foods containing higher contents of fats and sugars. With urban areas growing rapidly, so too have availability of these high fat, high sugar, processed 'fast foods' inclusive of foods that are often referred to as 'junk food', such as chocolates, fried potato chips, sweets, hamburgers, pizzas, and so many others. Dietary habits of humans, particularly

in urban areas, have become modified as human interactions with their natural environment decreased. This trend has also been evident throughout the Middle East, and in line with most urban centres, with Abu Dhabi seeing similar changes in dietary trends throughout its short history.

Today, people in urban settlements (including in Abu Dhabi), rely heavily on fast foods, processed foods, frozen foods and junk foods, particularly since urban living lends itself to a fast paced lifestyle where these convenient foods are readily available and at relatively low cost (Ukonu, 2016). Whilst the dietary habits of urban dwellers have changed with urbanisation, a reduction of natural environments (such as gardens, forests, and agricultural lands) in urban areas has also resulted in urban dwellers losing a direct interaction with the natural environment (Fuller & Irvine, 2010). Keniger, Gaston, Irvine and Fuller (2013) describe the physical, cognitive and psychological benefits of humans interacting with nature that include improved mental process ability (such as improved mood, self-esteem, and behaviour), cognitive ability or function (such as improved academic performance, improved productivity), physical function/ health (such as reduced stress, reduced blood pressure, better respiratory health), and social and spiritual benefits.

Given the isolation of Abu Dhabi and its inhabitants from any form of natural "green" vegetative environment, the benefits identified by Keniger et al. (2013) are relevant in the context of this study. Since Abu Dhabi and its surrounds is a heavily urbanised area, as well as being surrounded by extensive desert areas, the interactions between people and the green environment, as with many other urban areas, are substantially low, highlighting the need for access. Given these major dietary changes throughout history, one of the research objectives of this study was to evaluate whether exposure to garden activities in school impacts on students' aspirations towards healthier eating as well as improving their knowledge of healthy eating and nutrition (see research objectives in Section 1.4).

1.3.2 Greenhouses and Gardens in Abu Dhabi

The idea of the school garden is not new, nor is the concept of utilising the natural environment to enhance student experiences and learning (Canaris 1995; Graham,

Beall, Lussier, McLaughlin, & Zidenberg-Cherr, 2005; Klemmer et al., 2005; Shair, 1999; Triador, Farmer, Maximova, Willows, & Kootenay, 2015). The study reported in this thesis focused on the impacts of the introduction of a school greenhouse and garden and associated activities on students' perceptions of the learning environment and a range of outcomes. Therefore, this section provides a brief overview to the introduction of the greenhouse and gardens to Abu Dhabi schools (Section 1.3.2.1) and the use of the greenhouse and gardens at the sample school in Abu Dhabi (Section 1.3.2.2).

1.3.2.1 Introduction of Greenhouses and Gardens to Abu Dhabi Schools

A 'greenhouse' is essentially an enclosed structure which traps light and heat allowing for optimal conditions for plant growth (Omer, 2016). In most regions of the world, the greenhouse is used to keep heat inside to allow for growth in cooler unfavourable growing conditions (such as in winter). However, in the extreme heat of Abu Dhabi, the greenhouse was used to remove heat, using a water drip and fan system to pump out hot air and cool the interior using evaporative cooling. This system cools the interior sufficiently to allow for extended growth of plants until the full advent of the summer heat prevents any further possibility of outdoor growth of plants. The greenhouse is important in the context of this study in terms of being a space outside of the regular classroom where students could engage in learning activities (namely growing their own plants and associated learning). For this reason, the term "greenhouse" will be used interchangeably with the term "gardens", since the sample school had both a physical greenhouse enclosure, as well as an outdoor garden area which were used by students to conduct their gardening activities.

Whilst industrialisation and urbanisation were expanding in the 1800s, the concept of on-site greenhouses emerged from Europe which at that time was the industrial hub of the world (Shair, 1999). Scientists began using greenhouses and urban gardens experimentally for growing plants and foods in areas that no longer had large open agricultural lands, and thus allowing access to freshly grown foods in an urban environment (Van den Muijzenberg, 1980).

Given the challenges faced by the extremes of climate and geographic isolation (described in Section 1.2.1), the citizens of Abu Dhabi face increasing health-related problems associated with poor nutrition. The UAE has one of the highest global rates of diabetes and obesity, and these rates have been increasing since 1997 (Sulaiman et al., 2017). Poor eating habits and the availability of low cost processed fast foods is having a detrimental effect on residents as a whole, including school aged children (AlNohair, 2014). Although this issue was not the focus of this study, the concept of diet-related health issues is directly associated with the notion of healthy eating and consumption of healthy foods, which was one of the focuses of this study.

As well as the challenges faced in Abu Dhabi, from the climatic extremes that place such restrictions on daily life and limiting access to natural local vegetation (as a source of fresh food), the research reported in this thesis also aligns with the education reform efforts which pushed for increased student learning through cooperative learning. The topic choice was inspired by the introduction of a school garden/ greenhouse at a school in central Abu Dhabi. The United Nations Food and Agricultural Organisation (FAO) had provided the school with funding, in association with the FAO 'Gardens Project' (as well as funding from ADEC and the school for continued maintenance). The school was provided with the resources and funding to construct a large greenhouse and plantation areas for growing vegetables and other plants on-site.

1.3.2.2 The Use of the Greenhouse and Garden at the School

Given the selection of this particular school by the FAO for the implementation of the greenhouse/ garden project, and given that the author had been working at the same school, the decision to use this school for the present study was a logical one in terms of logistics, resourcing, and the close relationship of the researcher with the staff at the school (see Chapter 3 for more details related to the selection of the school). The greenhouse was constructed in a large unused area adjacent to the science laboratories at the school. Its construction involved a metal frame that was covered with strong transparent plastic (to allow the entry of sunlight) and contained a large exhaust fan and evaporative cooling system. Given the extreme heat of Abu Dhabi, such a system was essential for the growth of plants inside the greenhouse during the warmer months

of the year. In addition to the greenhouse, a large area near the greenhouse location was set aside for a separate gardening area which would also be used to grow plants given the placement of soil and access to water from nearby taps and hoses. Soils, seeds and seedlings, utensils for cultivating and growing, fertiliser and any additional sources were provided by the FAO and by the school.

The classes selected to participate in the garden activities (as described in Chapter 3) were provided with at least three one-hour time slots during their scheduled science classes per week. The focus of the greenhouse and gardens was to provide the students the opportunity to interact with their environment and to become involved in garden-related activities. This was timetabled into the teachers' schedules. Given that one of the research objectives of the study related to nutrition and healthy eating, the seeds provided to each class were of fruits and vegetables, including cucumbers, tomatoes, lettuce, cabbage, zucchini, beans, peas, carrots and strawberries. Part of this project then, was to promote simple planting practices in the hope that this would, in turn, promote healthy eating among students. In addition to promoting healthy eating, it was anticipated that using these gardens would also promote student interest in gardening practices, providing a base for better awareness of healthy eating practices by growing their own foods at home.

A specific area within the greenhouse or garden plot was designated for each class, to prevent overlap of planting. During each of the one hour sessions, teachers were asked to perform various tasks with their classes in the gardens, including preparing the land and soil, planting the seeds, cultivating the area, watering, making observations (including the use of some scientific skills such as measuring growth and fruit size, drawing diagrams, making predictions). Teachers were given the opportunity to conduct normal lessons within the garden areas, particularly for any topics they felt were relevant in the outdoor settings (for example the topics of plants and living things in biology). Once the fruits/ vegetables had grown sufficiently, the final task was to cultivate the products and for students to share amongst themselves, take them home and to eat them. In many cases, where time permitted, the land was re-cultivated and new seeds were planted again by the classes in their specific allotted area. Overall, teachers were provided with flexibility to utilise the gardens as they pleased with their classes once the set tasks of planting, watering, monitoring, and cultivating were

established across all classes. All students had regular opportunities to participate in the gardens throughout the duration of the growing period, which was approximately eight months.

1.4 Research Objectives

The overarching aims of the study reported in this thesis were, first, to examine the impact of an on-site garden and greenhouse facility and whether its use improved students' outcomes, and, second, to examine the relationships between learning environment perceptions and these outcomes. To investigate these overarching aims, the following three research objectives were delineated.

First, given that the study involved the use of three surveys that were modified to make them applicable in terms of the research objectives, and suitable for lower high school students (Cycle 2) in the UAE, it was necessary to provide support for the reliability and validity of the three surveys. In doing so, this would provide confidence in the results of the subsequent research objectives. To this end, the first objective was delineated.

Research Objective #1

To modify and validate three surveys for use with Cycle 2 students in Abu Dhabi, United Arab Emirates to assess students':

a. Perceptions of the learning environment;
b. Attitudes towards science classes; and
c. Aspirations with respect to gardening and healthier eating practices.

The second research objective sought to assess whether the introduction of the gardens/ greenhouse project, and associated activities within these, was beneficial in terms of improved student outcomes, including, students': perceptions of the learning environment, attitudes towards science classes, and aspirations for the students in tending a garden beyond the scope of the school gardens and aspirations in relation to adopting healthier eating practices after exposure and interactions within the gardens.

As well, to measure the impacts of the gardens on students' knowledge of healthy eating practices.

Research Objective #2

To investigate the impacts of a school garden project on students':

a. Perceptions of the learning environment;
b. Attitudes towards science classes;
c. Aspirations with respect to gardening and healthier eating practices; and
d. Knowledge of healthy eating and nutrition.

Finally, the study sought to examine the existence of relationships between the learning environment and student outcomes. Therefore, the third research objective was to:

Research Objective #3

To investigate the relationships between students' perceptions of the learning environment created during the garden project and their:

a. Attitudes (enjoyment and task value);
b. Aspirations with respect to gardening and healthier eating practices; and
c. Knowledge of healthy eating and nutrition.

The methodologies of the techniques used in examining these relationships, as well as the techniques used to investigate the first and second research objectives, are detailed in Chapter 3.

1.5 Theoretical Framework

Creswell (2014) highlights the importance of consideration of a philosophical 'worldview' assumption by any researcher planning a study, in addition to research design relating to this worldview, and the methods that allow this to be put into practice. The term 'worldview' is often referred to interchangeably as paradigm or

epistemology (Creswell, 2014), and is defined by Guba (1990) as: "a basic set of beliefs that guide action". Of the four paradigms suggested in Creswell (2014), the research presented in this study is most closely aligned to the post-positivist paradigm which is essentially an approach predominantly using a quantitative design, analyse numerical data and trends (as outlined in Section 3.4 of Chapter 3). The research reported in this thesis involved the collection of quantitative data with the aims of determining effects or outcomes from causes (Creswell, 2014). In the case of the study presented, the 'cause' is the introduction of the gardens into the sample school and the associated activities of students within the gardens (detailed in Section 3.3 of Chapter 3), and the 'outcomes' are the impacts on the students in relation to perceptions to the learning environment, attitudes, aspirations, and knowledge, which form the research objectives of this study (which are detailed in Section 1.5 below).

This study draws on Bandura's (1977; 1986) social cognitive theory. Social cognitive theory is applicable in three major fields, namely psychology, education, and media/communication sciences. Learning environment research is grounded in social cognitive theory which attempts to maximise student learning outcomes based on optimal learning environments (Bembenutty, White, & DiBenedetto, 2016). The theory attempts to explain the role and functions of human cognition in the social settings and how people learn from certain situations or by learning through interactions with other people and the environment (Lee, Park, Lee, Kim, & Park, 2018). It is these interactions (with other people and the environment) that form the basis of the study presented in this thesis, which involves student interactions with their peers in the context of their interactions in the gardens (as the learning environment, as described in Chapter 3). Social cognitive theory proposes that human growth, development, learning, adaptation, and interaction all take place within a triad of bidirectional environmental, behavioural and interpersonal determinants (Bembenutty et al., 2016). The social cognitive theory was considered suitable and relevant in the context of the research presented in this study since the study investigates relationships between the variables of learning environment, student perceptions, attitudes, aspirations, and knowledge.

1.6 Significance of the Study

This section provides an overview of the significance of the study, which is expanded on in Chapter 5. The results of the study are likely to be of value to a range of stakeholders as outlined below.

First, it is anticipated that the results of the study will be of significance to the Food and Agriculture Authority of the United Nations (FAO) (who provided funds specifically to the school to set up the greenhouse and garden areas). The results will provide empirical evidence related to changes in students' perceptions of the learning environment and a range of outcomes that could be useful in future FAO decisions with respect to expanding or implementing greenhouses/ gardens across other schools in Abu Dhabi.

Second, it is anticipated that the findings will provide the UAE Ministry of Education (MOE) and the Abu Dhabi Department of Education and Knowledge with useful information about the benefits of school gardens. This information could be used to influence future decisions with respect to the worth of future gardens projects in other schools, and the use of gardens as tools or resources for teaching and learning in schools in other parts of Abu Dhabi. Potentially, the results could also be used to guide future projects that seek to promote better health and nutrition in students.

Third, it is anticipated that the study will fill a void in the availability of valid and reliable research on the effects of school gardens on student outcomes. It is anticipated that the research and findings will help fill some gaps from findings presented in other similar studies, given the many limitations of studies in the area of impacts of school gardens (from the literature presented in Chapter 2).

1.7 Overview of the Thesis

To report this study, this thesis has been organised into five chapters. The following is a brief overview of each of the five chapters.

In this chapter, Chapter 1, information related to the context of the study was provided. This included a brief overview of the history and significance of on-site greenhouses/

gardens in schools, a description of the study location, Abu Dhabi, and a brief overview of the history of education in the UAE. In this chapter, the three research objectives were introduced, along with the theoretical framework of the study, and the significance of the study to various stakeholders.

In Chapter 2 of the thesis a review of the relevant literature pertinent to the research in this study is provided. First, a brief history of school gardens is presented, along with a review of literature related to the relationships between gardens in schools and student outcomes. Next, a review of literature related to the history and development of the field of learning environments is provided. This includes a review of various past instruments used in assessing learning environments. Finally, literature related to students' attitudes is reviewed. Past research about attitudes, as well as research related to associations between learning environments and student attitudes is also reviewed.

Chapter 3 provides a detailed description of the research methods used to complete this study. In this chapter, a description is provided of the selection process of the sample school and the sample classes. The chapter outlines the process of instrument development, based on past instruments. This chapter also describes the translation process of the instruments into Arabic, and the processes of conducting the data collection including a technical trial. A detailed description of the methods used to analyse the data is also provided in Chapter 3. Finally, the ethical considerations made throughout the study, and how these were addressed, are reported in this chapter.

In Chapter 4 the results of the analyses of the data collected form the surveys are reported. The results generated through statistical analysis are presented to address each research objectives. The chapter presents evidence to support the reliability and validity of the surveys (Research Objective #1), the pre and post differences in perceptions, attitudes, aspirations, and knowledge (Research Objective #2), and the associations between the learning environment and attitudes, aspirations, and knowledge (Research Objective #3).

In Chapter 5, a discussion of the results along with a summary of findings is presented. As well as the discussion, Chapter 5 also reports the limitations of the study, the significance of the study, and provides recommendations for future research.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides a review of literature pertinent to the study presented in this thesis. First, literature related to research pertaining to school gardens, including students' attitudes to learning in school gardens and the impact on healthy eating and nutrition, is provided in Section 2.2. Section 2.3 provides a review of literature related to the field of learning environments. Next, in Section 2.4, literature relating to student attitudes to learning is reviewed, including an historical overview, and a summary of instruments used to measure student attitudes in relation to various factors. Finally, Section 2.5 summarises the findings from the literature reviewed for this study.

2.2 School Gardens

This section reviews literature related to the use of gardens (and greenhouses) in schools. In the context of this study, the difference in the terminologies "garden" and "greenhouse" refers simply to the fact that the garden in the sample school was located outdoors in an open space without a cover from the sun, whereas the greenhouse was a similar outdoor space used for gardening, however with a plastic covering shading the garden area from direct sunlight. It is important to note that, for the purposes of this study, the use of the terminologies "garden" and "greenhouse" were interchangeable, since both relate to the students participating in gardening activities outside of their regular classroom space. Regardless of whether the students were in the garden space or in the greenhouse space, the activities provided to the students were similar. Section 2.2.1 provides a short history of the use of garden and reviews research related to school gardens. Section 2.2.2 reviews literature related to past research that has examined the relationships between school gardens and student outcomes. A review of literature related to school gardens and healthy eating and nutrition is provided in Section 2.2.3.

2.2.1 Historical Overview of Gardens and their use in Schools

This section provides a review of literature related to the history of the use of gardens in schools and reviews some of the literature related to research on school gardens. Although there is an abundance of literature on the history of garden use in schools, it was deemed more appropriate to provide a general historical overview since the focus of this study is on the impacts of gardens on various student outcomes. Historical records indicate that one of the first official school gardens was established in Roxbury, USA in the late 1800s (Wright & Rowell, 2010). Later, in many large cities of the United States, school gardens became more common, however the concept of school gardening was not adopted on a large scale in the United States and other countries at that time. It was only more recently during the past two decades, that the concept of school gardening re-emerged (Ratcliffe, Merrigan, Rogers & Goldberg, 2011). One of the main influences for this re-emergence was the result of increased research on the human environment and the role of school gardens on students' learning (Libman, 2007). Libman (2007) reported that the re-emergence of school gardening caught the attention of researchers globally, with increased interest in understanding the relationship between students' learning and school gardens.

In the mid-19th century, school gardening was promoted in Germany, Sweden, and Austria to increase the interactions of school students with nature in the hope of reducing the physical and mental strains brought about by living in urban residences (Shair, 1999). Recognition of the importance of school gardens at national levels, in 1870, resulted in the announcement that Hungary and Austria would allocate a school garden for each school (Shair, 1999). As a result, there was a rapid rise in the establishment of school gardens in these two countries. By 1898 there were more than 18,000 school gardens in Hungary and Austria, and by 1905 there were over 100,000 school gardens across Europe (Shair, 1999). Then in the 1970s, the environmental movement played a significant role in the rising number of school gardens in many countries once again.

There is a long history of the use of gardens in schools at various levels, from primary to tertiary, particularly in terms of human interactions with nature, and in the fields of biology and botany, and students learning in outdoor classrooms (Triador et al., 2015).

School gardening has a purpose that is linked with the behaviour and recreation of students, as well as their social environmental awareness and, as such, school gardening has been used as a tool to create a sense of respect for nature (Triador et al., 2015). This review of literature found that school gardens have primarily been used as an alternative to traditional classroom learning, particularly in the subject of science (Canaris 1995; Graham et al. 2005; Klemmer et al., 2005).

According to Blair (2009), the use of school gardening is likely to improve three major areas of personal development: physical development; cognitive development; and social/emotional development. Further, Blair's (2009) review of literature indicates that the most frequently measured outcomes in past research were science achievement, nutrition knowledge, and change in food behaviour with most studies demonstrating an improvement in each of these areas.

Although publications report positive findings with respect to the use of school garden and student outcomes, there is a dearth of literature that reports valid and reliable research. It is possible that this line of research has gained only limited attention because to the failure of many school gardening projects (Dyment, 2005; Ozer, 2007). Some of the failures, identified by Wells et al. (2015) include: modest sample sizes; lack of pre-intervention baseline data (pre-tests); failure to include a no-garden control or comparison group; and lack of random assignment to experimental and control groups. These shortcomings have been addressed and included in the study reported in this thesis.

Of note, the likely successes of many school garden projects has not been documented or is not available in the form of publications and literature, since they may have been administered without any documented research of the findings and successes of student involvement in gardens (Ozer, 2007). Thus, the limited reliable literature available on the success of school gardening projects most likely represents only a small fraction of the actual successes of such initiatives. Recent trends of increasing interest of academics and researchers in this field is providing more understanding of the importance of on-site school gardens for learning and eating habits of students, however to the best of the author's knowledge, no such studies have been carried out in the unique context of Abu Dhabi. Therefore, this study extends existing literature

and fills an overdue gap in research on this topic, and was thus one of the key factors behind the decision to pursue the topic for this research study.

The next two sections review the limited research related to important variables included in the present study, the impact of school gardens on student outcomes (Section 2.2.2) and the impact of school gardens on healthy eating (Section 2.2.3).

2.2.2 The Impact of School Gardens on Students' Outcomes

Despite the barriers and limitations to the implementation of school garden projects and the subsequent collection of reliable research data, there have been several studies which have reported the successes of garden projects on a range of student outcomes. There is significant historical and rational evidence acquired through research that supports the argument that involvement in school gardening is a source of improving learning outcomes of students (see for example, Huys et al., 2017). However, the review of literature suggests that, to date, there is limited research that has been carried out to examine school gardens and their impact on student outcomes. As a result, this section is limited to a review of individual studies. In 2007, Ozer conducted a review of the 'small literature' relating to the impacts of school gardens on school and student outcomes and, although highlighting some of the barriers to successful garden project implementations, was able to identify some positive research outcomes in the handful of studies he was able to find. These include potential direct and indirect improvements in academic performance (including student knowledge and achievement), improved health and nutrition, increased parent involvement, improved school-community relationships, promotion of conservation and ecological commitment, improvements in school setting and school environment, and increased school bonding and attachment. The first two of these positive outcomes have direct relationship with the research objectives of this study, in assessing the potential impacts of the gardens.

Past research has indicated that the use of gardens can lead to an improvement in student achievement (Pascoe & Wyatt-Smith, 2013; Smith & Motsenbocker, 2005) in different subject areas, including: science (Smith & Motsenbocker, 2005), and English (Pascoe & Wyatt-Smith, 2013). Blair (2009) synthesised the research by reporting that the use of school gardens is likely to lead to improved attitudes, pride in the gardens,

motivation, team work and student bonds. These findings are significant in relation to the present study since many of these factors are also variables in the current study with students at the sample school.

Smith and Motsenbocker (2005) examined the impact of student participation in a school garden on science achievement, across three sample schools in the USA. They reported a statistically significant increase in achievement for students in science who participated in the gardens, but not for students in the control group who did not. Similarly, Pascoe and Wyatt-Smith (2013) investigated the impacts of a school garden on literacy. Their findings indicated that, when combined with student engagement in the gardens, literacy amongst the participants improved as well as. These studies support Ozer's 2007 argument that, theoretically, students' academic achievement could improve indirectly through school gardens by improving nutrition and improved bonding or attitude to the school. The study presented in this thesis builds on and extends these studies by involving similar variables but in a novel context.

Past research has also found that the use of school gardens is related to student attitudes (see for example studies by, Alexander, Hendren & North, 1995; Graham et al., 2005; Klemmer et al., 2005; Lohr & Person-Mims, 2005; Passy, 2014; Skelly & Zajicek, 1998). Past studies have involved a range of research methods to examine the impact of gardening on student attitudes, including quantitative studies (Waliczek, Bradley & Zajicek, 2001), qualitative studies (Alexander et al., 1995), and mixed methods (Passy, 2014). This section provides a review of the research related to gardening and its impact on student attitudes and other outcomes.

Past research has found that active gardening in childhood had a positive effect on attitudes towards nature and subsequent attitudes in adulthood (Klemmer et al., 2005; Lohr & Person-Mims, 2005; Skelly & Zajicek, 1998). Further, participation in gardening provided some indication that students were more appreciative of nature after using the school garden (Johnson, 2013). Given these findings, it is possible that involvement in gardening at an early age could be an advocating step towards improvements in the cognitive development of students (Klemmer et al., 2005).

Past research has also found that participation in gardens could be related to improved memory (M. Francis, 1995; Jewell, 2002). In the study by M. Francis (1995), participation in school gardens was found to have an impact on student memory. According to M. Francis (1995), location based memory lasts for long periods of time in the minds of students. Hence, learning in a garden environment becomes incorporated in the minds of students as long lasting memories that reflects the usefulness of school gardens as learning tools for students. M. Francis (1995) found that results can be increased by including examples from the surrounding environment. Students remember their garden experiences for extended periods of time and they also better remember their lessons in school gardens. Jewell (2002) explained that learning of students is linked with their memory, and that time spent in school gardens can affect their long term memory positively. In one study, participation in a garden programme was found to provide children with a positive relationship in terms of their social interactions and cooperation with other students, such as sharing of practices, experiences and/or food (Tims, 2003).

Of relevance to the research reported in this thesis, is past research that has indicated that participating in gardens at schools is related to student attitudes. A study by Alexander et al. (1995) found that garden participation resulted in: increases in student pleasure; interactions (cooperation); relationships; and appreciation and value of their school garden. Similarly, Passy (2012) found a positive effect of the gardens on the school as a whole. However, Passey also identified some concerns, such as lack of teacher involvement and knowledge, and policy constraints. Additionally, Graham et al. (2005) conducted research examining the associations of school gardening with attitudes to using the gardens, perceptions of barriers to using gardens in schools, and using gardens in academic instruction. The findings indicated that gardens were mostly implemented in schools in the hope of enhancing academic instruction, particularly in science.

Based on the limited amount of research that has been carried out with respect to the impact of school gardens and its impact on student outcomes, the study reported in this thesis is timely. Not only does this study extend the past research on school gardens, but it also fills a research gap on studies related to school gardens, with no previous studies having been carried out in the UAE on school gardens and student outcomes.

In filling this research gap, with respect to the use of school greenhouses and gardens in the UAE, this thesis provides valuable information to a range of stakeholders (as outlined in Chapter 1), and future researchers.

2.2.3 School Gardens and Healthy Eating and Nutrition

Student knowledge of healthy eating practices depends on their interactions with the environment as well as their sources of information about food and nutritional sources (Skinner, Carruth, Bounds, Ziegler & Reidy, 2002). Ogden, Carroll and Flegal (2008) argued that the involvement of children in the preparation of meals can increase their knowledge about the nutritional values of different foods. Similarly, where students are involved in on-site school garden activities, students are likely to gain a better understanding about the benefits of consuming fresh vegetables and fruits. School gardening projects have been found to effectively increase fruit and vegetable knowledge, preference, and consumption in young children (Parmer, Salisbury-Glennon, Shannon & Struempler, 2009).

Past research has found that school gardening is positively associated with the healthy eating habits of students (Anzman, Rollins & Birch, 2010). This is a reflection of their understanding about the importance of freshly grown food items and of the time and effort required in the growing of fresh food items (Kohlstedt, 2008). As such, school gardening has the potential to educate the students about nutrition. The physical efforts of students in school gardening affects their awareness and nutritional knowledge, as well as helping them to understand the importance of physical activities to maintain a healthy life (Kohlstedt, 2008). Further, it has been reported that spending time in school gardens has a cognitive impact that helps students to select fresh foods rather than junk food items for consumption (Yu, 2012). Additionally, Yu (2012) found that the use of school gardens improves students' ability to identify vegetables and fruits through the process of growing individual items. This also led to a sense of ownership and pride in their grown products which played a role in increased consumption of freshly grown foods.

In addition to the studies on relationships between school gardens and student health and nutrition, a variety of literature related to school gardens and student diets suggest

that dietary habits of the students depend on their knowledge of healthy eating. Past research has found that an increase in students' knowledge of food items brought a change in the eating habits of the students (Ogden et al., 2008; Skinner et al., 2002). In these studies, healthy eating practices were the result of student understanding of the benefits of vegetables and fresh fruits. Another reason behind changes in the eating habits of students, according to Ratcliffe et al. (2011), is students' involvement in physical activities in school gardening and performing duties that were different to the ones in the regular classroom.

The review of literature indicated that the introduction of school gardens improves students' healthy eating and nutrition. In most of the literature, studies showed a clear relationship between involvement in school gardens and positive behaviours in relation to healthy eating and improved nutrition (see for example, Anzman et al., 2010; Herman & Parker, 2006; Huys et al., 2017; Kohlstedt, 2008; Ogden et al., 2008; Randler & Bogner, 2006; Ratcliffe et al., 2011; Skinner et al., 2002; Tims, 2003; Wells et al., 2015; Yu, 2012). In some studies, there was evidence to suggest that participation in school gardening influenced the nutrition and eating habits of students (Johnson, 2013). Some studies reported an improved awareness and knowledge of diet and nutrition (for example Wells et al., 2015), whilst in other studies, the outcomes included a better recognition of vegetables (see for example Huys et al., 2017; Ratcliffe et al., 2011; Tims, 2003) or better recognition of the parts of plants (see for example, Wells et al., 2015).

The results, with respect to improved consumption of vegetables, however, was mixed. Whilst some reported an improved preference for vegetable consumption (see for example, Ratcliffe et al., 2011) other studies did not (see for example Huys et al., 2019). Further, a study by Tims (2003), found that being involved in gardening helped to make students more food conscious and promoted healthy eating habits.

Despite these positive findings, the literature highlights that simple involvement in school garden activities is not sufficient to change students' attitude towards healthy food (Ogden et al., 2008). However, sharing information about the benefits of healthy food and varieties of healthy foods available in the surroundings of the gardens (and beyond the gardens) can encourage them to adopt healthy eating habits (Yu, 2011).

This is a long term effect on the attitude of individuals and is likely to become part of their attitude towards the selection of healthier food items (Ozer, 2007).

Other recent studies have found that students actively involved in school gardening also showed an increase in their consumption of vegetables and fruits (Hermann & Parker, 2006). This research suggests that this increase in the consumption of vegetables and fruits is due to shifts in tastes and preferences based on awareness from exposure (Lautenschlager & Smith, 2007). This awareness then leads children to gain a better understanding about the differences between processed foods and fresh organic vegetables and fruits, and hence contributes to better food choices. The study presented in this thesis, built on and extended this past research by examining students' aspirations to healthier eating.

Past research reports that students who are involved in school garden activities have more knowledge about the species of plants than students who do not (Bebbington, 2005; Schussler & Olzak, 2008). The researchers argued that school gardens provide students the opportunity to recognise plants and gain knowledge about the plants. According to Bebbington (2005), students who did not get the opportunity to participate in school garden activities were able to recall more animal pictures with their names and types than the pictures of plants. This is significant because better recognition of plants and associated structures (fruits and vegetables) could also influence better food choice (Gatt, Tunnicliffe, Borg & Lautier, 2007). Patrick and Tunnicliffe (2011) report that a knowledge about plants encourages students to include beneficial plants in their diet.

Findings of past research indicate that information obtained about plants during participation in school garden activities and during their interactions with the school garden makes them more likely to include more fresh vegetables in their regular meals and choose healthier options rather than fast foods (Patrick & Tunnicliffe, 2011). The interactions with school gardens also develops a sense of care about vegetation and the importance of plants in human life (Randler & Bogner, 2006).

Literature related to school gardens and its impact on student outcomes is limited. This review of literature found no publications related to school gardens and their impacts

on students' health and nutrition in the UAE. For this reason, the study presented in this thesis fills a void in literature.

2.3 Learning Environments

Given that the study reported in this thesis examined the impacts of the school garden on perceptions of the learning environment, it was important to review relevant literature pertaining to research that has been carried out in this field. Section 2.3.1 provides an historical overview of the field of learning environments while Section 2.3.2 examines instruments used in assessing variables associated with learning environments. Finally, Section 2.3.3 provides a review of past research relevant to the present study.

2.3.1 Learning Environments- Historical Context and Research

The context in which students learn has been found to play a significant part in achieving improved student outcomes (Zandvliet & Fraser, 2019). Particular factors related to the setting, whether in or out of the classroom, can contribute to creating a climate that is conducive to learning. These factors can influence the motivational levels of students as well as their health and wellbeing, emotional, social and behavioural characteristics, all of which can obstruct their capacities for learning (OECD, 2017). Evidence suggests that the learning environment of students has a strong effect on various student outcomes (Fraser, 2019; Fraser & Kahle, 2007; Lim & Fraser, 2018), including academic achievement (Aluri & Fraser, 2019; Malik & Rizvi, 2018). Literature reviews by Fraser (2012, 2014) and, more recently, by Zandvliet and Fraser (2019), suggest that students' perceptions of the learning environment are significant in improving student learning and academic outcomes.

Recently, Ghosh (2015) conducted a review on the historical perspectives of the classroom learning environment. The review covered the history of research on classroom learning environments from 1920 to present, and several major findings emerged. Ghosh (2015) identified that, in the US, Dorothy Thomas conducted the earliest recorded research on classroom climate in the 1920s, and this was used as a source for learning by later researchers.

Lewin (1936) is regarded as a pioneer of initiating systematic research relating to human environments. In 1936, Lewin introduced a formula of 'person-environment interaction' positing that B=f(P, E), where B denotes human behaviour, f represents the interactive function, P represents the person, and E represents environment. The focus of this formula was to study the influence of the environment on human behaviour as a result of human-environment interactions. In modern times, this is mirrored in the context of the learning environments that exist within schools, where the learning environment can impact on student behaviour, which in turn, can ultimately impact on the levels of student learning within a school. As this work by Lewin (1936) was an early stage of research in this field, there were many methodological challenges for early researchers. Hence, this formula established a context for researchers to explore this area further.

Later, the concept of human environment research, presented by Murray (1938), extended Lewin's original field theory in what he described as a needs-press model. This model suggests that an individual's personal needs might be supported or else frustrated by an environmental press, or factors beyond a person's control. These may ultimately inhibit or enhance the achievement of a person's needs or goals. Murray's (1938) work was based on two main perspectives, namely the external perspective and internal perspective. The external perspective, referred to as 'alpha' press, was related to how researchers or administrators observe and describe the environment. The internal perspective, referred to as 'beta' press, was related to how the environment is perceived by teachers and students.

Research related to learning environments in classrooms became a focus for academics and researchers with the independent studies carried out by Walberg and Anderson (1968) and Moos (1979). As part of the Harvard Project Physics, the Learning Environment Inventory (LEI) was developed by Walberg and Anderson, (1968), which allowed researchers to establish parameters for their research on learning environments. Following this, another significant step in learning environment research occurred when Moos (1979) developed the Classroom Environment Scale (CES) as part of a program of research that involved many different environments. The CES provided researchers with a new dimension to classroom environment research. These two pioneering instruments created by Walberg and Anderson (1968) and Moos

(1979) became the foundations for the development of many subsequent learning environment instruments and measures.

At around the same time that Moos developed the CES, Walberg (1991) argued that it was difficult to understand the classroom learning environment in relation only to the physiological environment. According to Walberg, in addition to the physiological environment of classrooms, consideration should also be made to the psychosocial environment of classrooms because educational productivity cannot be optimized without studying both types. This opened a new dimension of research on the human environment. The psychosocial environment versus physiological environment and classroom learning established a new framework of thinking for researchers who were working on classroom learning environments. This was the start of the modern era research on classroom learning environments.

Holahan and Moos (1987) further extended the work on the human environment research by introducing instruments of social climate scales that were used to study human environment interactions at different places such as schools, hospitals, workplaces, prisons, groups of students, university residences, and classrooms. The work was based on three dimensions of the human environment, including relationship, personal development, and maintenance and system change. The relationship dimension examines the nature and intensity of the individuals' relationship with the environment, while personal development examines the tendency for occurrence of basic directions for self-enhancement and personal growth. Finally, the system maintenance and system change dimensions examine the expectations from the environment and the extent to which a person is able to maintain control and respond to changes in the environment. The development of many subsequent learning environment tools has sought to provide coverage for all three of these dimensions.

Subsequently, Goldstein (1987) presented multilevel models in the field of educational and social research. This work highlighted the characteristics and types of data and methods for research on the classroom environment, including the use of appropriate research methodologies and data collection tools. Popular models included the two-level model, three-level model, multilevel model, and the latent normal model for multivariate. The multilevel models developed by Goldstein (1987), provided a boost

in research on the classroom environment, and were adopted and tested by dozens of researchers in the 1990s and early 2000s (Seker, 2011).

Given the numerous studies and literature related to topics in the field of learning environments, the development and use of a variety of instruments has been essential for the collection of reliable data from the sample studies. The next section provides a review of some of the instruments that been developed in the field of learning environments (Section 2.3.2). The review was used to help to select an appropriate survey for the study reported in this thesis.

2.3.2 Instruments used to assess the learning environment

This section reviews historical and contemporary instruments that have been developed to assess variables related to the learning environment over the past fifty years. As mentioned in Section 2.3.1, the LEI (Walberg & Anderson, 1968) and the CES (Moos, 1979) were revolutionary instruments in that they have been sources in the development of so many subsequent instruments used to measure learning environment variables, and many of these have been used to measure students' perceptions of learning environments across different countries and in different languages (Fraser, 1998; Fraser, 2019). Fraser (2012) highlights the importance of selecting the appropriate instrument for the variables being measured. Hence, this review of literature provided a basis for the selection of the instruments drawn on in developing the survey that would be used to collect data to assess students' perceptions of the learning environment in the study described in this thesis (the process for which is described in Chapter 3.4).

In the process of selecting an appropriate instrument, numerous surveys were reviewed. These instruments are summarised in Table 2.1 which provides, for each instrument: the grade level for which it was intended; the number of items in each scales; and the classification of the scales according to Moos (1979) (see previous section for details). These instruments comprise a large range of different scales, items, questions, and survey techniques. The instruments include, Learning Environment Inventory (LEI; Walberg & Anderson, 1968); Classroom Environment Scale (CES; Moos & Trickett, 1974); Individualised Classroom Environment Questionnaire

(ICEQ; Rentoul & Fraser, 1979); College and University Classroom Environment Inventory (CUCEI; Fraser & Treagust, 1986); My Class Inventory (MCI; Fisher & Fraser, 1981); Questionnaire on Teacher Interaction (QTI; Wubbels, Creton, & Hoomayers, 1985); Science Laboratory Environment Inventory (SLEI; Fraser, Giddings & McRobbie, 1995); Constructivist Learning Environment Survey (CLES; Taylor et al. , 1997); What Is Happening In this Class? (WIHIC; Fraser, McRobbie & Fisher, 1996) questionnaire.

A review of literature indicated that there were no existing surveys that could adequately assess students' perceptions of the learning environment created in a garden setting. As such, it was necessary to develop a new survey to capture the learning environment adequately. The following sections provide a brief review of the three instruments that were drawn on in the development of the new learning environment survey: the Science Laboratory Environment Inventory (SLEI) (Section 2.3.2.1), the Constructivist Learning Environment Survey (CLES) (Section 2.3.2.2), and the What Is Happening In this Class? (WIHIC) questionnaire (Section 2.3.2.3).

2.3.2.1 Science Laboratory Environment Inventory (SLEI)

The Science Laboratory Environment Inventory (SLEI) was developed Fraser et al. (1995) to assess the learning environment created in a science laboratory. Developed for use in senior high schools and in higher education institutions, the SLEI is comprised of five scales: student cohesiveness, open-endedness, investigation, rule clarity and material environment. Each scale is comprised of seven items, forming a total of 35 items. Items are responded to using a five-point format of almost never, seldom, sometimes, often, and very often. Sample items from the SLEI include: "I am able to depend on other students for help during laboratory classes" (for the student cohesiveness scale), and "My regular science class work is integrated with laboratory activities" (for the integration scale).

Table 2.1 Overview of scales in a selection of learning environment instruments

Instrument	Grade Level	Items per Scale	Source	Scales according to Moos' (1979) Dimensions		
				Relationship	Personal development	System maintenance and change
Learning Environment Inventory (LEI)	Secondary	7	Walberg & Anderson (1968)	Cohesiveness Friction Favouritism Cliqueness Satisfaction Apathy	Speed Difficulty Competitiveness	Diversity Formality Material Environment Goal direction Disorganisation Democracy
Classroom Environment Scale (CES)	Secondary	4	Moos & Trickett (1974)	Involvement Affiliation Teacher support	Task orientation	Order and organisation Rule clarity
Individualised Classroom Environment Questionnaire (ICEQ)	Secondary	5	Rentoul & Fraser (1979)	Personalisation Participation	Independence Investigation	Differentiation
College and University Classroom Environment Inventory (CUCEI)	Tertiary	7	Fraser & Treagust (1986)	Personalisation Involvement Student cohesiveness Satisfaction	Task orientation	Innovation Individualisation
My Class Inventory (MCI)	Primary	6-9	Fisher & Fraser (1981)	Cohesiveness Friction Satisfaction	Difficulty Competitiveness	
Questionnaire on Teacher Interaction (QTI)	Primary/ Secondary	8-10	Wubbels, Creton, & Hoomayers (1985)	Helpful/Friendly Understanding Dissatisfied Admonishing		Leadership Student responsibility and freedom Uncertain Strict
Science Laboratory Environment Inventory (SLEI)	Upper Secondary / Tertiary	7	Fraser, Giddings & McRobbie (1995)	Student cohesiveness	Open-endedness Integration	Rule clarity Material environment
Constructivists' Learning Environment Survey (CLES)	Secondary	7	Taylor. Fraser & Fisher (1997)	Personal relevance Uncertainty	Critical voice Shared control	Student negotiation
What Is Happening In this Classroom (WIHIC)	Primary/ Secondary	8	Fraser, McRobbie & Fisher (1996)	Student cohesiveness Teacher support Involvement	Investigation Task orientation Cooperation	Equity

Adapted from Fraser (2012) with consent from the author (Appendix 1).

The SLEI has been cross-validated and used to assess science laboratory classes in many countries around the world (Fraser & McRobbie, 1995; Quek, Wong, & Fraser,

2005; Wong & Fraser, 1996). Given its reliability from so many past studies, as well as its relevance to the study presented in this thesis, the SLEI was one of the instruments considered as a good starting point for the development of the new survey. In particular, the scale of integration was drawn upon since it was anticipated that the garden work would be integrated with the regular science work of students as well as integrated with students' daily eating habits (integrating garden practices with food choice).

2.3.2.2 Constructivist Learning Environment Survey (CLES)

The Constructivist Learning Environment Survey (CLES) was originally developed by Taylor and Fraser (1991), but it was then revised by Taylor, Fraser, and Fisher (1997). It was developed to assess the extent to which a classroom environment is consistent with constructivist teaching practices, and assumes that meaningful learning is a cognitive process that requires students to relate their knowledge to their surroundings. The CLES is composed of five scales with a total of seven items per scale. These scales include: personal relevance, uncertainty, critical voice, shared control, and student negotiation. Items of the CLES are responded to using a five-point frequency scale of: almost never, seldom, sometimes, often, and almost always. Examples of two items on the CLES include: "I enjoy learning about things in the world outside of school" (for the personal relevance scale), and "I explain my ideas and understandings to other students" (for the student negotiation scale).

As with the SLEI, the CLES has been successfully validated in multiple locations and different languages (Aldridge, Fraser, Taylor & Chen, 2000; Kim, Fisher & Fraser, 1999). Aside from the constructivist teaching practices and the expectation that student would learn better when relating their learning to their surroundings (this being the gardens in this study), the strong reliability made the CLES a suitable choice for drawing on in the development of the new instrument. Specifically, the three scales were drawn on (relevance, shared control and student negotiation) to help assess the learning and interactions in the garden environment.

2.3.2.3 What Is Happening In this Class? (WIHIC)

The 'What Is Happening In this Class' instrument (WIHIC) was originally developed by Fraser et al. (1996) and includes nine scales with 10 items in each scale (a total of 90 items). This original version incorporated scales from a variety of preceding questionnaires, as well as scales of contemporary relevance to classrooms (Dorman, 2001). The original version of the WIHIC was later refined by Aldridge, Fraser and Huang (1999), with the revised version being composed of seven scales and a total of 56 items: student cohesiveness; teacher support; involvement; investigation; task orientation; cooperation; and equity. Items of the WIHIC are responded to using a five-point frequency scale of almost never, seldom, sometimes, often, and almost always. Two examples of items from the WIHIC instrument are: "I am involved in class discussions" (for the involvement scale), and "I work with other students in Science" (for the cooperation scale).

The WIHIC has been successfully translated into many languages and used in many countries around the world. The results of these studies have consistently supported the reliability and validity of the WIHIC and its usefulness in a range of contexts (Aldridge, Fraser & Ntuli, 2009; Dorman, 2008; Fraser, 2012; Kim, Fisher & Fraser, 2000; Velayutham & Aldridge, 2013). This strong reliability and validity was one of the major reasons why the WIHIC was considered for use in the development of the learning environment survey used in this study. Since it was anticipated that students working in the gardens would be involved in garden activities as well as working cooperatively with their peers, two scales, involvement and cooperation, were drawn upon for the new survey. See Chapter 3 for more information about the development and validation of the new learning environment survey.

2.3.3 Review of Past Research on Learning Environment Associations

This section reviews literature related to past research pertinent to the present study. Fraser (2012) delineated several categories or lines of research within the field of learning environments, these being: the associations between the learning environment and student outcomes; using environment dimensions as criterion variables to evaluate educational innovations; teachers' practical attempts in improving their classroom and

learning environments; differences between students' and teachers' perceptions of the learning environment; combining quantitative and qualitative research methods; incorporating learning environment ideas into school psychology; links between the different learning environments; cross-national studies; typologies of classroom environments; and transition between different levels of schooling. Of these lines of research, two were pertinent to the present study: the associations between the learning environment and student outcomes (reviewed in Section 2.3.3.1), and learning environment as process criteria in evaluating educational innovations (reviewed in Section 2.3.3.2).

2.3.3.1 Learning Environment- Student Outcome Associations

Numerous past studies have involved the investigation of relationships between learning environment perceptions and a range of student outcomes. As early as 1994, Fraser (1994) listed 40 different studies that showed links between perceptions of the classroom environment and student outcomes, using a variety of instruments such as the ones detailed in the previous section, with a range of learning outcomes and different sample types and sizes. More recent reviews by Fraser (2012) and Zandvliet and Fraser (2019) found more evidence to suggest that there are strong associations between students' perceptions of the learning environment and a range of student outcomes. Given that the study presented in this thesis examines the relationships between the learning environment, in the context of a school garden, and various student outcomes, a review of related literature is provided below.

Many studies have found positive and statistically significant relationships between students' perceptions of the learning environment and student outcomes in a range of different countries, including: Australia (Chipangura & Aldridge, 2017; Dorman, 2001; Fisher & Fraser, 1983; Henderson, Fisher & Fraser, 2000; Kerr, Fisher, Yaxley, & Fraser, 2006; Velayutham, Aldridge, & Fraser 2011); India (Gupta, Koul & Sharma, 2015; Koul & Fisher, 2005); Korea (Fraser & Lee, 2009; Kim et al., 1999; Kim et al., 2000); Myanmar (Khine, Fraser, Afari, Oo & Kyaw, 2018); Singapore (Goh, Young & Fraser, 1995; Quek et al, 2005; Wong & Fraser, 1996); Hong Kong (Kwan & Wong, 2014); Thailand (Koul, Roy, & Lerdpornkulrat, 2012); Nigeria (Ogun, Nottidge & Roff, 2018); South Africa (Aldridge, Fraser, & Sebela, 2004); Turkey (Telli,

Cakiroglu, & den Brok, 2006; Telli, den Brok, & Cakiroglu, 2010); Canada (Zandvliet, Stanton & Dhaliwal, 2019); New Zealand (Taylor, 2012); Uganda (Opolot-Okurut, 2010); USA (Allen & Fraser, 2007; Robinson & Fraser, 2013; Wolf & Fraser, 2008). Of interest to this study, are studies carried out in countries that are located in the Middle East, which include Jordan (Alzubaidi, Aldridge & Khine, 2016); Israel (Barak, Ashkar, & Dori, 2011); Saudi Arabia (Al-Qahtani, 2015) and the UAE (Afari, Aldridge, Fraser & Khine, 2013; Khalil & Aldridge, 2019). These studies, despite being carried out in countries with very different cultural backgrounds, found strong and consistent relationships between the learning environment and student outcomes.

Studies that have found positive relationships between the learning environment and student outcomes have been carried out in a range of schooling levels, including tertiary (see for example, Al-Qahtani, 2015; Alzubaidi et al., 2016; Khine et al., 2018; Ogun et al., 2018); secondary school (Chipangura & Aldridge, 2017; Khalil & Aldridge, 2019; Nix, Fraser, & Ledbetter, 2005); primary school level (Allen & Fraser, 2007; Robinson & Fraser, 2013).

Of particular interest to the study reported in this thesis are studies related to the specific outcomes of attitudes, aspirations and achievement (knowledge). A review of studies that have focused on relationships between the learning environment and these three outcomes are provided in the following paragraphs.

This review of literature found numerous studies that have been carried out across different science disciplines and found consistent and strong relationships between the learning environment and student attitudes. In particular, these relationships were found across different science disciplines, including: general science (Aldridge et al., 2000; Fraser & Lee, 2009; Gupta et al., 2015; Liu, Liu, Pan, Zou & Li, 2019; Taylor, 2012); science and technology (Basarmak & Mahiroglu, 2016); chemistry (Quek et al., 2005); biology (Henderson et al., 2000). Additionally, these relationships were found across different countries. Although the measures of attitudes were different across the different studies, the evidence suggests that there are strong, positive associations between student attitudes and their perception of their learning environment.

Although not as prolific as research related to environment—attitude associations, there has also been much research to suggest that students' perceptions of the learning environment is related to their achievement. Studies from around the world including Middle Eastern countries, have reported positive associations between students' perceptions of the learning environments and their achievement, including: the USA (Allen & Fraser, 2007, Robinson & Fraser, 2013, Wolf & Fraser, 2008); Saudi Arabia (Al-Qahtani, 2015); Myanmar (Khine et al., 2018); Pakistan (Malik & Rizvi, 2018); and India (Aluri & Fraser, 2019). Similar patterns have been found across a range of subjects, and across a range of age groups, including: undergraduate medical science students (Al-Qahtani, 2015); high school biology students (Rita & Martin-Dunlop, 2011); tertiary science students (Khine et al., 2018), high school chemistry students (Boz, Yerdelen-Damar, Aydemir, & Aydemir, 2016); kindergarten science students (Robinson & Fraser, 2013); kindergarten general achievement (Shoval, Sharir, Arnon, & Tenenbaum, 2018); third-grade mathematics students (McLean & Connor, 2015); secondary mathematics students (Malik & Rizvi, 2018); undergraduate arts students (Ellis, 2016); undergraduate Greek philosophy students (Karagiannopoulou & Milienos, 2015). Although measures of achievement differ between studies, the abundance of evidence suggesting that the learning environments has an influence on student achievement makes it difficult to ignore.

In conclusion, the consistent results across numerous studies suggest that the learning environment created by teachers influences student outcomes. That is, the findings of past research generally suggest that more positive learning environments lead to more positive student outcomes (Dorman & Fraser, 2009). Despite this plethora of research, there is a lack of literature that examines the relationships between student outcomes and the learning environment created in a school garden setting. Hence, the study presented in this thesis fills this gap as it investigates the associations between the school garden learning environment and student outcomes, attitudes, and achievement.

Additionally, this review of literature found there to be a dearth of literature related to the relationships between students' perceptions of the learning environment and their aspirations to pursuing future gardening activities and aspirations for healthier eating. Although two studies relating to the influence of the learning environment on students' aspiration were located, both were related to career aspirations (Webster & Fisher,

2004; Tseng, Chang, Lou & Chen, 2013) and not specifically to gardening or healthier eating. Given the lack of studies that have examined the relationship between the learning environment and student aspirations towards gardening and healthier eating, the study reported in this thesis fills this gap.

2.3.3.2 Learning Environment as Process Criteria in Evaluating Educational Innovations

Past studies have successfully used learning environment instruments to assess the effectiveness of innovations in education systems. More specifically, research has been undertaken to assess the impacts of innovations in improving the learning environment, and these have included innovative programs and activities within the school framework on innovations such as teaching programs, student activities, technologies, and alternatives to regular classroom teaching (Fraser, 2012). Fraser (2012) suggests that the use of learning environment instruments as process criteria can provide a more accurate perspective of the impacts of innovations on educational processes when compared with using other outcomes such as attitudes or achievement. In the context of the study presented in this thesis, the interactions and learning activities that took place in the greenhouse and garden areas constituted the innovation. This section reviews literature related to the learning environment as process criteria in evaluating a variety of educational innovations.

Educational innovations have been evaluated using learning environment instruments in numerous studies. Some of these have used learning environment instruments to evaluate the effectiveness of a particular innovation on students' perceptions of the learning environment (see for example, Afari et al., 2013; Lightburn & Fraser, 2007). In other studies, the use of learning environment perceptions was used as an indication of whether teacher professional development had the desired impact on students' perceptions of the learning environment (see for example, Nix et al., 2005; Soebari & Aldridge, 2015). In all cases, these studies used students' perceptions to examine changes in the learning environment, a variable that contributes strongly to a range of student outcomes.

In the present study, the introduction of the greenhouse and gardens, and the associated garden activities, was regarded to be an 'innovation' in the context of the school – as students (and teachers) had never been exposed to these in the teaching setting. Whilst understanding whether the introduction of the greenhouse and gardens influenced a range of student outcomes was important, the present study also sought to examine whether the introduction influenced students' perceptions of the learning environment. In this study, it was hypothesised that the garden activities would bring improvements in students' perceptions of the learning environment. To the researchers' knowledge, past research related to the introduction of gardens and greenhouses has not been examined with respect to students' perceptions of the learning environment. Additionally, with so few studies having been conducted on educational innovations and their impacts on learning environment perceptions in the UAE, this study extends the existing literature in this setting. As such, this study fills a gap in the current literature on this topic.

2.4 Student Attitudes

Attitudes of students towards learning (in science classes) and attitudes of students towards healthy eating were central to the evaluation of the gardening activities in this study. Section 2.4.1 reviews literature on studies related to student attitudes, while Section 2.4.2 reviews the two instruments that were drawn on to assess students' attitudes in the study reported in this thesis.

2.4.1 Student Attitudes: Definition

This section, first, defines the concept of attitudes and, second, reviews past literature on research into student attitudes in the context of learning. The attitudes of students are regarded to be an indicator of the success or failure of the activities designed for the learning of the students (Jewell, 2002). In early research related to attitudes, Thurstone (1928) described attitudes as a person's inclinations and feelings, prejudice or bias, preconceived notions, ideas, fears, threats, and convictions about any specified topic. Baron and Byrne (1977) described attitudes as individually recognised emotions, beliefs, behavioural tendencies that a person has towards specific abstract or concrete objects. Of relevance to science, Koballa and Crawley (1985) described

attitude as a learned positive or negative feeling towards science. In the context of the study presented in this thesis, the term 'attitudes' pertains to the feelings and perceptions of the students towards their studies in science. More specifically, the scales relating to attitudes used in this study sought to assess students' enjoyment of their class and the value that they placed on the tasks provided (task value). The following paragraphs review literature which includes research relating to enjoyment and task value.

The first attitudinal construct of interest to the study reported in this thesis was students' enjoyment of their science class. In this context, enjoyment, according to Fraser (1981), relates to the level of pleasure attained by a student during science classes. Improved enjoyment is considered beneficial to students since it is associated with improved student learning, performance and well-being (Frenzel, 2014), and in enhanced student outcomes such as deeper involvement in learning, and hence improved learning overall (Ainley & Hidi, 2014; Gomez, Wu & Passerini, 2010). Numerous studies have attempted to measure impacts on student enjoyment resulting from a variety of activities or processes, in a range of subjects, student levels and countries. In science education, studies have examined student enjoyment (see for example, Desy, Peterson & Brockman, 2011; Fraser & Lee, 2009; Peer & Fraser, 2015; Salta & Tzougraki, 2004; Telli et al., 2010). In studies that have introduced a construct variable, the results with respect to enjoyment have been mixed for some studies, students' enjoyment improved (see for example, Afari et al., 2013; Fraser & Lee, 2009; Frenzel, Becker-Kurz, Pekrun, Goetz & Lüdtke, 2018; Koul, Fraser, Maynard, & Tade, 2018; Penn & Ramnarain, 2019; Telli, den Brok, & Cakiroglu, 2010), and, in other studies, the imposed construct variables had a negative impact on student enjoyment (see for example, Deieso & Fraser, 2019; Peer & Fraser, 2015). Despite the numerous studies on student enjoyment across a range of subjects and different countries, there is a dearth of studies that have examined the impact of the introduction of school gardens on students' enjoyment of science, therefore the study presented in this thesis attempts to fill this gap.

The second attitudinal construct of interest to the study was task value. Task value is a motivational construct which has been included in many past studies and, according to Velayutham et al. (2011), task value relates to the level of students' perceptions of

the interest, usefulness and importance of a task in the science class. Further, task value encourages motivation and engagement in student learning (Kaplan & Maehr, 2007). Wigfield and Cambria (2010), reported positive relationships between students' task value and their cognitive and affective learning outcomes. Wigfield, Eccles and Rodriguez (1998) also found relationships between the school environment and task value, while Tuan, Chin and Shieh (2005) reported that student's attitudes towards science as well as science achievement were influenced by task value.

Numerous past studies have reported positive relationships between a range of student variables and task value, including: achievement (Bong, 2001; Cox & Whaley, 2004); motivation (Barron & Hulleman, 2015; Bong, 2004); future interest of science and mathematics (Barron & Hulleman, 2015); increased class participation and interest in computerised practising (Cornelisz & Van Klaveren, 2018); and student effort and ability (Cornelisz & Van Klaveren, 2018). In all of these studies, there was a positive relationship between the variables being examined and task value. Given the importance of task value to student learning, and the hope that students would place greater value in their science work and associated activities when exposed to the school garden, this construct was included in the present study. Given the lack of the literature pertaining to students' task value when using school gardens, this study filled a gap in the research.

2.4.2 Instruments Designed to Assess Student Attitudes

In reviewing the literature on student attitudes, consideration was given to several instruments that have been developed to measure various attitudes towards science, including: the Attitudes Toward Science (ATS; L.J. Francis & Greer, 1999); the Scientific Attitude Inventory (SAI; Moore & Sutman, 1970); the Dimensions of Attitude toward Science (DAS; van der Molen & van Aalderen-Smeets, 2013); the Test of Science-Related Attitudes (TOSRA, Fraser, 1981); and the Students' Adaptive Learning Engagement in Science (SALES; Velayutham et al., 2011).

In selecting the instruments to be used, the work of Kind, Jones and Barmby (2007), who identified a number of pit-falls associated with attitude instruments (such as vague and ambiguous scale constructs, and low reliability and validity of constructs used)

was taken into consideration. With this in mind, the development of the new instruments drew on two reliable instruments that had been used in past studies. The following sections provide a brief review of the two surveys drawn on in the development of the new instrument: the Test of Science-Related Attitudes (TOSRA) (Section 2.4.2.1), and the Students' Adaptive Learning Engagement in Science (SALES) (Section 2.4.2.2).

2.4.2.1 Test of Science-Related Attitudes (TOSRA)

One of the more commonly utilised and referenced tools used to assess students' attitudes towards science is the: Test of Science-Related Attitudes (TOSRA), developed by Fraser (1981). Fraser developed this tool as a result of problems he identified from previously developed tools used to assess student attitudes (Fraser, 1978), and for this reason the final tool was improved and aligned to support Klopfer's (1971) rationale of science attitudes.

The final version of the TOSRA included seven scales consisting of five items in each (Fraser, 1981): social implications of science; normality of scientists; attitudes towards science enquiry; adoption of scientific attitudes; enjoyment of science lessons; leisure interest in science; and career interest in science. The original form of TOSRA includes many negatively-worded and reverse-scored items. TOSRA items are scored using a five-point Likert format with answer choices of Strongly Agree, Agree, Not Sure, Disagree and Strongly Disagree.

The use of TOSRA for the assessment of students' attitudes towards learning science is not new (Ali, Mohsin & Iqbal, 2013). There is much research literature which shows that the use of TOSRA provides a detailed and reliable assessment of science related attitudes of the students and that it has been cross validated in several countries, including: Singapore (Wong & Fraser, 1996); Indonesia and Australia (Fraser, et al., 2010); and Turkey (Telli et al., 2010). Given the relevance of the instrument to the research objectives of the study and the reliability of the instrument across different contexts, the enjoyment scale was drawn on for use in this study.

2.4.2.2 Students' Adaptive Learning Engagement in Science (SALES)

The Students' Adaptive Learning Engagement in Science (SALES) survey was developed by Velayutham et al. (2011), to assess students' motivation and engagement in science lessons. The survey was developed for use with secondary students in Australia.

The survey consists of four scales related to attitudes towards science: self-efficacy, self-regulation, learning goal orientation, and task value. Each of the four scales of the SALES survey has eight items, making 32 items in total. All of the items in each scale are positively worded and responded to using a five point likert-type scale.

Given that the SALES is a more recent survey than the TOSRA, there are fewer studies that have used it. However, since its development, the SALES has been modified and used in several countries and in different languages, including: Turkey (Yetisir & Ceylan, 2015); and Jordan (Alzubaidi et al., 2016). In all cases, the SALES has been found to be valid and reliable. Given the importance of motivation to science learning, and the reliability of the survey, the study described in this thesis drew on the Task Value scale of the SALES in developing the new survey.

2.5 Chapter Summary

In this chapter, literature pertinent to the study presented in this thesis was reviewed. The chapter began with a review of literature pertaining to school gardens, including the historical context of school gardens, and research related to school gardens and its impact on student outcomes. Historically, gardens in schools have been established since the 1800s (Wright & Rowell, 2010), and a variety of literature suggests that school gardens have been primarily used as an alternative to traditional classroom learning, particularly in science (Canaris 1995; Graham et al. 2005; Klemmer et al, 2005). Blair (2009) indicates that the most frequently measured outcomes in past research have been science achievement, nutrition knowledge, and change in food behaviour with most studies demonstrating an improvement in each of these areas.

Past research has reported positive research outcomes, including improvements in academic performance, health and nutrition, parent involvement, school-community relationships, conservation and ecological commitment, school setting and environment, and school bonding and attachment. Additionally, studies have shown that school gardens improve students' healthy eating and nutrition, increase students' consumption of vegetables and fruits, and knowledge of plants. One of the key findings in reviewing the literature on school gardens, and supported by Dyment (2005) and Ozer (2007), is the shortage of valid and reliable research related to the impacts of school gardening. For this reason, the study presented in this thesis extends existing literature and fills an overdue gap in research on this topic.

The next section reviewed literature pertaining to the field of learning environments. An historical overview of learning environment research revealed that Dorothy Thomas conducted the earliest recorded research on classroom climate in the 1920s. Lewin (1936) then conducted studies on the influence of the environment on human behaviour as a result of human-environment interactions. Research relating to learning environments in the classroom became the focus of studies such as Walberg and Anderson (1968) and Moos (1979). Since then, a range of studies suggest that students' perceptions of the learning environment are important in improving student learning and academic outcomes.

With the increasing research on learning environments, a variety of instruments were developed to measure data collected on learning environments. Two pioneering instruments were the LEI (Walberg & Anderson, 1968) and the CES (Moos, 1979). These were revolutionary in that they were sources for the development of many subsequent learning environment instruments. Three existing instruments were used in the development of the learning environment survey for the study reported in this thesis: Science Laboratory Environment Inventory (SLEI; Fraser et al., 1995); Constructivist Learning Environment Survey (CLES; Taylor et al., 1997); What Is Happening In this Class? (WIHIC; Fraser et al., 1996) questionnaire.

Nine lines of learning environment research have been identified. Of these, two lines, the associations between the learning environment and student outcomes, and learning environment as process criteria in evaluating educational innovations, were pertinent

to the study presented in this thesis. The first, associations between the learning environment and student outcomes has been the focus of numerous studies, and an overwhelming proportion of these studies reported that student outcomes were positively associated with perception of the learning environments. Studies carried out across different countries, in different languages, for different subject areas and age groups, provide evidence to support positive learning environment- student outcome relationships.

The second line of research pertinent to this study was the use of learning environment measures as process criteria in evaluating educational innovations. Past research suggests that using learning environment instruments as a process criteria can provide a more accurate perspective of the impacts of innovations.

In the next section, literature pertaining to student attitudes towards learning in science was reviewed. Attitude was defined by Koballa and Crawley (1985) as a learned positive or negative feeling towards science, was used for this study. The specific attitudinal constructs used in this study sought to assess students' enjoyment of their class and the value that they placed on the tasks provided (task value). Numerous studies have examined impacts on student enjoyment resulting from different processes, in a range of subjects, student levels and countries. Additionally, studies have also reported positive relationships between student variables (such as achievement, motivation, and interest) and task value.

Whilst many instruments have been designed to assess student attitudes, with many developed specifically for measuring students' attitudes towards science, two were considered to be pertinent for use in this study: Test of Science-Related Attitudes (TOSRA; Fraser, 1981), and Students' Adaptive Learning Engagement in Science (SALES; Velayutham et al., 2011). Both instruments have reported strong reliability and validity in a range on contexts.

The next chapter, Chapter 3, describes the research methods used.

Chapter 3

RESEARCH METHODS

3.1 Introduction

The focus of this study was, first, to examine whether the use of an on-site school garden improved student' perceptions to their learning environment, attitudes, aspirations, and knowledge of healthy eating and second, to investigate the environment—outcome relationships. As outlined in Chapter 1, Section 1.5, the theoretical framework for this study was drawn from Bandura's social cognitive theory, which proposes that human growth, development, learning, adaptation, and interaction all take place within a triad of bidirectional environmental, behavioural and interpersonal determinants (Bembenutty et al., 2016). Given the information presented Chapter 2 on studies involving learning environments and attitudes, the decision to draw upon this theory for the purposes of this study was considered relevant since the study investigates relationships between the variables of learning environment, student perceptions, attitudes, aspirations, and knowledge, which are all embedded within this bidirectional "triad" of environmental, behavioural and interpersonal determinants suggested by Bandura (1977, 1986).

Social cognitive theory conceptualises students' learning in terms of interrelations between environmental factors (such as activities held within the classroom, or more specifically, the gardens in the case of this study), students' personal influences (such as their thoughts or beliefs, or attitudes such as enjoyment or task value, the relevant attitudes in relation to this study), and students' behaviours (Bandura. 1977). The theory emphasises the environmental factors that influence people's behaviour which, in the case of this study, takes place within the context of the gardens, and the impacts of the gardens on students' perceptions, attitudes, aspirations, and knowledge.

This chapter provides information about the research methods used for the completion of this study. The first section of this chapter reiterates the research objectives that were introduced in Chapter 1 (Section 3.2). Section 3.3 describes the sample, including the selection of the school, the classes and the teachers, as well as selection of the

students. In Section 3.4 the instruments and their development are described, as well their translation into Arabic. Section 3.5 outlines the different analyses used to examine each of the research objectives, while Section 3.6 provides a discussion of the ethical considerations of the research. Finally, Section 3.7 provides a summary of this chapter.

3.2 Research Objectives

To investigate the overarching aims of the study, the following research objectives, introduced in Chapter 1, were addressed:

Research Objective #1

To modify and validate three surveys for use with Cycle 2 students in Abu Dhabi, United Arab Emirates to assess students':

a. Perceptions of the learning environment;
b. Attitude towards science classes; and
c. Aspirations with respect to gardening and healthier eating practices.

Research Objective #2

To investigate the impacts of a school garden project on students':

a. Perceptions of the learning environment;
b. Attitudes towards science classes;
c. Aspirations with respect to gardening and healthier eating practices; and
d. Knowledge of healthy eating and nutrition.

Research Objective #3

To investigate the relationships between students' perceptions of the learning environment created during the garden project and their:

a. Attitudes (enjoyment and task value);

b. Aspirations with respect to gardening and healthier eating practices; and
c. Knowledge of healthy eating and nutrition.

3.3 Sample of the Study

This section describes the sample used for the collection of the data including the selection of the school (Section 3.3.1), the selection of classes and teachers (Section 3.3.2), and selection of the students (Section 3.3.3).

3.3.1 Selection of the School

The selection of the school for the research was based on several factors, but primarily involved convenience sampling since the researcher had been assigned to work at this school for extended periods, and was familiar with the staff members. This same school had also been selected and funded by the United Nations Food and Agricultural Organisation (FAO) to construct a working on-site greenhouse and garden area as part of their 'Gardens Project', one of only two schools selected in Abu Dhabi to participate in this project. Approval for the construction of the greenhouse and garden area was also given by the Abu Dhabi Education Council (ADEC), and this occurred just prior to the commencement of the study.

The selected school was a city-based public school located in central Abu Dhabi, comprising a student population of about 750 boys from Grades 6 to 9 (referred to as a Cycle 2 school in Abu Dhabi). Based on data obtained from comparative results and from various ADEC sponsored inspections, the school was regarded as a relatively high achieving school when compared with other boys' public schools across the Emirate of Abu Dhabi. Students' language levels were also considered to be relatively good in both their native Arabic, as well as in English. With the progression of the ADEC education reform process, English had become the main language of instruction across most subjects in the school, including for the subject of science.

3.3.2 Selection of the Classes and Teachers

Since all of the classes from grade 6 to 9 studied science, and following consultation with school administration and with the science teachers, it was decided that 19 of the

28 science classes would be involved in the study. The selection of classes was made to ensure that classes from all grade levels were involved in the study: at least two classes from each of the seven science teachers at the school were involved in the study, ensuring that students taught by all seven science teachers participated in the study. This sample provided eight classes from grade 6, four from grade 7, four from grade 8, and three from grade 9, making a total of 19 classes. The selection of classes within each year level was random to avoid bias.

As outlined in Chapter 1, the classes were timetabled to work in the gardens at least one lesson per week. During the intervention, the teachers used garden-based activities specific to gardening and healthy eating, and included relevant content based material wherever possible (see Chapter 1 for more details related to the activities involved).

3.3.3 Selection of Students

Since classes at the school were not streamed according to ability, the classes were composed of students of mixed abilities, and similar ages within the same grade level groupings. To reduce bias and to increase generalisability, intact classes were used. For each administration only students who consented to participate and were present on the day were included in the sample. Table 3.1 shows that for the pre-test, a total of 441 student responses were collected prior to any student involvement in the gardens. For the post-test administered, after the students had participated in the garden activities for eight months, a total of 336 student responses were collected. A breakdown of the number of students in each year level for these two data sets is shown in Table 3.1. This complete data set was used to address Research Objective #1.

Of the total sample, to examine the pre–post differences (Research Objective #2), only matched pairs of student responses (e.g. those who were present for both administrations of the surveys and of the knowledge tests) were included. For the three perception surveys (assessing learning environment, attitudes, and aspirations), this provided a sample of 307 students. That is, 307 students were present for both pre and post administrations of these three surveys.

Table 3.1 Breakdown of class and student numbers in each grade that responded to the pre-test and post-test surveys (Research Objective #1)

Grade level	Number of Classes		Number of students	
	Pre	Post	Pre	Post
6	8	8	158	150
7	4	4	107	75
8	4	4	108	58
9	3	3	68	53
Total	19	19	441	336

As the knowledge test (pre–post) was carried out on a different day to the perception surveys (which were all administered on the same day) the sample was slightly different. For the knowledge test, there were 368 matched responses. That is, 368 students were present for both the pre and post administrations of the knowledge tests. Table 3.2 shows the breakdown of numbers for the perception surveys (pre-test and post-test) and knowledge test (pre-test and post-test), which were used for the analyses for Research Objective #2.

Table 3.2 Breakdown of class and student numbers in each grade that responded to both the pre-test and post-test administrations of the surveys and knowledge test (Research Objective #2)

Grade level	Number of Classes		Number of students	
	Surveys	Knowledge Test	Surveys	Knowledge Test
6	8	8	121	132
7	4	4	79	85
8	4	4	54	89
9	3	3	53	62
Total	19	19	307	368

Finally, to examine the relationships between learning environment perceptions and the three student outcomes (attitudes, aspirations and knowledge), Research Objective #3, only those students who were present and responded to the pre and post administrations for all three surveys and the knowledge tests were included. This provided a sample of 263 students. That is, 263 students responded to all three surveys

as well as the knowledge tests. A breakdown of the number of students in each year level for this sample is provided in Table 3.3.

It should be noted that the high attrition rate between the pre and post-test numbers was related to the timing of the post-test. The administration of the post-test surveys and knowledge test were conducted during a study week at the end of term, which resulted in an unanticipated number of absent students.

Table 3.3 Breakdown of class and student numbers in each grade that responded to the knowledge tests and final numbers that responded to all four pre and post sessions (Research Objective #3)

		Number of Students			
Grade level	Number of Classes	Pre-test	Post-test	Pre and post for knowledge test	Pre and post for surveys and knowledge tests
6	8	168	147	132	102
7	4	102	90	85	64
8	4	103	92	89	47
9	3	67	68	62	50
Total	19	440	397	368	263

3.4 Instruments and Data Collection

This section describes the instruments used to collect the data, including the perception surveys and a knowledge test. The three perception surveys all were developed for the purpose of this study to assess: students' perceptions of the learning environment (described in Section 3.4.1); students' attitudes towards their science classes (described in Section 3.4.2); students' aspirations towards gardening and towards healthier eating and nutrition (described in Section 3.4.3). Finally, a knowledge test comprising of 13 multiple choice questions (related to healthy eating and nutrition) is described in Section 3.4.4.

3.4.1 Perceptions of the Learning Environment

To assess students' perceptions of the learning environment that were relevant to the garden setting a survey, named the Gardening and the Learning Environment (GALE)

was developed for the purpose of this study. The survey was made up of six scales drawn from three existing surveys, namely, the Constructivist Learning Environment Survey (CLES; Taylor et al., 1997), the What Is Happening In this Class? (WIHIC) instrument, (Fraser et al., 1996) and from the Science Laboratory Environment Inventory (SLEI; Fraser et al., 1995).

Three of the scales, personal relevance, shared control, and student negotiation, were drawn from the Constructivist Learning Environment Survey (CLES), developed by Taylor et al. (1997). First, the relevance scale, which assesses the level of relevance of the activities to students' lives, was selected because it was anticipated that the use of the gardens would make the science classes more relevant to the students. Second, the shared control scale, which assesses the level of participation that students have in the planning and assessment of the learning, was selected as it was anticipated that students would play a larger role in some of the activities taking place in the gardens, than they would in their regular science classes held in a classroom. Finally, the student negotiation scale, which assesses the level of involvement with other students in assessing the viability of ideas, was selected as it has been used to assess the extent to which students explain and justify their ideas to their peers and to reflect on these ideas (Taylor et al., 1997). Since it was anticipated that, through the use of the gardens, students would have more opportunities to participate with their peers and in sharing and justifying their ideas during these activities throughout the study duration, the student negotiation scale seemed an appropriate selection.

Two scales, involvement and cooperation, were drawn from the What Is Happening In this Class? (WIHIC) instrument, developed by Fraser et al. (1996) and later modified by Aldridge et al. (1999). First, given that students would be participating in a range of activities in the gardens, it was anticipated that the involvement scale, which assesses the level of attentive interest and participation in the class, would provide a suitable measure of the changes. Similarly, since much of the work in the gardens would involve the students working cooperatively in teams, the cooperation scale, which aims to measure the level of student cooperation rather than competition with their peers (Aldridge et al., 1999), was included.

The last scale, integration, was drawn from the Science Laboratory Environment Inventory (SLEI), which was developed by Fraser et al. (1995). This survey was developed to assess the environment of the science laboratories, in which students conduct practical work (Fraser et al., 1995). With respect to the study described in this thesis, the integration scale was selected as it was anticipated that this scale would measure the extent to which garden activities were integrated with student learning in their normal science classes.

The selection of the scales was made to ensure that the survey was relevant to the aims of the study and significant in the cultural and environmental context of the UAE. While some items were modified, other items were developed by the researcher, to ensure relevance in the context of the garden activities. Table 3.4 provides an overview of the scales, including a description of what the scale assesses, a sample item from each scale used in the final survey, and the authors of the original survey.

Table 3.4 Sample items and descriptions relating to scales in the GALE survey

GALE scale	Scale Description	Sample item	Original Survey
Relevance	Level of relevance of the activities to students' lives	I enjoy learning about things in the world outside of school (Item 6)	Constructivist Learning Environment Survey (CLES)
Shared control	Level of participation in planning, conducting and assessing of learning	I help the teacher to plan activities in science (Item 10)	Constructivist Learning Environment Survey (CLES)
Student Negotiation	Level of involvement with other students in assessing viability of ideas	I explain my ideas and understandings to other students (Item 13)	Constructivist Learning Environment Survey (CLES)
Involvement	Level of attentive interest, participation in the class	I am involved in class discussions (Item 15)	What Is Happening In this Class? (WIHIC)
Cooperation	Level of student cooperation with each other during activities	I work with other students in Science (Item 23)	What Is Happening In this Class? (WIHIC)
Integration	Level in which garden activities are integrated with regular life activities	Working in a garden can help me learn about healthy eating (Item 33)	Science Laboratory Environment Inventory (SLEI)

The final version of the GALE was comprised of six scales, with six items in relevance, four items in shared control, four items in student negotiation, five items in student involvement, nine items in student cooperation, and seven items in integration, making

a total of 35 items for the survey. A complete copy of the GALE survey can be found in Appendix 2. All items were responded to using a five-point Likert scale of strongly agree, agree, uncertain, disagree, and strongly disagree (Likert, 1932). The items were arranged within their scale with a heading to provide students with contextual cues.

3.4.2 Attitudes Towards Science Classes

The second survey, named the Gardening and Attitudes Towards Science survey (GATS) was developed to assess students' attitudes towards their science classes, and included two scales, enjoyment and task value. The first scale, enjoyment of science lessons, was modified from the Test of Science-Related Attitudes (TOSRA), developed by Fraser (1981). This scale sought to assess the changes in enjoyment of science pre and post garden use. The original enjoyment scale in TOSRA included 10 positively and negatively worded items (examples of a negatively worded item from TOSRA include, "Science is man's worst enemy", "I dislike science lessons"). For the purpose of this research, these negative items were re-worded to ensure that all the items were positively worded. Further, two additional items were developed by the researcher to assess enjoyment in the gardens outside of the classroom environment, making a total of 12 items for this scale.

The second scale, task value, was drawn from the Students' Adaptive Learning Engagement in Science (SALES) survey developed by Velayutham et al. (2011). As outlined by Velayutham et al. (2011), task value refers to the levels that students perceive tasks in science as interesting and important. Since students who were using the gardens would be exposed to a variety of tasks, different to those in their regular classroom, it was deemed important to include this scale to measure task value pre and post garden use.

The GATS was made up of a total of 19 items, all of which are responded to using the same Likert style responses as the first survey with strongly agree, agree, uncertain, disagree, and strongly disagree. Table 3.5 provides a scale description and sample item for each of the two scales. A full copy of the GATS survey can be found in Appendix 3.

Table 3.5 Sample items and descriptions relating to scales in the GATS survey

GATS tool scale	Scale Description	Sample item	Original Survey
Enjoyment	Level of enjoyment and pleasure a student attains during science classes	Science is one of the most interesting school subjects (Item 11)	Test of Science-Related Attitudes (TOSRA)
Task value	Level of students' perceptions of the interest, usefulness and importance of a task in science classes	What I learn in science is helpful to me. (Item 14)	Students' Adaptive Learning Engagement in Science (SALES)

3.4.3 Aspirations for Gardening and Healthy Eating and Nutrition

The third survey, Aspirations to Gardening and Healthy Eating and Nutrition (AGHEN) involved three scales that were developed by the researcher. The first scale, aspirations towards healthier eating, sought to examine students' aspirations towards eating healthier foods. The second scale, preferences towards healthy eating, sought to assess students' preferences with respect to healthy food, as opposed to fast foods or junk foods. The third scale, aspirations towards gardening, sought to assess students' aspirations towards tending a garden outside of the school garden. These three scales were made up of 12, 13 and five items, respectively. The AGHEN was made up of a total of 30 items that were all responded to using the same Likert scale response format used in the other two surveys: strongly agree, agree, uncertain, disagree, and strongly disagree. A description of each of the three scales and a sample item are provided in Table 3.6. A full copy of the newly-developed AGHEN survey can be found in Appendix 4.

Table 3.6 Sample items and descriptions relating to scales in the AGHEN survey

AGHEN tool scale	Scale Description	Sample item	Original Survey
Aspirations (healthier eating)	Level to which students aspire to eat healthier foods	Improving my diet is important to me (Item 7)	Developed by the author
Preferences (healthy eating)	Level to which students prefer to make healthier food choices (grown foods)	Eating fruit and vegetables is better for my health (Item 20)	Developed by the author
Aspirations (gardening)	Level to which students want to be more involved in gardening beyond their science classes	I want to have a garden in my home (item 27)	Developed by the author

3.4.4 Knowledge Test — Healthy Eating

In addition to the surveys described in the previous sections, a basic knowledge test comprising 13 multiple choice questions on the topics of healthy foods, non-healthy foods, growing healthy foods in gardens, and basic nutrition was developed by the researcher to obtain data on students' knowledge of healthy eating and nutrition, and to compare the knowledge results pre and post garden use. The question topics were developed by the researcher to cover a range of general knowledge topics in the context of healthy eating and gardening. A copy of the knowledge test is included in Appendix 5.

3.4.5 Translation of the Instruments

Although the language of instruction in Cycle 2 science classes in Abu Dhabi public schools was English, it was acknowledged that English was not the first/native language of the students. Therefore, to increase reliability, a dual language version of the surveys and the knowledge test was developed in both English and Arabic. This dual-language approach was used to minimise discrimination according to language, by allowing the students to read and respond in the language of their choice. To translate the surveys the rigorous process of back-translation (as recommended by Ercikan, 1998) was used. This process involved providing the English version of the instruments to an Arabic-English translator who worked at the school. Once translated, the surveys were all translated back into English by two other proficient Arabic-English speakers at the school (neither of whom had seen the original English versions of the surveys). The two English versions were then compared, and the equivalence of the translations verified. This process helped to ensure accuracy and validity of the final text.

The final version of each survey included both parallel English and Arabic language instructions, labelling, items and response format, as shown in Figure 3.1. A copy of

the final dual-language surveys and the knowledge test can be seen in Appendices 2 to 5.

HEALTHY EATING AND NUTRITION – PART C

	Aspirations (Healthy Eating and Diet)	Strongly Disagree غير موافق بشدة	Disagree غير موافق	Uncertain غير متأكد	Agree موافق	Strongly Agree موافق بشدة
1.	I want to be healthier أفضل أن أكون أكثر صحة	1	2	3	4	5
2.	I want to eat healthier foods at school أريد أن أتناول الطعام الصحي في المدرسة	1	2	3	4	5
3.	I want to eat healthier foods at home أريد أن أتناول الطعام الصحي في البيت	1	2	3	4	5
4.	I want my family to eat healthier أريد أن تتناول عائلتي طعاماً صحياً	1	2	3	4	5

Figure 3.1 Sample items from the final AGHEN survey showing the layout of the parallel versions of the English and Arabic translations

3.4.6 Technical Trial and Data Collection

To examine the face validity of the three surveys, a technical trial was conducted. This was carried out at a separate nearby Cycle 2 school, and involved a random selection of 13 students across all grades. During the technical trial, students were observed whilst they responded to the survey, to monitor any difficulties both logistically and in terms of the scales and items. Feedback from students after they had responded was positive with no student complaining of any difficulties. Most of the students required between 30 to 40 minutes to complete all three of the surveys. Based on the technical trial, it was decided that for administration with the main sample, a full 50 minute lesson duration would be allocated for all classes simultaneously.

Data collection for the main sample involved a pre-test, carried out prior to the commencement of the garden activities, and a post-test, carried out eight months later. A period of eight months was considered optimum as this was the duration of

acceptable weather conditions before the extreme heat and humidity made the garden activities intolerable. This eight month period provided the more ideal growing period for plants in the region whilst allowing sufficient time for the novelty of using the garden to wear off.

Given the time constraints, the knowledge test and perception surveys were administered to the students on separate days. To ensure consistency in administering the survey, the researcher was actively involved.

3.5 Data Analysis

Once the data had been collected, the data was entered into an Excel spreadsheet. Cases for which more than 20% of the data was missing, were removed from analysis. Consideration was given to missing/ incomplete data during the analyses using the "exclude cases pairwise" option in SPSS. This excluded any cases (participants) if they were missing for a specific analysis, but still included them in other analyses if all of the data was availed.

Once the data were entered, the Statistical Package for Social Sciences (SPSS) software package (version 23) was used to analyse the data to address each of the research objectives. Section 3.5.1 outlines the analyses used to support the reliability and validity of the surveys (Research Objective #1). Section 3.5.2 describes the analyses used to examine the pre–post differences (Research Objective #2). Finally, Section 3.5.3 describes the analyses used to examine the relationships between the learning environment and the student outcomes (attitudes, aspirations, and knowledge; Research Objective #3).

3.5.1 Research Objective 1- Validation of the three surveys

The first objective involved providing support for the validity of the surveys used in the research. Evidence used to support the reliability and validity of the surveys included factor loadings, Eigenvalues and internal consistency reliability, as described below.

As a first step, Kaiser Normalisation was used so as to determine whether the data was suitable for analysis. The validation process then involved principal axis factor analysis with oblique rotation. Oblique rotation was used as it allows for correlations and provides realistic representation of the interrelationships between factors (Field, 2009). During factor analysis, the criteria for an item to be retained was that it must have a factor loading of at least .30 on its own scale and less than .30 on all other scales (as recommended by Kline, 1994, and Thompson, 2004). Additionally, the cumulative variance was used to check whether a sufficient number of factors had been retained, and eigenvalues showed the relative importance of each factor (Field, 2009). Items not meeting the aforementioned criteria were removed to improve the internal consistency and factorial validity of the instrument. Included in this analysis was the examination of the Eigenvalues to ensure that they were adequate to constitute a scale.

Next, the internal consistency reliability for the items in each scale were examined using the Cronbach alpha reliability coefficient. Internal consistency reliability is a measure of the extent to which each item in a particular scale measures the same concept as the other items in that scale, and this was applied for each of the scales of the research surveys. The magnitude of the alpha coefficient depends on the number of items and on the strength of the correlations among the items, and with alpha coefficient values ranging from 0 to 1, the higher the coefficient value, the greater the reliability (Nunnally & Bernstein, 1994). Based on the recommended cut-off suggested by George and Mallory (2003), scales with an internal consistency reliability of over 0.50 was considered to be satisfactory.

3.5.2 Research Objective 2- Examining Pre–Post Differences

The second research objective examined pre–post differences in terms of students' learning environment perceptions, attitudes towards science classes, aspirations towards gardening and healthier eating, and knowledge of healthy eating (as outlined in Section 3.2). To examine the pre–post differences, a one-way Multivariate Analysis of Variance (MANOVA) analysis was used. The six scales from the GALE survey, two scales from the GATS survey, three scales from the AGHEN survey, and items

from the knowledge test were used as the dependent variables, while garden use (pre-test and post-test) was the independent variable. Additionally, effect sizes for each scale were calculated to determine the magnitude of the differences using Cohen's d formula ($d = M_1 – M_2 / S$ pooled; where M_1 is the mean of group 1; M_2 is the mean of group 2; S pooled is the pooled standard deviations for the two groups which is found using he formula: $\sqrt{[(S_1^2 + S_2^2) / 2]}$ (Thompson, 2001).

3.5.3 Research Objective 3: Learning Environment – Outcome Relationships

The third research objective examined the relationships between the learning environment and the three outcomes (attitudes, aspirations, and knowledge). Simple correlation and multiple regressions were used to address this research objective. Simple correlation was used to examine the bivariate relationships between the learning environment scales and each outcome scale and knowledge test. To provide a more parsimonious understanding of the relationship between the learning environment and the three outcomes (students' attitudes, aspirations, and knowledge), multiple regression analysis was used. Standardized regression coefficients (beta values) were interpreted to determine the contribution of individual learning environment scales to the students' attitudes, aspirations, and knowledge of healthy eating when all other learning environment scales were mutually controlled.

3.6 Ethical Considerations

Prior to commencement, ethics approval was applied for and given by the Human Research Ethics Committee of Curtin University (Approval ID SMEC-02-04). A copy of the approval letter is provided in Appendix. Written consent was also obtained from the Abu Dhabi Education Council, who approved the research and data collection. A copy of this approval letter is provided in Appendix 7.

Throughout the research, ethical issues were considered to ensure the wellbeing and rights of the participants. This section outlines the ethical considerations made throughout the study. These included: informed consent (Section 3.6.1); and confidentiality (Section 3.6.2).

3.6.1 Informed Consent

Since the author had been working for several years at the school where the research was conducted, obtaining consent from the principal and administration was not difficult, and given the close relationship between the author and the staff there, the staff at the school were enthusiastic for their classes to be involved.

Informed consent was obtained to ensure that the participants were aware of what the research entailed, their roles and their rights. The Principal, teachers, participating students, and parents of participating students were all provided with information prior to being asked to be involved in the study. The information sheets stated the intended purpose of the research, the role of the participant, the voluntary nature of participation, the option to withdraw at any time without penalty, and confidentiality information including measures in maintaining confidentiality of participants (outlined in Section 3.6.2). In all cases, participants were informed that they had the right to withdraw from the research at any time, without prejudice or negative consequences. By signing the consent forms, all parties involved agreed to participate, and for the data collected from the research and from the surveys to be included in the study. Students that did not provide signed consent forms from their parents, participated in the normal classroom and gardening activities, but did not respond to any of the surveys.

Before approaching staff or students, first, consent was sought from the principal (see Appendix 8 for a copy of the information sheet and consent form provided to the principal). Once consent had been provided by the principal, the teachers were approached. Given the long-standing relationship that the researcher had with the school, teachers were keen to be involved. A copy of the teacher's information sheet and consent form is provided in Appendix 9.

Once the teachers had provided their consent, the parents of students in the selected classes were provided with information about the research. A copy of this information sheet is provided in Appendix 10.

Finally, those students whose parents had provided consent, were given information about the research. This information was provided to students both verbally and in written form. Students were given the opportunity to ask questions and informed of the voluntary nature. A copy of the information sheet and consent form given to students is provided in Appendix 11.

3.6.2 Confidentiality

An important ethical consideration was the notion of confidentiality. The confidentiality of all information provided by the participants was maintained throughout the study, with only the researcher and the researcher's supervisor having any access to any data or other information. The researcher ensured confidentiality of the school and participants by not divulging details of the research to any stakeholders outside of the school (apart from the Abu Dhabi Education Council research section, who approved the use of the school for research). Additionally, personal details of the participants and the name of the school were not divulged to any external body, and assurance was given that data and information collected from the study would remain separate from any personal details. Teachers and administrators were also given the right to review and withhold any data obtained from their classes.

At all stages of the research process, the completed surveys and all data collected was stored in a locked cabinet at the researcher's private residence. All digital data stored on the researcher's personal laptop was password protected to prevent access of the data from anyone else. This data will be stored at Curtin University for a period of seven years, after which time it will be destroyed. All data related to the research were only accessible to the researcher and his university supervisor.

Since students at the school each had a unique student code (provided by the school), students were informed to use this code rather than their names on the written questionnaires, and that their names would not be used in the collection and analyses of data. The codes were only used to match up the attendees for the pre and post analyses of the data, after which they were deleted to maintain the anonymity of individual students.

3.7 Chapter Summary

This chapter detailed the methods that were used in this study. This chapter described the processes used in selecting the sample, developing the surveys, collecting and analysing the data. Additionally, the chapter outlined the ethical considerations made throughout the study, the collection and analyses of data collected from these surveys and the test, to examine the three research objectives of the study which are outlined in Section 3.2.

The sample site included one school in which an on-site greenhouse and garden area had been developed. From the school, the students from 19 classes were selected. All of these students were exposed to the gardening activities. The student sample for the pre-test administration of the surveys was 441 students and 336 for the post-test administration. In total, 307 students completed both the pre and post surveys. Given that the knowledge test was administered on a different day to the surveys, the sample was slightly different. The number of students who completed both the pre-test and post-test surveys as well as the pre-test and post-test knowledge test was 263.

For this study, three perception surveys were developed. The first survey, the Gardening and the Learning Environment (GALE), assessed students' perceptions of the learning environment. The GALE was made up of six scales that were considered to be relevant to the research objectives (relevance, shared control, student negotiation, student involvement, collaboration, and integration). The scales were drawn from three previously developed surveys, namely, the Constructivist Learning Environment Survey (CLES; Taylor et al., 1997), the What Is Happening In this Class? (WIHIC) instrument, (Fraser et al., 1996) and from the Science Laboratory Environment Inventory (SLEI; Fraser et al., 1995).

The second survey, the Gardening and Attitudes towards Science (GATS), was used to assess students' attitudes towards their science classes. The GATS included two scales, enjoyment and task value, that were drawn from two previously used surveys, the Test of Science-Related Attitudes (TOSRA; Fraser, 1981), and the Students' Adaptive Learning Engagement in Science (SALES; Velayutham et al., 2011).

The third survey, the Aspirations for Gardening and Healthy Eating and Nutrition (AGHEN), was used to assess students' aspirations towards gardening and healthier eating. This survey contained three scales that were developed by the researcher. These scales include aspirations towards being healthy, food choice preferences, and aspirations towards tending a garden.

In addition to the three perception surveys, a knowledge test was also developed by the researcher. The test, administered before and after the use of gardens, involved 13 multiple choice questions on healthy eating and nutrition.

The surveys and knowledge test were all translated and provided to students using a dual language (English-Arabic) format. The students were all of Arabic speaking background, and this format sought to minimise confusion in interpretation. A technical trial was then conducted before the final surveys were administered to students.

The data were analysed using the SPSS software package to address each research objective. To support the reliability and validity of the three surveys (Research Objective #1) factor loadings, Eigenvalues, and internal consistency reliability, were used. To examine pre–post differences in terms of learning environment perceptions, attitudes, aspirations, and knowledge (Research Objective #2) a one-way multivariate analysis of variance (MANOVA) and effect sizes were used. Finally, to identify relationships between the learning environment and students' attitudes, aspirations, and knowledge of healthy eating (Research Objective #3) simple correlations and multiple regression analysis were used.

An outline of the ethical considerations, including informed consent and confidentiality, are also included in this chapter. In all cases, participants and the parents of students were provided with information regarding the nature and methods of the study, and of the confidential nature of the information obtained.

Chapter 4

RESULTS AND FINDINGS

4.1 Introduction

This chapter reports the results of the analyses of data collected using three perception surveys and one knowledge test (described in Chapter 3). The surveys and test were administered once before the introduction of garden use and again eight months after the introduction. During the eight-month period, students utilised the gardens during their science classes as described in Chapter 1.

The major sections of this chapter are organised around the research objectives of the study. In Section 4.2, evidence to support the validity and reliability of the surveys used to collect the data is reported. In Section 4.3, the results pertaining to differences in students' perceptions of the learning environment, attitudes, aspirations and knowledge of healthy eating before and after the use of gardens are reported. The results of the analysis used to assess the associations between the learning environment perceptions and attitudes, aspirations and knowledge are reported in Section 4.4. Finally, Section 4.5 summarises the chapter.

4.2 Reliability and Validity of the Surveys

This section provides evidence to support the validity and reliability of the surveys used in the study to address the first research objective of this study which was to:

Modify and validate three surveys for use with Cycle 2 students in Abu Dhabi, United Arab Emirates to assess students':

a. *Perceptions of the learning environment;*
b. *Attitudes towards science classes; and*
c. *Aspirations with respect to gardening and healthier eating practices.*

Whilst details of the analysis methods used are provided in Chapter 3, this chapter reports the results of the analyses of data (N=441 students for the pre-test

administration and *N*=336 students for post-test administration). This section reports the evidence to support the reliability and validity of the three surveys: Gardening and the Learning Environment survey (GALE; Section 4.2.1); Gardening and Attitudes Towards Science survey (GATS; Section 4.2.2); and Aspirations for Gardening and Healthy Eating and Nutrition survey (AGHEN; Section 4.2.3).

4.2.1 Gardening and the Learning Environment Survey (GALE)

The GALE survey was developed to assess students' perceptions of the learning environment created in gardens using five scales: relevance; shared control; student negotiation; student involvement; collaboration; and integration. The development of the GALE survey is provided in Chapter 3 (Section 3.4). This section reports the evidence used to support the reliability and validity of the GALE in terms of the: factor structure (Section 4.2.1.1); internal consistency reliability (Section 4.2.1.2); and ability to differentiate between classes (Section 4.2.1.3).

4.2.1.1 Factor Structure

As a first step, principal axis factoring with oblique rotation and Kaiser Normalisation was used to examine the factor structure of the GALE. The criteria for retaining an item was that it should have a factor loading greater than or equal to .30 on its own scale, and less than .30 with each of the other scales. Item analysis indicated that, of the original 35 items, 11 did not meet these criteria. As a result, the following items were omitted from further analysis: items 15 to 19 of the student involvement scale (all five items), items 24, 27 and 28 of the collaboration scale, and items 29 to 31 of the integration scale. Once these items had been removed, all other items, with one exception, loaded at .30 on its own scale and not on any other scale. For the exception (item 5 of the relevance scale) for the post-test, this item did not load on its own or any other scale. This item was retained as it added to the reliability of the survey over all. Table 4.1 reports the factor loadings for the items of the GALE survey.

Table 4.1 Factor loadings, percentage and eigenvalue variance for the GALE

Item No	Factor Loading									
	Relevance		Shared Control		Student Negotiation		Collaboration		Integration	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	.70	.68								
2	.68	.30								
3	.57	.66								
4	.42	.45								
5	.51	-								
6	.52	.60								
7			.66	.69						
8			.76	.75						
9			.71	.76						
10			.75	.69						
11					.46	.55				
12					.55	.66				
13					.64	.34				
14					.71	.54				
20							.64	.61		
21							.55	.60		
22							.73	.78		
23							.55	.69		
25							.55	.60		
26							.50	.38		
32									.63	.51
33									.79	.92
34									.83	.72
35									.75	.70
Eigenvalue	1.66	1.46	1.88	1.93	1.33	1.21	6.75	7.54	1.94	1.59
% Variance	6.92	6.07	7.83	8.04	5.33	5.05	28.13	31.43	8.10	6.60

N= 441 students in 19 classes for the pre-test and 336 students in 19 classes for the post-test.
Loadings less than .30 have been omitted.

Whereas the factor loadings showed how strongly each item was related to a specific factor, the eigenvalues indicated the relative importance of each factor. The results, reported at the bottom of Table 4.1, show that the eigenvalues ranged from 1.21 to 7.54 for the different scales, which meet the criteria based on the Kaiser criterion, where factors should be retained if their eigenvalues are greater than or equal to one (Beavers et al, 2013). The percentage of variance, which was used to check whether a sufficient number of factors had been retained, ranged from 5.05 to 31.43 for different

scales. The total percentage of variance was 56.31% for the pre-test and 57.10% for the post-test.

4.2.1.2 Internal Consistency Reliability

To examine the degree to which the items within a scale assessed the same construct, the internal consistency reliability was estimated for each scale using the Cronbach alpha reliability (using the individual and class means as the unit of analysis). As with the factor analysis, this was conducted separately for data collected for the pre-test and post-test administrations. The results, reported in Table 4.2, show that the reliability estimates (Cronbach alpha coefficient) for each of the refined learning environment scales, with the individual student as the unit of analysis, ranged from .71 to .83 for the pre-test and from .71 to .84 for the post-test. With the class as the unit of analysis, scale reliabilities ranged from .67 to .91 for the pre-test data and from .56 to .94 for the post-test.

Given that the lowest Cronbach alpha reliability, for the individual as the unit of analysis, was .67 (for relevance pre-test), based on the guidelines suggested by George and Mallery (2003), and using .5 as the acceptable cut-off, the results for all five scales were considered to be acceptable. Using these guidelines, the results for the class mean as the unit of analysis again indicated that all five scales were acceptable for the data collected for both the pre-test and post-test administration, with the lowest score being .56 for the student negotiation scale.

Table 4.2 Internal consistency reliability for the GALE

Scale	No. of Items	Unit of Analysis	Cronbach Alpha	
			Pre-test	Post-test
Relevance	6	Individual	.73	.71
		Class Mean	.67	.83
Shared Control	4	Individual	.79	.82
		Class Mean	.90	.89
Student Negotiation	4	Individual	.71	.70
		Class Mean	.76	.56
Collaboration	6	Individual	.81	.84
		Class Mean	.82	.94
Integration	4	Individual	.83	.83
		Class Mean	.91	.89

N= 441 student in 19 classes for the pre-test and 336 students in 19 classes for the post-test

4.2.2 Gardening and Attitudes towards Science Survey (GATS)

The GATS survey (the development of which is described in Chapter 3) was used to assess students' attitudes towards their science classes, particularly for the scales of enjoyment and task value. This section reports the evidence used to support the reliability and validity of the GATS in terms of the: factor structure (Section 4.2.2.1), internal consistency reliability (Section 4.2.2.2), and ability to differentiate between classes (Section 4.2.2.3).

4.2.2.1 Factor Structure

Principal axis factor analyses with oblique rotation, involving the data collected from the 441 students for the pre-test and 336 students for the post-test, was used to examine the factor loadings for individual items and Eigenvalues and percentage of variance for the scales of the GATS survey. Using the criteria described in Chapter 3, four items (items 2, 4, 7 and 12 for the enjoyment scale) were omitted from further analysis because of their unsatisfactory factor loadings. The results, reported in Table 4.3, show that all of the remaining items, for both the pre-test and post-test, without exception, loaded on their a priori scale and no other scale. For the pre-test data, the percentage of variance ranged from 8.69 to 52.07, while eigenvalues ranged from 1.30 to 7.81, as reported at the bottom of Table 4.3. For the post-test data, the percentage of variance ranged from 9.30 to 48.71, while eigenvalues ranged from 1.40 to 7.31. The total of percentage variance was 60.67% for the pre-test and 58.01% for the post-test. The final survey was composed of 15 items in two scales.

4.2.2.2 Internal Consistency Reliability

The internal consistency reliability was examined using the Cronbach alpha coefficient for the individual and class mean as a unit of analysis. The results, shown in Table 4.4, with the individual as the unit of analysis, was .96 and .88 for the enjoyment and task value scale, respectively, for the pre-test, whilst the internal consistency reliability was .88 for the post-test for both scales. There was an increase in the values for both scales when the class mean was used, with Cronbach alpha coefficients of .96 and .95 for the pre-test, for the enjoyment and task value scales, respectively, and .95 for both

the pre-test and post-test. The Cronbach alpha coefficients for both the pre-test and post-test with the individual student level and the class mean as the unit of analysis were considered to be satisfactory.

Table 4.3 Factor analysis for the reliability of GATS scales

Item Number	Factor Loading			
	Enjoyment		Task Value	
	Pre	Post	Pre	Post
1	.81	.78		
3	.66	.64		
5	.84	.83		
6	.62	.50		
8	.80	.77		
9	.86	.83		
10	.67	.68		
11	.72	.53		
13			.59	.85
14			.83	.92
15			.68	.57
16			.90	.74
17			.76	.79
18			.64	.68
19			.63	.57
Eigenvalue	7.81	7.31	1.30	1.40
% Variance	52.07	48.71	8.69	9.30

N= 441 students in 19 classes for the pre-test and 336 students in 19 classes for the post-test.
Loadings less than .30 have been omitted.

Table 4.4 Internal consistency reliability for GATS scales

Scale	Number of Items	Unit of Analysis	Cronbach Alpha	
			Pre	Post
Enjoyment	8	Individual	.90	.88
		Class Mean	.96	.95
Task Value	7	Individual	.88	.88
		Class Mean	.95	.95

N= 441 students in 19 classes for the pre-test and 336 students in 19 classes for the post-test

4.2.3 Aspirations for Gardening and Healthy Eating and Nutrition (AGHEN)

The AGHEN survey (the development of which is described in Chapter 3) was used to assess students' aspirations to gardening and to healthier eating. This section reports

the evidence used to support the reliability and validity of the AGHEN in terms of the: factor structure (Section 4.2.3.1), internal consistency reliability (Section 4.2.3.2), and ability to differentiate between classes (Section 4.2.3.3).

4.2.3.1 Factor Structure

As with the other surveys, principal axis factor analyses with oblique rotation was used to examine the factor structure of the AGHEN survey. As with the previous two surveys, items with loadings less than .30 on their own scale were omitted from further analyses. All of the items in one of the three scales, preferences for healthy eating, was found not to meet the criteria, therefore, this scale was omitted from all further analysis. Of the remaining items, five from the aspirations for healthier eating scale (items 8 to 12) were also found not to meet the criteria and omitted from further analysis. The factor loadings of the remaining 12 items of the AGHEN in two scales, reported in Table 4.5, all met the criteria. Eigenvalues for these two scales were 5.58 (for aspirations for healthier eating) and 1.62 (for aspirations for gardening) for pre-test and 5.87 (aspirations for healthier eating) and 1.13 (aspirations for gardening) for the post-test. The percentage of variance for the pre-test was 46.51% for aspirations for healthier eating and 13.54% for aspirations for gardening, with a total variance of 60.05%. For the post-test, the percentage of variance was 48.94% for aspirations for healthier eating and 9.38 for aspirations for gardening, with a total variance of 58.32%.

4.2.3.2 Internal Consistency Reliability

Cronbach's alpha coefficient was used to provide an estimation of the internal consistency reliability for each scale. The reliability estimates using individual and class mean units of analysis for both the pre-test and post-test results are reported in **Error! Reference source not found.**. Cronbach alpha coefficients for the pre-test, were .89 and .80 with the individual as the unit of analysis and .87 and .83 with the class mean as the unit of analysis. For the post-test, the Cronbach alpha coefficients were .82 and .80 for the individual as the unit of analysis and .94 for both scales with the class mean as the unit of analysis. These results provide support for the internal consistency reliability of the scales.

Table 4.5 Factor analysis for aspirations and healthy eating and nutrition (AGHEN) survey

Item Number	Aspiration (Healthier Eating)		Aspiration (Gardening)	
	Pre-test	Post-test	Pre-test	Post-test
1	.78	.68		
2	.80	.46		
3	.82	.68		
4	.83	.81		
5	.76	.84		
6	.72	.77		
7	.68	.86		
26			.68	.91
27			.63	.77
28			.79	.85
29			.81	.68
30			.67	.41
Eigenvalue	5.58	5.87	1.62	1.13
% Variance	46.51	48.94	13.54	9.38

N= 441 students in 19 classes for the pre-test and 336 students in 19 classes for the post-test.
Loadings less than .30 have been omitted.

Table 4.6 Internal consistency reliability (Cronbach Alpha Coefficient) for the AGHEN survey

Scale	Number of Items	Unit of Analysis	Cronbach Alpha	
			Pre	Post
Aspiration (Healthier eating)	7	Individual	.89	.82
		Class Means	.87	.94
Aspiration (Gardening)	5	Individual	.80	.80
		Class Means	.83	.94

N= 441 students in 19 classes for the pre-test and 336 students in 19 classes for the post-test.

This section provided evidence to support the reliability and validity of the three perception surveys used to collect data in this study. These results provide support for confidence in the subsequent findings.

4.3 Pre–Post Differences: Perceptions of the Learning Environment, Attitudes, Aspirations and Knowledge of Healthy Eating

This section reports the results of analyses used to examine the impact of the school gardens in terms of students' perception of the learning environment, attitudes towards

science classes, aspirations for gardening and healthier eating, and knowledge of healthy eating (Research Objective #2), which sought to:

Investigate the impacts of a school garden project on students':

a. *Perceptions of the learning environment;*
b. *Attitude towards science classes;*
c. *Aspirations with respect to gardening and healthier eating practices; and*
d. *Knowledge of healthy eating and nutrition.*

As described in Chapter 3 (Section 3.4), the study involved a pre–post design. For this analysis, only those students who were present for both the pre-test and post-test administrations were included, providing a sample of 307 students in 19 classes for the perception surveys and 368 students in 19 classes for the knowledge tests. To examine whether there were changes in students' perceptions of the learning environment, attitudes towards their science classes, aspirations towards gardening and towards eating healthier foods, and their knowledge of healthy eating and nutrition, a multivariate analysis of variance (MANOVA) was used. The MANOVAs were conducted separately for the different surveys and for the knowledge test. In addition, the magnitude of these differences was examined by calculating the effect-size, as recommended by Thompson (2001).

Prior to using MANOVA analysis the data was checked to ensure that it conformed to assumptions of normality and multicollinearity. For a perfectly normal distribution the skewness and kurtosis should be zero. The results reported in Appendix 12 show that, based on the cut-offs recommended by West et al (1996), of >2.1, for skewness and >7.1 for Kurtosis, the assumption of normality was considered to be acceptable for both. Data were checked for multicollinearity and singularity, with no serious violations noted.

4.3.1 Learning Environment Perceptions

The average item means for responses to the GALE survey, reported in Table 4.7, indicate that students' scores increased for all five learning environment scales. These

results, portrayed graphically in Figure 4.1, which shows an increase in the mean values from pre-test to post-test for each of the scales.

Table 4.7 Pre–post differences: effect size and MANOVA results- perceptions of the learning environment (GALE Survey)

Learning Environment Scales	Average Item Mean		Average Item Standard Deviation		Differences	
	Pre	Post	Pre	Post	Effect Size	F
Relevance	3.84	3.99	0.72	0.88	0.19	6.54**
Shared Control	3.42	3.58	0.93	0.90	0.17	5.13*
Student Negotiation	3.48	3.62	0.96	0.87	0.15	4.26*
Collaboration	4.04	4.11	0.75	0.75	0.09	1.62
Integration	3.81	3.97	0.93	0.90	0.17	5.66**

N= 307 students in 19 classes
**p*<.05; ** *p*<.01

Because the MANOVA results, in terms of Wilk's lambda were statistically significant, the univariate analysis of variance (ANOVA) results were interpreted (see right hand column of Table 4.7). The ANOVA results indicate that the pre–post differences were statistically significant ($p<.05$) for four of the five scales, the exception being the collaboration scale. The effect sizes, calculated to provide an estimation of the magnitude of the differences, reported in Table 4.7, ranged from 0.15 standard deviations to 0.19 standard deviations for those scales with a statistical significance. These effect sizes, according to Cohen (1992) were considered to be medium in effect.

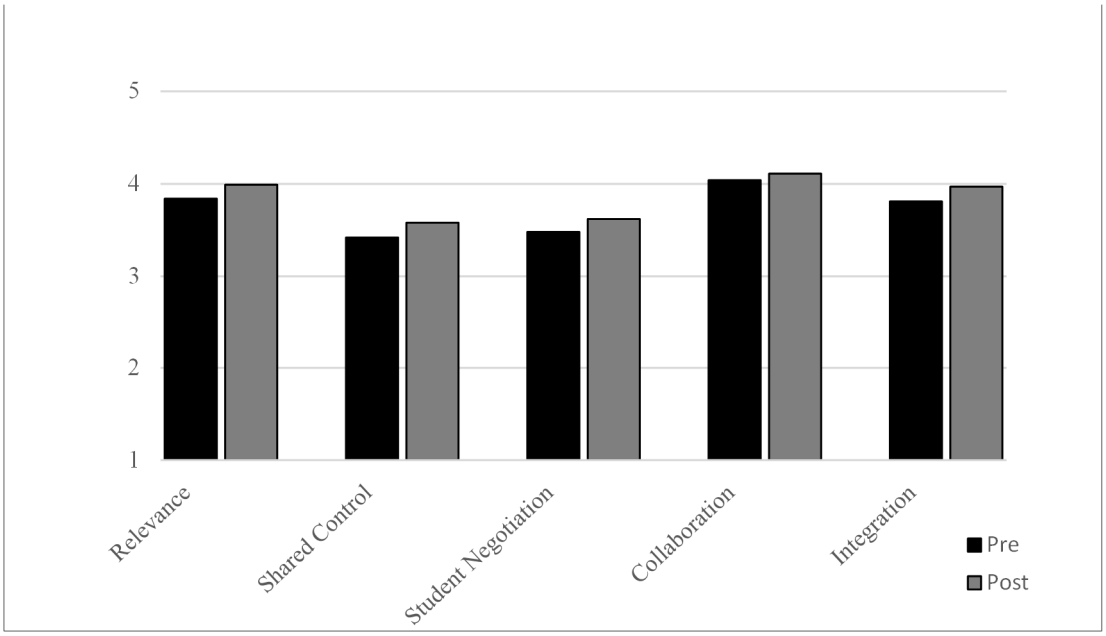

Figure 4.1 Average item mean for responses to the pre-test and post-test administrations of the GALE survey

4.3.2 Attitudes Towards Science Classes

The average item means for the two scales, reported in Table 4.8, indicates that students' scores increased from pre-test to post-test for both GATS scales. These results are portrayed graphically in Figure 4.2.

Table 4.8 Pre–post differences: effect size and MANOVA results- attitudes towards science classes (GATS Survey)

Attitudes Scales	Average Item Mean		Average Item Standard Deviation		Differences	
	Pre	Post	Pre	Post	Effect Size	F
Enjoyment	3.66	3.72	.97	.92	0.06	1.08
Task Value	3.85	3.92	.84	.84	0.08	1.01

N= 307 students in 19 classes
**p*<.05; ** *p*<.01

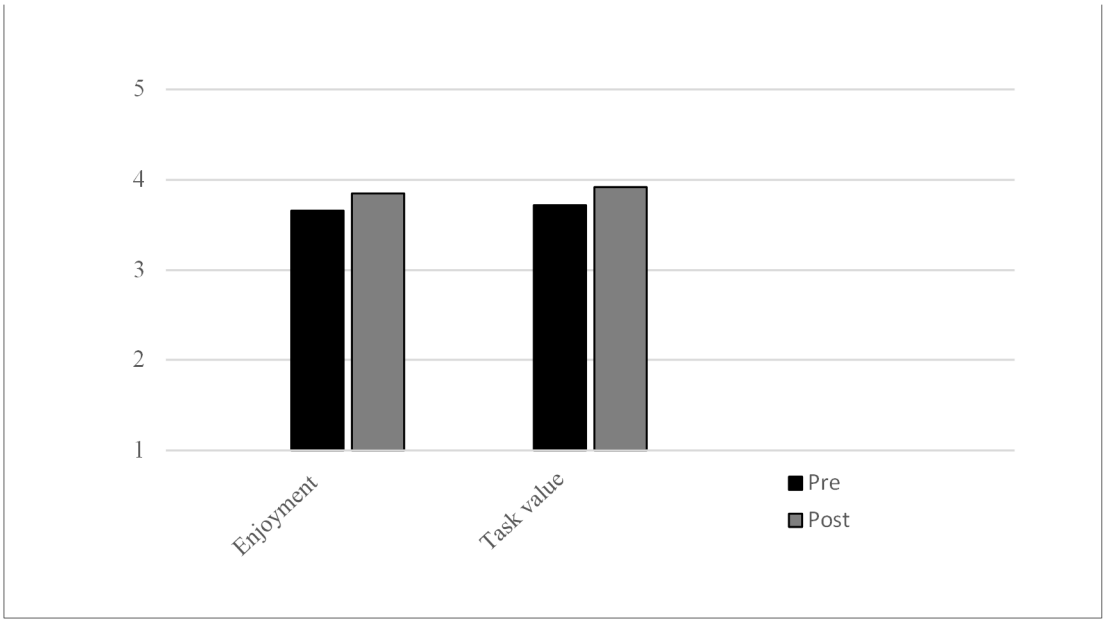

Figure 4.2 Average item mean for responses to the pre-test and post-test administrations of the GATS survey

The MANOVA results, in terms of Wilk's lambda were statistically non-significant, therefore, the univariate ANOVA results were not interpreted (although these are reported in the right hand column of Table 4.8). The effect sizes for both scales were also small, according to the scale devised by Cohen (1992), being 0.06 standard deviations for enjoyment and 0.08 standard deviations for task value.

4.3.3 Aspirations for Gardening and Healthier Eating

The average item means for the pre-test and post-test administrations of the AGHEN survey are provided in Table 4.9. The results indicate that there was a slight increase in students' scores (pre–post) for both the healthier eating and gardening scales. These results are depicted graphically in Figure 4.3, below.

The MANOVA results, in terms of Wilk's lambda, were statistically significant, therefore the univariate ANOVA results were interpreted (see right hand column of Table 4.9). The ANOVA results indicate that the pre–post differences were statistically significant ($p<.05$) only for the aspirations towards gardening scale. The effect size

for this scale was 0.11 standard deviations which is considered to be medium according to the scale devised by Cohen (1992).

Table 4.9 Pre–post differences: effect size and MANOVA results- aspirations to gardening and healthy eating (AGHEN Survey)

Aspirations Scale	Average Item Mean		Average Item Standard Deviation		Differences	
	Pre	Post	Pre	Post	Effect Size	F
Healthier eating	4.27	4.29	0.84	0.86	0.02	.06
Gardening	3.95	4.05	0.91	0.86	0.11	2.19*

N= 307 students in 19 classes *p<.05; ** p<.01

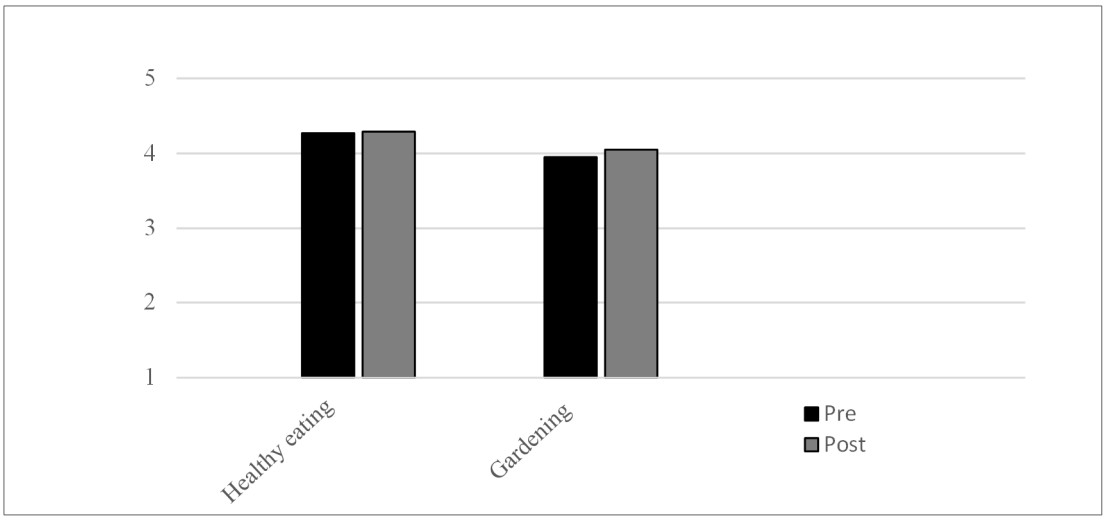

Figure 4.3 Average item mean for responses to the pre-test and post-test administrations of the AGHEN survey

4.3.4 Knowledge of Healthy Eating

The pre–post differences for the knowledge test are reported in Table 4.10. The average test scores indicate that there was an increase in scores from pre to post test. This difference is portrayed graphically in Figure 4.4.

Table 4.10 Pre–post differences: effect size and MANOVA results- knowledge of healthy eating

Scale	Average Item Mean		Average Item Standard Deviation		Differences	
	Pre	Post	Pre	Post	Effect Size	F
Knowledge	9.64	11.28	2.81	1.96	0.68	52.55**

N=307 students in 19 classes
** *p*<.01

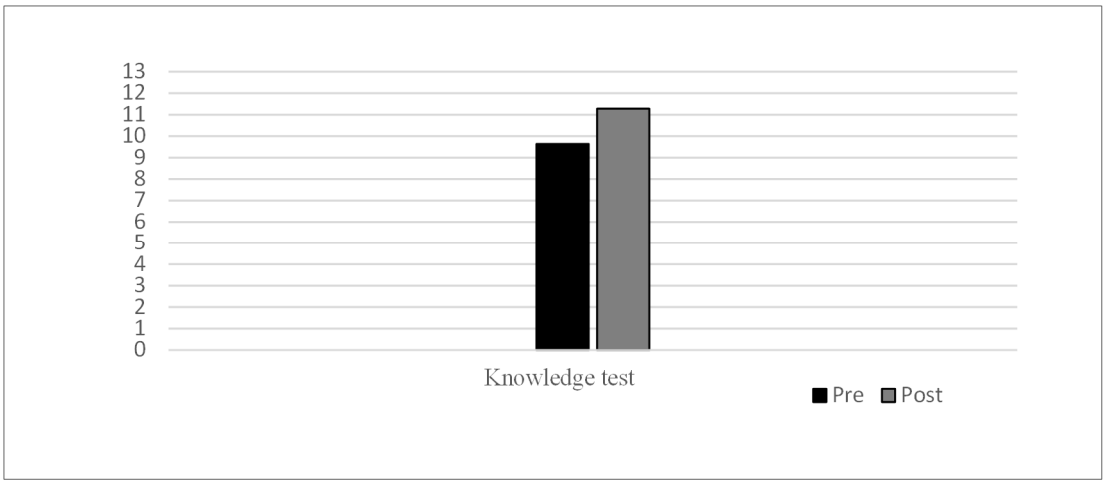

Figure 4.4 Average item mean for responses to the pre-test and post-test administrations of the knowledge test

The MANOVA results, in terms of Wilk's lambda were statistically significant, therefore, the univariate ANOVA result was interpreted (see right hand column of Table 4.10). The ANOVA result indicates that the pre–post differences for the results of the knowledge test were statistically significant ($p<.01$). The effect size, calculated to provide an estimation of the magnitude of the differences, reported in Table 4.10, was 0.68 standard deviations, and according to Cohen (1992), this can be considered to be large in effect.

4.4 Associations between Learning Environment and Attitudes, Aspirations and Knowledge

The third research objective sought to investigate the relationships between students' perceptions of the learning environment and their attitudes, aspirations, and knowledge

of healthy eating and nutrition. The results of the analysis reported in this section sought to:

Investigate the relationships between students' perceptions of the learning environment created during the garden project and their:

a. *Attitudes (enjoyment and task value);*
b. *Aspirations with respect to gardening and healthier eating practices; and*
c. *Knowledge of healthy eating and nutrition.*

As described in Chapter 3, simple correlation analyses (r) were used to provide information about the bivariate associations between each of the individual learning environment scales and attitudes in science (enjoyment and task value), aspirations towards gardening and healthier eating, and knowledge of healthy eating.

In addition, multiple regression analysis (R) (Gay, Mills, & Airaisian, 2006) was used to provide information relating to the multivariate associations between enjoyment of science, task value, aspirations to gardening, aspirations to healthier eating, and knowledge of healthy eating with all of the five learning environment scales. In this model, the five scales of the GALE survey (relevance, shared control, student negotiation, collaboration, and integration) were used as the independent variables, while the GATS scales (enjoyment and task value), aspirations scales (gardening and healthier eating), and the knowledge of healthy eating test, were set as the dependent variables. To identify which of the learning environment scales contributed most to the multivariate association when the other scales were mutually controlled, the standardised regression coefficients (β) were examined for each of the variables. The R squared values were also included for the multiple regression analyses, to measure the strengths of the relationships being examined. The results are reported below in terms of the relationships between the learning environment and students': attitudes (Section 4.4.1); aspirations (Section 4.4.2); and knowledge of healthy eating (Section 4.4.3).

4.4.1 Learning Environment – Attitude Relationships

The results of simple correlations, reported in Table 4.11, indicate that all of the five learning environment scales were statistically significantly (p<.01) and positively related to both attitude scales (enjoyment and task value). The strongest correlations were between relevance and task value (r=.53, p<.01), collaboration and task value (r=.52, p<.01), and integration and task value (r=.51, p<.01). These same three learning environment scales also showed the strongest associations with the enjoyment scale (integration, r=.44, p<.01; relevance, r=.41, p<.01; collaboration, r=.39, p<.01).

Table 4.11 Simple correlation analyses for relationships between the learning environment, attitudes, aspirations and knowledge with the individual as unit of analysis

Scale	Enjoyment	Task Value	Aspirations (Gardening)	Aspirations (Healthier eating)	Knowledge
	r	*r*	*r*	*r*	*r*
Relevance	.41**	.53**	.40**	.47**	.41**
Shared Control	.38**	.38**	.20*	.28**	.04
Student Negotiation	.25**	.36**	.26**	.32**	.15**
Collaboration	.39**	.52**	.44**	.65**	.25**
Integration	.44**	.51**	.41**	.43**	.22**

N= 263 students in 19 classes (matched pairs) pre and post
*p<.05 **p<.01

For the two attitude scales the multiple correlations (R), reported in Table 4.12, were positive and statistically significant (p<.05) for both, with values of .55 for enjoyment, and .67 for task value. Further, the R square value suggest that the learning environment scales, as a set, accounted for 31% of variance in students' enjoyment and 36% of variance in students' task value.

Table 4.12 Multiple regression analyses for relationships between the learning environment, attitudes, aspirations and knowledge– with the individual as unit of analysis

Scale	Enjoyment	Task Value	Aspirations (Gardening)	Aspirations (Healthier eating)	Knowledge
	β	*β*	*β*	*β*	*β*
Relevance	.15*	.22**	.15*	.02	.14*
Shared Control	.27**	.17**	.10	.06	.18**
Student Negotiation	.03	.02	.07	.08	.06
Collaboration	.22**	.30**	.15*	.19*	.17*
Integration	.07	.14*	.43**	.32**	.23**
Multiple Correlation (*R*)	.55*	.67*	.63**	.46**	.31**
R Square	.31	.36	.32	.21	.11

N= 263 students in 19 classes (matched pairs) pre and post
*p<.05 **p<.01
Multiple correlations (*R*), standardized regression (*β*)

The standardised regression coefficients, used to identify the influence of individual learning environment scales when the other scales were mutually controlled are also shown in Table 4.12. These indicated that, three of the five learning environment scales were independent predictors of enjoyment: relevance (p<.05); shared control (p<.01); and collaboration (p<.01). Further, four of the five learning environment scales were independent predictors of task value (p<.05): relevance; shared control; collaboration; and integration. Shared control was the strongest independent predictor of enjoyment (r=.27 at p<.01), whilst collaboration was the strongest independent predictor of task value (r=.30 at p<.01). One learning environment scale, student negotiation, was not an independent predictor of either enjoyment or task value.

4.4.2 Learning Environment – Aspirations Relationships

Simple correlations and multiple regression analysis were also used to examine the learning environment–aspiration relationships. The simple correlation results, reported in Table 4.11, indicate that all of the five learning environment scales were statistically

significantly related to both of the aspirations scales (gardening and healthier eating, $p<.05$).

The multiple correlations (R) between the set of learning environment scales and the aspirations scales, reported at the bottom of Table 4.12, was positive and statistically significant ($p<.01$) for both the aspirations to gardening scale ($R=.63$) and the aspirations to healthier eating scale ($R=.46$). The R square values, also reported at the bottom of Table 4.12, indicate that the learning environment scales account for 32% of the variance in aspirations for gardening scale and 21% of variance in the aspirations for healthier eating scale. These scores support the notion that the learning environment scales, as a set, had significant multivariate associations with students' aspirations towards keeping of gardens as well as towards healthier eating.

The standard regression coefficients (β), reported in Table 4.12, were interpreted to determine how much influence individual learning environment scales had on each of the aspiration scales when the other learning environment scales were mutually controlled. The results indicated that three of the five learning environment scales were statistically significant independent predictors of students' aspirations to gardening: integration ($p<.01$), collaboration ($p<.05$) and relevance ($p<.05$). Whereas two of the five learning environment scales were statistically significant and independent predictors of students' aspirations to healthier eating: integration ($p<.01$) and collaboration ($p<.05$).

4.4.3 Learning Environment – Knowledge Relationships

The results of the simple correlations, reported in Table 4.11, indicate that four of the five learning environment scales (the exception being for the shared control scale) were statistically significantly ($p<.01$) and positively related to students' knowledge of healthy eating: relevance, collaboration, integration and student negotiation. The multiple correlation (R) between the set of learning environment scales and the knowledge of healthy eating test results, reported in Table 4.12, was positively and statistically significant ($R=.31$, $p<.01$). Further, the R square indicates that the learning environment scales as a set accounts for 11% of the variance in student knowledge of healthy eating. This result indicates that the set of learning environment scales had

significant multivariate associations with students' knowledge of healthy eating and nutrition.

The standard regression coefficients (β), reported in the far right column of Table 4.12, indicate that four of the five learning environment scales (the exception being student negotiation) were statistically significant predictors of student test results: relevance ($p<.05$), shared control ($p<.01$), collaboration ($p<.05$), integration ($p<.01$), with only student negotiation having a non-significant influence on students' test results.

4.5 Chapter Summary

This chapter reported the results for the present study which sought to address three research objectives. First, to address Research Objective #1, evidence was provided to support the reliability and validity of the three perception surveys.

For the GALE survey, developed to assess students' perceptions of the learning environment, principal factor analysis with oblique rotation indicated that, 11 items did not meet the cut off criteria and were removed, leaving 24 items in five scales. The eigenvalues for the retained scales all met the criteria based on the Kaiser criterion (where factors are retained when eigenvalues are greater than or equal to one, Beavers et al, 2013). The total percentage of variance was 56.31% for the pre-test and 57.10% for the post-test. The Cronbach alpha coefficients for both the pre-test and post-test with both the individual and class mean as the unit of analysis all were above .70; well above the .50 cut-off guidelines suggested by George and Mallery (2003). These combined results provide evidence to support the validity and reliability of the final 24 item version of the GALE survey.

For the GATS survey, developed to assess students' attitudes (enjoyment and task value), the factor analysis resulted in four items being omitted from further analyses because of their unsatisfactory factor loadings. A total of 15 items in two scales were retained. The eigenvalues for the refined scales met the Kaiser criterion (Beavers et al, 2013), while the total percentage of variance was 60.67% for the pre-test and 58.01% for the post-test. Internal consistency reliabilities for both the pre-test and post-test with the individual and class mean as the unit of analysis were all above .80, providing

further evidence that the refined scales were both statistically reliable. These results provided evidence to support the validity and reliability of the refined 15-item version of the GATS survey.

The factor analysis results for the AGHEN survey, developed to assess students' aspirations, resulted in one scale (preferences to healthy eating) being omitted from further analysis. A further five items were omitted from the aspirations to healthier eating scale since these fell short of the criteria. The final AGHEN survey was made up of two scales with a total of 12 items. The eigenvalues for the retained scales all met the criteria based on the Kaiser criterion (Beavers et al, 2013). Additionally, the total percentage of variance was 60.05% for the pre-test and 58.32% for the post-test. Internal consistency reliabilities, for the pre-test and post-test and with the individual and class mean as the unit of analysis were all above .80, providing evidence that the refined scales were reliable. These combined results provide evidence to support the validity and reliability of the refined 12-item version of the AGHEN.

To address Research Objective #2, MANOVA was used to examine whether there were pre and post differences in terms of students' perceptions of the learning environment, attitudes, aspirations, and knowledge of healthy eating. The MANOVA results suggest that there were statistically significant ($p<.05$) pre–post differences for four of the five learning environment scales (assessed using the GALE). In all four cases, the scores increased. The effect sizes for these four scales ranged from 0.15 to 0.19 standard deviations, which is considered to be small in effect according to Cohen (1992). In terms of students' attitudes (enjoyment and task value), the MANOVA results suggest that the pre–post differences were non- significant for both scales of the GATS. In terms of aspirations towards gardening and towards healthier eating (measured using the AGHEN survey), the MANOVA results suggest that there were statistically significant pre–post differences ($p<.05$) for only the aspirations to gardening scale (but not for the aspirations to healthier eating scale). The score for this scale increased from pre to post test. The effect size for the aspirations to gardening scale was 0.11 standard deviations, which is considered to be medium according to Cohen (1992).

The MANOVA results also showed a statistically significant ($p<.01$) difference between the pre-test and post-test for knowledge of healthy eating. The results showed an increase in average test scores from pre-test to post-test. The effect size for the difference in scores was 0.68, which is considered to be large in effect according to Cohen (1992).

Finally, to address Research Objective #3, simple correlation and multiple regression analysis was used to examine whether relationships exist between students' perceptions of the learning environment (GALE scales) and the outcomes (attitudes, aspirations, knowledge of healthy eating). The results of the simple correlations suggest that all of the five learning environment GALE scales were statistically significantly ($p<.01$) and positively related to both attitude (GATS) scales (enjoyment and task value). The multiple correlation was positive and statistically significant ($p<.05$) for both scales. The standardised regression coefficient (beta values) indicated that student enjoyment was statistically significantly and positively related to relevance ($p<.05$), shared control ($p<.01$), and collaboration ($p<.01$). Further, the task value scale was statistically significantly and positively related ($p<.05$) to relevance, shared control, collaboration, and integration.

For students' aspirations, simple correlations indicated that all five learning environment (GALE) scales were statistically significantly ($p<.05$) and positively related to both aspirations (AGHEN) scales (gardening and healthier eating). The multiple correlation was positive and statistically significant for both scales ($p<.01$). The standardised regression coefficient (beta values) indicated that three learning environment scales were independent predictors of students' aspirations to gardening: integration ($p<.01$); collaboration ($p<.05$); and relevance ($p<.05$). Further, two learning environment (GALE) scales were independent predictors of students' aspirations to healthier eating: integration ($p<.01$); and collaboration ($p<.05$).

Finally, for the knowledge of healthy eating test, simple correlation indicated that four of the five learning environment scales (the exception being shared control) were statistically significantly ($p<.01$) and positively related to students' knowledge of healthy eating. The multiple regression was positively and statistically significant ($p<.01$). The standardised regression coefficient (beta values) indicated that four

learning environment scales were statistically significant independent predictors of students' knowledge of healthy eating: relevance ($p<.05$); shared control ($p<.01$); collaboration ($p<.05$); and integration ($p<.01$).

The next chapter, Chapter 5, provides a discussion of these findings.

Chapter 5

DISCUSSION AND CONCLUSIONS

5.1 Introduction

The aim of the study reported in this thesis was two-fold. First, the study sought to examine whether the use of an on-site school greenhouse/garden and associated activities led to improved learning environment perceptions, attitudes, aspirations and knowledge. To address this aim, a pre–post design involving the administration of three surveys (N=307) and a knowledge test (N=368) was used. In the eight months between the pre-test and post-test administrations, students were involved in a range of lessons and activities within the gardens. To examine the pre–post differences, multivariate analysis of variance (MANOVA) and effect sizes, using only matched pre–post responses, were calculated. To address the second aim, which examined whether students' perceptions of the learning environment created in the school garden was related to their outcomes (attitudes, aspirations and knowledge), simple correlation (r) and multiple regression (R) analyses were used.

In this chapter, a summary and discussion of the major findings is provided in Section 5.2. The chapter also reports on the limitations of the study, which are outlined in Section 5.3. The recommendations are summarised in Section 5.4. In Section 5.5, the significance of the research is described, and, in Section 5.6, some concluding remarks are provided.

5.2 Summary and Discussion of the Major Findings

The sections that follow summarise and discuss the major findings of the study. Section 5.2.1 summarises and discusses the findings relating to the evidence provided to support the reliability and validity of the surveys (Research Objective #1). Findings related to the pre–post garden differences in students' perceptions of the learning environment, attitudes towards science classes, aspirations towards gardening and healthier eating, and knowledge of healthy eating (Research Objective #2) are summarised and discussed in Section 5.2.2. Section 5.2.3 summarises and discusses the findings relating to the associations between the learning environment and

students' attitudes towards science classes, aspirations towards gardening and healthier eating, and knowledge of healthy eating and nutrition (Research Objective #3).

5.2.1 Research Objective One – Reliability and Validity of the Surveys

As a first step, evidence to support the validity and reliability of the three surveys (GALE, GATS and AGHEN) used to collect data for the present study, was provided to address Research Objective #1, which was:

To modify and validate three surveys for use with Cycle 2 students in Abu Dhabi, United Arab Emirates to assess students':

a. *Perceptions of the learning environment;*
b. *Attitudes towards science classes, and*
c. *Aspirations with respect to gardening and healthier eating practices.*

As outlined in Chapter 3 (Section 3.5.1), analysis of the data (*N*=441 students for the pre-test administration and *N*=336 students for post-test administration) included an examination of the factor structure, Eigenvalues, and internal consistency reliability. A summary and discussion is provided for the findings related to each of the three surveys: the GALE survey (Section 5.2.1.1); the GATS survey (Section 5.2.1.2); and the AGHEN survey (Section 5.2.1.3).

5.2.1.1 Gardening and the Learning Environment Instrument (GALE)

The Gardening and the Learning Environment (GALE) survey was developed for the purpose of this study to assess students' perceptions of the learning environment created in a garden setting. The scales of the GALE were drawn from three existing instruments, namely: the Constructivist Learning Environment Survey (CLES; Taylor et al, 1997); the What Is Happening In this Class? (WIHIC; Aldridge et al., 1999; Fraser et al., 1996); and the Science Laboratory Environment Inventory (SLEI; Fraser et al., 1995). The GALE was comprised of 35 items in six scales, these being: relevance, shared control, student negotiation, student involvement, collaboration, and integration. The evidence used to support the reliability and validity of the GALE, reported in Chapter 4, is summarised below.

- Of the original 35 items, 11 did not meet the criteria and were omitted from all further analyses. The remaining 24 items all loaded at least .30 on their own scale and less than .30 on the other scales.
- The internal consistency reliability (Cronbach alpha coefficient) for the remaining 24 items in five scales were above .71 for the individual as the unit of analysis (for both the pre-test and post-test). With the class mean as the unit of analysis, the Cronbach alpha coefficients were all above .6 for the pre-test and post-test, with the exception of one scale, which was .56 for the post-test. These results indicated that all five scales were within the accepted range, with the acceptable cut-off used as .50 (as suggested by George and Mallery, 2003).

These findings support the reliability and validity of the final GALE survey used in this study, and were consistent with the findings of past studies that have used the instruments from which the GALE was created. In particular, these results were in line with studies that have used the SLEI across many countries around the world (see for example, Fraser & McRobbie, 1995; Quek et al., 2005; Wong & Fraser, 1996) and the CLES when used in multiple locations and different languages (see for example Aldridge et al., 2000; Kim et al., 1999). The findings also are consistent with findings reported for the reliability and validity of, the WIHIC, one of the most commonly used of the learning environment instruments when used across different countries and in a large variety of languages (see for example Kim et al., 2000; Dorman, 2008; Aldridge et al., 2009; Fraser, 2012; Velayutham & Aldridge, 2013). The findings of the present study provide strong support for this newly developed learning environment survey, the GALE.

5.2.1.2 Gardening and Attitudes Towards Science Instrument (GATS)

The second instrument, the Gardening and Attitudes Towards Science survey (GATS), was used to assess students' attitudes towards their science classes, and included 19 items in two scales drawn from previously-developed surveys. One of the scales, enjoyment, was drawn from the Test of Science-Related Attitudes (TOSRA; Fraser, 1981); and the other, task value, was drawn from the Students' Adaptive Learning Engagement in Science (SALES; Velayutham et al., 2011). The evidence used to support the reliability and validity of the GATS is summarised below.

- Factor analysis indicated that four of the original 19 items were problematic and, therefore, omitted from further analysis. The remaining 15 items in two scales all loaded at .30 or higher on their own scale and less than .30 on the other scale.
- The internal consistency reliability of the two scales was above .8 for the pre-test and post-test with both the individual and class mean as the unit of analysis. These results suggested a high internal consistency reliability for both scales of the modified GATS.

These findings support the reliability and validity of the modified GATS survey, and are consistent with similar findings for the instruments from which the GATS was drawn. Past studies involving the enjoyment scale of the TOSRA have reported similar reliability results across numerous studies and in many countries (see for example, Telli et al., 2010; Long & Fraser, 2015; Navarro, Förster, González & González-Pose, 2016). Similarly, the results of this study support those of past studies that have used the task value scale of the SALES (see for example, Alzubaidi et al., 2016; Chipangura & Aldridge, 2017). Thus, these results provide support for the reliability of the GATS survey when used with this group of students.

5.2.1.3 Gardening and Healthy Eating and Nutrition Instrument (AGHEN)

The third survey, AGHEN, was used to assess students' aspirations towards gardening and healthier eating practices. Unlike the previous two surveys, the scales and items in the AGHEN were developed by the researcher. The AGHEN was made up of 30 items in three scales: aspirations towards healthier eating and nutrition; food preferences; and aspirations towards gardening. The evidence used to support the reliability and validity of the AGHEN survey is summarised below.

- Principal axis factor analysis with oblique rotation indicated that 18 of the original items, which included all of the items in the food preference scale, were problematic and were omitted from further analysis. The remaining 12 items all loaded at .30 or higher on their own scale and less than .30 on all other scales.
- The internal consistency reliability (Cronbach alpha coefficient) for the remaining two scales (with both the class mean and individual as the unit of

analysis), were all above .8 for the pre-test and post-test, indicating that the refined scales were reliable.

Given that the AGHEN was developed for the purpose of this study, there are no previous studies to compare these findings. However, the evidence to support the reliability and validity of the retained 12 items for two scales of the AGHEN survey, indicated that the factor analysis and internal consistency reliability results all were satisfactory. It is acknowledged that the large number of items that were lost during factor analysis could have been reduced had a pilot test been used prior to administering this survey.

The combined results of the analyses summarised in Section 5.2.1 provide evidence to support the validity and reliability of the three surveys used in the present study (GALE, GATS and AGHEN). The retained items in all three surveys loaded at .30 or higher on their own scale and less than .30 on all other scales in the principal axis factor analyses with oblique rotation. In all three surveys, the internal consistency reliability (Cronbach alpha coefficient) met the cut-off guidelines suggested by George and Mallery (2003). These findings suggest that the results obtained for the remaining research objectives can be interpreted with confidence.

5.2.2 Research Objective Two – Pre–Post Differences

This section summarises and discusses the results of the second research objective which was:

To investigate the impact of a school garden project on students':

a. *Perceptions of the learning environment;*
b. *Attitudes towards science classes;*
c. *Aspirations with respect to gardening and healthier eating practices; and*
d. *Knowledge of healthy eating and nutrition.*

To examine pre–post differences, a multivariate analysis of variance (MANOVA) was used, in addition to effect sizes. The sample sizes for the analysis included only students who were present for two pre-test and post-test administrations. In this section the results for the pre–post differences are reported for students' perceptions of: the learning environment (Section 5.2.2.1); attitudes towards science classes (Section

5.2.2.2); aspirations towards gardening and healthier eating practices (Section 5.2.2.3); and knowledge of healthy eating and nutrition (Section 5.2.2.4).

5.2.2.1 Pre–post differences in learning environment perceptions

The pre–post differences in students' perceptions of the learning environment (assessed using the GALE) are summarised below.

- The average item means for responses indicated that students' scores were higher for the post-test than the pre-test for all five GALE scales.
- The MANOVA results indicated that the pre–post differences were statistically significant ($p<.05$) for four of the five scales, these being relevance, shared control, student negotiation, and integration.
- The effect sizes for the pre–post differences ranged from 0.15 to 0.19 standard deviations for different GALE scales. These effect sizes, were considered to be medium in effect, based on Cohen's (1992) rule of thumb.

The changes in mean item scores suggest that, after participating in the gardens, students viewed the learning environment more positively. As outlined in Chapter 2, there is a scarcity of research that has been published in relation to school gardens and their effect on students' learning environment perceptions. The results, however, are congruent with other studies that have used learning environment surveys as a source of process criterion (see for example, Arnon, Mohamed & Daher, 2019; Lightburn & Fraser, 2007; Nix et al., 2005; Soebari & Aldridge, 2015). In these studies, changes to the way in which a subject was taught also brought about changes to the way in which the students' perceived the learning environment. The study presented in this thesis, which reports an innovation in science (the use of gardens), corroborates these past in which students' perceive the learning environment more positively (see for example, Nix et al., 2005; Wolf & Fraser, 2008).

Whilst four of the five scale showed statistically significant improvements in perceptions of the learning environment, the results for the collaboration scale was not statistically significant. This result was unexpected given that much of the work in the gardens involved students working with peers in teams. This finding is not consistent with other studies that have found that pedagogies involving more group work improve

students' perceptions of similar scales (e.g., cooperation; see for example, Fernandez-Rio, Sanz, Fernandez-Cando & Santos, 2017; Hanze & Berger, 2007; Premo, Cavagnetto, Davis, & Brickman, 2018).

Despite the anomaly regarding the collaboration scale, overall, students' perceptions of important learning environment dimensions improved with the use of gardens. Importantly, the effect size for those scales with statistically significant changes ranged from 0.15 to 0.19. Given the context in which these changes took place, these effect sizes are noteworthy. It is recommended, therefore, that science teachers wishing to improve students' perceptions of the learning environment consider including the use of gardens as part of the teaching and learning (Recommendation #1).

5.2.2.2 Pre–post differences on attitudes towards science

The pre–post differences in students' attitudes towards science classes (assessed using the GATS) are summarised below.

- The average item means indicated that there was an increase from pre-test to post-test for both GATS scales (enjoyment and task value).
- However, the MANOVA results indicated that pre–post differences were not significant for either of the GATS scales.
- Further, the effect sizes for the pre–post differences were considered small in effect, according to Cohen's (1992) criteria, for both scales.

The pre–post average item means suggest that after participating in the gardens, students responded slightly more positively to items in the enjoyment and task value scales. However, the MANOVA results (reported in 5.2.2.1) indicated that neither of the changes were statistically significant. These findings contradict the findings of past research which suggests that the use of school gardens has a positive impact on students' attitudes (see for example studies by, Alexander et al., 1995; Graham et al., 2005; Klemmer et al., 2005; Lohr & Person-Mims, 2005; Passy, 2014; Skelly & Zajicek, 1998; Waliczek et al., 2001). Whilst it is likely that many of the studies will have used different methods to assess students' attitudes and, in some cases the studies were qualitative, the lack of difference in students' attitudes was unexpected. Given the contradiction between the results of this study and those of previous studies, all of

which were carried out in Western settings, it is recommended, that future research consider including the collection of information that examines cultural factors that influence students' attitudes (Recommendation #2).

5.2.2.3 Pre–post differences on aspirations towards gardening and healthier eating

The pre–post difference in students' aspirations towards gardening and towards healthier eating (as assessed using the AGHEN) are summarised below.

- The average item means indicated a slight pre–post increase for both scales.
- The MANOVA results indicated that pre–post differences were statistically significant ($p<.05$) only for the aspirations towards gardening scale.
- The effect sizes for the pre–post differences was small (0.02 standard deviations) for the aspirations towards healthier eating scale and medium in effect (0.11 standard deviations) for the aspirations towards gardening scale, according to Cohen's (1992) criteria.

The pre–post results suggest that, after participating in the gardens, students were more likely to aspire to working in gardens in the future. This is an important outcome given that past studies have found that school gardens can: improve appreciation of, and linkages with, nature (Johnson, 2013; Klemmer et al., 2005; Lohr & Person-Mims, 2005; Skelly & Zajicek, 1998); increase appreciation and value of their school garden (Alexander et al., 1995); increase students' sense of care about vegetation and the importance of plants in human life (Patrick & Tunnicliffe, 2011). However, none of these studies specifically focussed on students' aspirations towards gardening. Given the scarcity of literature relating to the impact of school gardens on students' aspirations towards further gardening, it is recommended that future studies related to student aspirations might include a longer timeframe to determine the effects of the implementation of gardens in students' homes, and on food selection after the programme has finished (Recommendation #3).

Unlike students' aspirations to gardening, the results suggested that the change in students' aspirations towards healthier eating was not significant. This outcome was unexpected, since it was anticipated that students would aspire to eat healthier foods (fruits and vegetables) once they experienced the benefits of growing and eating foods

from a garden. This finding also contradicted the findings of past research which report that school gardens helped students to make better choices about their diet (Anzman et al., 2010; Dirks & Orvis, 2005; Herman & Parker, 2006; Huys et al., 2017; Johnson, 2013; Kohlstedt, 2008; Ogden et al., 2008; Patrick & Tunnicliffe, 2011; Randler & Bogner, 2006; Ratcliffe et al., 2011; Skinner et al., 2002; Tims, 2003; Wells et al., 2015; Yu, 2012).

The difference in findings from past research could be attributed to different angles of research. For example, while the study in this thesis examined students' aspirations towards healthier eating, other studies have focused on food choice and eating habits (Anzman et al., 2010; Johnson, 2013; Patrick & Tunnicliffe, 2011; Yu, 2012); actual consumption of fruits and vegetables (Hermann & Parker, 2006); awareness and knowledge of diet and nutrition (Wells et al., 2015). Given that none of the studies were conducted in the Middle East, another reason for the difference in findings could be attributed to cultural and environmental differences. Additionally, none of the past studies were conducted in a desert environment like Abu Dhabi, where a diversity of natural vegetation is not a normal part of students' daily surroundings. Given the high obesity rates reported in the UAE, further research is recommended to determine whether working in the school gardens effects students' food choices (Recommendation #4).

5.2.2.4 Pre–post differences on student knowledge of healthy eating

The pre–post difference in students' knowledge of healthy eating and nutrition (as assessed using the knowledge test) are summarised below.

- The average item means for the knowledge test indicated that there was a pre–post increase in students' scores.
- The MANOVA results indicated that pre–post difference in scores were statistically significant ($p<.01$).
- The effect size (0.68 standard deviations) for the pre–post differences for the knowledge test can be considered large in effect (based on Cohen's (1992) criteria).

The results indicate that, after participating in the gardens, there were significant changes to students' knowledge of healthy eating and nutrition. Additionally, the large effect size reported for the pre–post differences, indicates the educational importance of the impact of the gardens on students' knowledge of healthy eating and nutrition.

A review of literature indicated that there were no other studies that focused on the impact of school gardens on students' knowledge of nutrition and healthy eating. Although other studies focused on science knowledge achievement, it was not possible to make a direct comparison with these studies. However, if we consider the overall test results, the findings of this study corroborate past studies that indicate that students test results improved after garden use (see for example, Dirks & Orvis, 2005; Klemmer et al., 2005; Mabie & Baker,1996; Pascoe & Wyatt-Smith, 2013; Smith & Motsenbocker, 2005; Wells et al., 2015; Williams, Brule, Kelley & Skinner, 2018). It is recommended that further studies examine the changes on students' knowledge of healthy eating and nutrition pre and post school garden use, thus filling this void in research on the subject (Recommendation #5).

It is interesting to note that, although students' knowledge of healthy eating and nutrition improved, their aspirations to eat a more healthy diet did not. That is, students may know that fresh fruits and vegetables grown in the gardens are healthier, but they would still prefer to eat a less healthy diet (e.g. have a preference for 'junk' or fast foods). It is important, therefore, that future studies focus on how to improve students' aspirations for healthier eating (Recommendation #6).

5.2.3 Research Objective Three – Environment–Outcome Relations

This section summarises and discusses the results of the third research objective which was:

To investigate the relationships between students' perceptions of the learning environment created during the garden project and their:

a. *Attitudes (enjoyment and task value);*
b. *Aspirations with respect to gardening and healthier eating practices; and*
c. *Knowledge of healthy eating and nutrition.*

To examine these associations, simple correlation (*r*) and multiple regression (*R*) analyses were used. For these analyses, only data from students who responded to all three perception surveys and the knowledge test, for the post-test administration, were used, providing a sample of 263 students. The major findings are summarised and discussed for the associations between students' perceptions of the learning environment and their: attitudes (Section 5.2.3.1): aspirations (Section 5.2.3.2): and knowledge (Section 5.2.3.3).

5.2.3.1 Environment – Attitude Relationships

The results of the analyses for associations between the learning environment and students' attitudes are summarised below.

- The simple correlation results indicated that all five learning environment scales were statistically significantly ($p<.01$) related to both attitude scales (enjoyment and task value).
- The multiple correlations (*R*) were positive and statistically significant ($p<.05$) for both enjoyment ($R=.55$) and task value ($R=.67$).
- Regression coefficients revealed statistically significant relationships for both attitude scales, with positive and statistically significant results found between:
    - Enjoyment and:
        - relevance ($p<.05$);
        - shared control ($p<.01$); and
        - collaboration ($p<.01$).
    - Task value and:
        - relevance ($p<.05$);
        - shared control ($p<.05$);
        - collaboration ($p<.05$); and
        - integration ($p<.05$).

These results provide evidence to suggest that there were positive associations between the learning environment and student attitudes, which replicates other studies with similar findings (as reviewed by Fraser, 2007 and Zandvliet & Fraser, 2019). Given that improving students' attitudes towards science is one of the aims of school reform

(such as the reform which was taking place in Abu Dhabi; Abu Dhabi Education Council, 2010; 2012), these findings could be useful to a range of stakeholders. In particular, teachers wishing to improve students' attitudes towards science learning, might consider focusing on improving these learning environment elements (relevance, shared control, collaboration, and integration) (Recommendation #7).

5.2.3.2 Environment – Aspirations Relationships

The results of the analyses for associations between the learning environment and students' aspirations towards gardening and towards healthier eating are summarised and discussed below.

- The simple correlation results indicated that all five learning environment scales were statistically significantly ($p<.05$) related to both aspirations scales (healthier eating and gardening).
- The multiple correlations (R) were positive and statistically significant ($p<.01$) for both the aspiration to gardening scale ($R=.63$) and the aspirations to healthier eating scale ($R=.46$).
- Interpretation of the beta values indicated positive and statistically significant relationships for:
    - Aspirations to gardening and:
        - integration ($p<.01$);
        - collaboration ($p<.05$); and
        - relevance ($p<.05$).
    - Aspirations to healthier eating and:
        - integration ($p<.01$); and
        - collaboration ($p<.05$).

These results provide evidence to suggest that the learning environment had significant multivariate associations with students' aspirations towards healthier eating as well as towards keeping of gardens. Although there is a void of literature on studies that have specifically examined the associations between learning environment in a school garden and aspirations to gardening and to healthier eating, some findings from studies that have found that involvement in school gardens has positive impacts on knowledge of healthy eating are included in the next section. Given the findings of positive

associations between the learning environment and aspirations of students towards gardening and towards healthier eating, teachers wishing to improve their students' aspirations towards gardening might consider focusing on providing lessons that are inclusive of these learning environment elements (integration, collaboration, relevance) (Recommendation #8).

5.2.3.3 Environment – Knowledge Relationships

The results of the analyses for associations between the learning environment and students' knowledge of healthy eating are summarised and discussed below.

- The results of the simple correlation indicated that four of the five learning environment scales (relevance, collaboration, integration, student negotiation) were statistically significantly ($p<.01$) and positively related to students' knowledge of healthy eating.
- The multiple correlation (R) between the set of learning environment scales and the knowledge test results was positively and statistically significant ($R= .31$, $p<.01$).
- The standard regression coefficients (β) results indicated that four of the five learning environment scales were statistically significant independent predictors of students' test scores: relevance ($p<.05$), shared control ($p<.01$), collaboration ($p<.05$), and integration ($p<.01$).

These results provide evidence to suggest that the learning environment created by the school gardens was strongly related to students' knowledge of healthy eating and nutrition. That is, the more positively students viewed the learning environment the better their test scores with respect to their knowledge of healthy eating. This finding replicates the findings of studies that have examined the relationship between the use of gardens and students' knowledge of nutrition (see for example, Anzman et al., 2010; Herman & Parker, 2006; Kohlstedt, 2008; Ogden et al., 2008; Randler & Bogner, 2006; Ratcliffe et. al., 2011; Skinner et al., 2002; Tims, 2003; Wells et al., 2015; Yu, 2012).

To the best of the researchers' knowledge, there are no other studies that have examined associations between students' perceptions of the learning environment created during the use of gardens and their achievement. However, there is much past research that suggests that the learning environment is an important factor in students' achievement (see for example: Al-Qahtani, 2015; Allen & Fraser, 2007; Aluri & Fraser, 2019; Khine et al., 2018; Malik & Rizvi, 2018; Robinson & Fraser, 2013; Wolf & Fraser, 2008). In particular, past research related to science classes has found a positive relationship between students' perceptions of the learning environment and their achievement outcomes (see for example, Al-Qahtani, 2015; Boz et al., 2016; Khine et al., 2018; Robinson & Fraser, 2013). Given the findings reported in this thesis, it would appear that using gardens could indeed improve the learning environment and, therefore, student achievement. The lack of literature related to the impact of school gardens on student achievement paves the way for further research related to associations between the learning environment and achievement outcomes other than only knowledge of healthy eating (Recommendation #9).

As with the sparsity of literature related to associations between the learning environment and achievement in relation to school gardens, when comparing the overall findings of the associations between the learning environment and students' attitudes, aspirations and knowledge, there has also been a shortage of studies that have focused more generally on student outcome relationships with learning environments in a school garden setting. In fact, a review of literature on school gardens research found only one other study that examined the use of school gardens and the learning environment. The study, by Cutter-Mackenzie (2009), was qualitative in nature and examined how the use of gardens provided "…a medium (or space) for slow and experientially driven pedagogies, allowing opportunities for intercultural and environmental learning experiences…". The results of this study found that the garden provided "a space for improved cultural awareness and sensitivity among the students and teachers". The scarcity of literature related to school gardens and its impact on student outcomes, highlighted in Chapter 2 as well as in Ozer's (2007) review of "small literature", makes it difficult to compare the results of this study with past findings. However, in Ozer's (2007) review, he identifies research findings related to relationships between gardens and student outcomes including improvements in achievement, health and nutrition, parent involvement, school environments, and

school bonding and attachment. The lack of research related to school gardens and their impact on student outcomes, and the positive findings presented in this study, pave the way for further research that examines whether the positive findings presented in this study hold true of outcomes in other science domains (for example, biology) (Recommendation #10).

5.3 Limitations of the Research

Although every effort was made to ensure the accuracy and validity of the research, there were a number of limitations in this study that must be considered when interpreting the results. This section acknowledges and discusses these limitations.

With respect to the sample, there were a number of limitations. First, although still relatively large, the sample size was smaller than anticipated, particularly with respect to the analyses related to achievement. As a result of the timing of the second round of surveys (and of term) and the subsequent large number of absentees, of the 750 students in 19 classes, only 263 students responded to all three surveys and the knowledge tests for both the pre-test and post-test administrations. A larger sample would have allowed for more powerful statistics (particularly with respect to the validation of the surveys). It is recommended, therefore, that future studies include a larger sample of students (Recommendation #11).

It is acknowledged that the absence of a pilot test of the surveys was a limitation to the study. Pilot testing would have provided useful information which could have been used to enhance the outcomes of the surveys. It is recommended that future studies, therefore, include a pilot test of the surveys used for data collection (Recommendation #12).

A limitation of the sample was that it was comprised only of boys. Although it was outside of the scope to include an all-female school (due to restricted access for the male researcher), the generalisation of results to female students should be made with caution. To further examine the benefits of gardens to students, it is recommended that future studies include both all-male and all-female classes and/or co-educational classes to increase generalisability of the findings (Recommendation #13).

A further limitation to the sample was that the study was carried out in only one school. Further, the school was located within Abu Dhabi city, where socioeconomic standards are generally higher than most schools located in regional areas further from the city. Therefore, the findings of the study should be interpreted and generalised to other schools in other settings with caution. It is recommended that future research related to the benefits of school gardens in Abu Dhabi include both inner city schools as well as schools in regional areas (Recommendation #14).

The exploratory nature of the study leant itself to the collection of only quantitative data. It should be noted, therefore, that causal explanations were not provided. Although, given the scope of the study, it was neither practical nor possible to include the collection of qualitative data, it is acknowledged that its inclusion would have provided further insights into students' perceptions. It is recommended, therefore, that future research combine the strengths of both quantitative and qualitative approaches to provide causal explanations and deeper understanding of the relationships between the variables (Recommendation #15).

Although the study included a large sample size (N=441) in 19 classes, convenience, rather than probability, sampling was used. Given that this is the case, care should be taken when generalising the findings of this study to larger or different populations. It is recommended, therefore, that future studies involve probability sampling to ensure that the findings are more generalizable (Recommendation #16).

Finally, although the study examined a number of outcomes with respect to the use of gardens, the knowledge component was relatively narrow (knowledge of healthy eating). Given the obesity rate in the UAE and the need to educate students about the benefits of eating a healthy diet, it is recommended that future studies include an examination of the impacts of a wider range of outcomes related to diet (Recommendation #17).

5.4 Summary of Recommendations

The recommendations, outlined above, are summarised here.

Recommendation #1: Given that the findings indicated that use of gardens resulted in improved student perceptions to their learning environment, it is recommended that science teachers wishing to improve students' perceptions of the learning environment include the use of school gardens as part of the teaching and learning.

Recommendation #2: Given the contradiction between the results of this study and those of previous studies, all of which were carried out in Western settings, it is recommended, that future research consider including the collection of information that examines cultural factors that influence students' attitudes.

Recommendation #3: Given that the findings revealed that students' aspirations towards future gardening improved, to determine the effects of the implementation of gardens in students' homes after the programme has finished, it is recommended that future studies include a longer timeframe.

Recommendation #4: Given the obesity rates reported in the UAE, it is recommended that future studies examine the impacts of school gardens on students' actual food choices.

Recommendation #5: With the lack of research related to the impact of school gardens on students' knowledge of healthy eating, it is recommended that future studies examine the changes to students' knowledge of healthy eating and nutrition as a result of school garden use.

Recommendation #6: Given that the findings indicated that students' aspirations to eat healthier foods did not improve after using the

gardens, it is recommended that future studies examine methods to improve these.

Recommendation #7: Since strong relationships were found between the learning environment and student attitudes towards science classes, teachers might consider focusing on improving the learning environment to improve students' attitudes.

Recommendation #8: Given that strong relationships between the learning environment and students' aspirations towards gardening were found, teachers might consider providing lessons that are inclusive of these learning environment elements (integration, collaboration, relevance).

Recommendation #9: Given the positive relationships found between the learning environment and student outcomes, and the lack of research relevant to this, to further strengthen the findings presented in this study, it is recommended that future studies examine the relationships between the learning environment created in the garden and other achievement outcomes.

Recommendation #10: Given that the learning environment created in the school garden had a positive impact on student outcomes, and with a large void in research related to this topic area, it is recommended that future studies examine whether the findings of this study are replicated in other science domains (for example, biology).

Recommendation #11: Since this study took place in one school with a defined number of students, it is recommended that future studies include a larger sample (both in terms of student sample

size, as well as number of schools) to increase generalisability of the findings.

Recommendation #12: Given that only a simple technical trial was conducted on the surveys used in this study, it is recommended that future studies include a pilot test of the surveys so as to enhance the quality of the surveys being used.

Recommendation #13: Given this study was conducted in an all-male school, to increase the generalisability of the findings, it is recommended that future studies include both all-male and all-female classes and/or co-educational classes.

Recommendation #14: Given that this study took place in an Abu Dhabi inner city school, and with likely different socio-economic and educational standards in some regional areas, to increase generalisability of the findings and to further strengthen the validity and reliability of the instruments used, it is recommended that future studies include both inner city and regional schools.

Recommendation #15: To provide a deeper understanding and causal explanations, it is recommended that future studies on school gardens include qualitative information.

Recommendation #16: Given that the study involved a convenient sample only, it is recommended that future studies include the use of probability sampling for more accuracy when comparing the findings to larger populations.

Recommendation #17: Given the relatively narrow knowledge outcomes examined in the knowledge test, to provide a broader

perspective of findings, it is recommended that future studies include a wider range of outcomes related to diet.

5.5 Significance of the Research

The research presented in this thesis has extended the field of learning environment research. It is one of the first studies (if not the only study) of its kind to examine the impacts of school gardens on students' learning environment perceptions, attitudes, aspirations, and knowledge of healthy eating, and the relationships that exist between these outcomes, in the context of Abu Dhabi, United Arab Emirates. As such, the study fills a void in the literature, and provides impetus for further research in this area, particularly in the context of Abu Dhabi.

Methodologically, the study provides future researchers with three newly-developed, valid and reliable instruments that can be used for assessing the impacts of schools gardens on: students' perceptions of the learning environment (the GALE survey); students' attitudes towards science classes (the GATS survey); and students' aspirations towards gardening and towards healthier eating (the AGHEN survey). These instruments are available for use in future studies involving the implementation of school gardens.

The results of the study will be of significance to a number of stakeholders, including the United Arab Emirates Ministry of Education (MOE), which now oversees the responsibilities of the Abu Dhabi Department of Education and Knowledge (ADEK). The results of the study provide evidence to support the benefits of implementing school gardens, and for incorporating school garden activities in the science classroom and beyond. For example, the study could provide evidence to curriculum developers of the benefits of incorporating school gardens and garden activities into the science curriculum. At the school level, the study provides evidence to administrators and teachers of the benefits of having an on-site school garden to use in science lessons (and perhaps for other uses outside of science lessons).

The findings add to the literature base, supporting the notion that school gardens, when implemented in extreme climatic conditions, provide benefits to students. Given the benefits of such programs to students in Abu Dhabi reported in this study, policy makers, curriculum developers and teachers could use these findings to assist in justifying the incorporation of school gardens in science learning programs.

The findings, which indicated strong and positive associations between the learning environment and various student outcomes, could benefit teachers wishing to improve student outcomes. In particular, the results, which provide strong support for the positive relationship between students' perceptions of the learning environment and their test achievement could be used to improve the learning environment in ways that improve student outcomes in science.

The results of the study could be of significance to the United Nations Food and Agricultural Organisation (FAO) who have initiated school 'gardens projects' to promote simple planting practices to encourage healthy eating and student interest in gardening practices. The results of the present study, which indicated that the use of gardens in science lessons promoted aspirations towards gardening in the future could support the work of the FAO, as this is in line with the aims of the FAO gardens project. Additionally, the findings provide evidence of increased student knowledge of healthy eating and nutrition after using the school gardens, which might also be of significance to the FAO as it supports one of aims of the FAO garden project.

The result of this study, which indicated that students continued to aspire to gardening after having worked in the school gardens, could be of significance to health authorities and organisations in the UAE, in their attempt to encourage citizens to improve their nutrition by eating fresh foods (as well as to purchase fresh foods that they may now be more familiar with as a result of the gardens). Additionally, these findings could benefit health authorities in the UAE, as well as parents and the general community, due to the increase in knowledge of healthy eating and nutrition demonstrated by students after using the school gardens. Although more research is needed in this area, this finding supports the notion that school gardens could have a positive influence on the eating habits of school students, particularly those in urban areas such as Abu Dhabi city. Given that students living in a city such as Abu Dhabi encounter mostly

fast foods, processed foods, frozen foods and junk foods (Ukonu, 2016), this finding could support the attempts of the health authorities to promote healthier eating in Abu Dhabi (and other areas), particularly given the increasing rates of diabetes and obesity among UAE citizens (Sulaiman, et al., 2017).

5.6 Concluding Remarks

The use of gardens in schools provides educators with an environment outside of the classroom where students can learn, affording a space where students can undertake hands-on activities, admire the aesthetics of a garden, and grow foods. In the study reported in this thesis, the school garden was used as a space for science lessons, in which students participated in gardening activities aligned with the science curriculum. A pre–post design was used to provide information about whether exposure to the gardens improved students' perceptions of the learning environment and a range of outcomes.

The findings of the study revealed that, after having participated in the school gardens for eight months, students reported positive changes in their learning environment perceptions, aspirations towards gardening and their knowledge of healthy eating and nutrition. Furthermore, the findings provided evidence to support the strong, positive, relationships between students' perceptions of the learning environment created in the garden and these outcomes. Aside from providing future researchers with a set of validated instruments suitable for assessing the impacts of gardens on student outcomes, the study also extends the field of learning environment research, particularly in the context of school gardens. The study paves the way for a multitude of future research on school gardens and student outcomes, and of the benefits of implementing an on-site garden in schools, not just in Abu Dhabi, but in schools across the globe. The results of the study support the use of school gardens, as an alternative learning environment to the regular classroom environment, to improve a range of cognitive and affective outcomes.

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Appendix 1

APPROVAL FOR USE OF DATA FROM DR BARRY FRASER

RE: Permission to use content

Getting too much email? Unsubscribe

BF

Barry Fraser <[redacted]>
Sat 31/08/2019 15:55
William Baini; Jill Aldridge <[redacted]>

William

Fine and good luck with your thesis.

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Curtin University

From: William Baini [mailto:[redacted]]
Sent: Saturday, 31 August 2019 7:14 PM
To: Barry Fraser
Cc: Jill Aldridge; [redacted]
Subject: Permission to use content

Dear Prof Fraser,

I hope you are well.

I am currently in the final stages of my Masters thesis on measuring the impacts of school gardens on student outcomes in a school in Abu Dhabi. In my Chapter 2 literature review, I make reference to your 2012 review on learning environments. I am requesting permission from you to use or modify one of the tables in your literature review, to include the relevant information that relates to my study. My research supervisor is Dr Jill Aldridge (also copied into this email), and she made the suggestion that I contact you for permission. Your support is much appreciated.

Best regards
William Baini

Appendix 2

GARDENING AND THE LEARNING ENVIRONMENT (GALE) SURVEY[1]

[1] Three of the scales in the GALE survey, personal relevance, shared control, and student negotiation, were drawn from the Constructivist Learning Environment Survey (CLES), developed by Taylor et al. (1997).

Relevance		Strongly Disagree غير موافق بشدة	Disagree غير موافق	Uncertain غير متأكد	Agree موافق	Strongly Agree موافق بشدة
1.	I learn about the world outside of school أتعلم عن العالم الموجود خارج المدرسة	1	2	3	4	5
2.	I learn how science can be a part of my out-of-school life أتعلم كيف يكون علم العلوم جزء من حياتي خارج المدرسة	1	2	3	4	5
3.	I learn interesting things about the world outside of school أتعلم أشياء ممتعة عن العالم خارج المدرسة	1	2	3	4	5
4.	Working in a garden helps me to learn about the world outside my classroom. يساعدني عملي في المزرعة في التعرف على العالم خارج غرفة الفصل الدراسي	1	2	3	4	5
5.	What I learn in science is relevant to my out-of- school life. ما أتعلمه في مجال العلوم متعلق ويفيد حياتي خارج المدرسة	1	2	3	4	5
6.	I enjoy learning about things in the world outside of school اجد متعة في تعلم أشياء عن العالم خارج المدرسة	1	2	3	4	5
Shared Control						
7.	I help the teacher to plan what I'm going to learn in science أساعد المدرس في تخطيط ما أريد أن أتعلمهفي العلوم	1	2	3	4	5
8.	I help the teacher to decide which activities I do in science classes أساعد المدرس لكي يقرر أي أنشطة أقوم بها في صفوفمادة العلوم	1	2	3	4	5
9.	I help the teacher to assess my learning in science. أساعد أستاذي في تقييم ما أتعلمه في مادة العلوم	1	2	3	4	5
10.	I help the teacher to plan activities in science أساعد المدرس في تخطيط الأنشطة التي تنفذ في مادة العلوم	1	2	3	4	5

Student Negotiation		Strongly Disagree غير موافق بشدة	Disagree غير موافق	Uncertain غير متأكد	Agree موافق	Strongly Agree موافق بشدة
11.	I get the chance to talk to other students in science أحظى بفرصة التحدث مع الطلاب الأخرين في حصة العلوم	1	2	3	4	5
12.	I talk with other students to solve problems in science class أتحدث مع الطلاب الأخرين لحل المشاكل في حصة العلوم	1	2	3	4	5
13.	I explain my ideas and understandings to other students. أشرح أفكاري و مفاهيمي للطلاب الأخرين	1	2	3	4	5
14.	Other students explain their ideas to me. يشرح لي الطلاب الآخرين أفكارهم	1	2	3	4	5
Student Involvement						
15.	I am involved in class discussions. أنا اشارك في المناقشات التي تحصل في الفصل	1	2	3	4	5
16.	I am involved in inquiry work in science أنا اشارك في دروس الاستقصاء في مادة العلوم	1	2	3	4	5
17.	I am involved in investigations in science أنا اشارك فيدروس التحقيقات في مادة العلوم	1	2	3	4	5
18.	I am involved in experiments أنا اشارك في التجارب العلمية	1	2	3	4	5
19.	I am involved in working in the gardens أنا اشارك في أعمال الزراعة	1	2	3	4	5

Collaboration/ Cooperation		Strongly Disagree غير موافق بشدة	Disagree غير موافق	Uncertain غير متأكد	Agree موافق	Strongly Agree موافق بشدة
20.	I cooperate with other students in this class when doing assignment work. أتعاون مع بقية الطلاب في الفصل عندما نكلف بالقيام بمهمة معينة	1	2	3	4	5
21.	I work in a team with other students when doing inquiries. أعمل من خلال فريق مع الطلاب الآخرين عندما نقوم بالأبحاث	1	2	3	4	5
22.	I am involved in group work in science أنا اشارك في في العمل الجماعى الذي يتم في حصة العلوم	1	2	3	4	5
23.	I work with other students in Science أعمل مع بقية الطلاب في حصص مواد العلوم	1	2	3	4	5
24.	I work with other students on assessments in Science أعمل مع الطلاب الآخرين لحل امتحانات مواد العلوم	1	2	3	4	5
25.	When I work in groups in this class, there is team work. عندما أعمل بشكل فريق في الفصل فهذا يشكل عملا جماعيا	1	2	3	4	5
26.	I cooperate with other students on class activities. أتعاون مع الطلاب الآخرين في كافة أنشطة الفصل	1	2	3	4	5
27.	I work in a team in my science class. أنا أعمل داخل فريق خلال حصة العلوم	1	2	3	4	5
28.	I prefer to work individually than in a team in my science class. أفضل العمل بشكل فردي أكثر منالعمل الجماعي في مادة العلوم	1	2	3	4	5

Integration		Strongly Disagree غير موافق بشدة	Disagree غير موافق	Uncertain غير متأكد	Agree موافق	Strongly Agree موافق بشدة
29.	Working in a garden is relevant to the work I do in my science class. العمل في المزرعة متعلق بالعمل الذي أقوم به في حصة العلوم	1	2	3	4	5
30.	My regular science class work is related with activities that can be used in a garden. ما أدرسه وأعمله في حصة العلوم يتعلق بالأنشطة التي تتم في المزرعة	1	2	3	4	5
31.	Working in a garden can help me to understand some of the topics covered in my regular science classes يمكن أن يساعدنيالعمل في المزرعة لفهم بعض المواضيع المغطاة في حصص العلوم	1	2	3	4	5
32.	Working in a garden can help me to learn in science. يمكن أن يساعدني العمل في المزرعة على التعلم في مادة العلوم	1	2	3	4	5
33.	Working in a garden can help me learn about healthy eating. يمكن أن يساعدني العمل في المزرعة على تناول الأطعمة الصحية	1	2	3	4	5
34.	Growing a garden can help me eat better foods الزراعة في المزرعةيمكن أن تساعدني في تناول أطعمة أفضل	1	2	3	4	5
35.	Growing my own food helps me improve my diet يمكن أن تساعدني زراعة غذائي بنفسي لتحسين نظامي الغذائي	1	2	3	4	5

Appendix 3

GARDENING AND ATTITUDES TOWARDS SCIENCE (GATS) SURVEY[2]

[2] Two scales in the GATS survey, involvement and cooperation, were drawn from the What Is Happening In this Class? (WIHIC) instrument, developed by Fraser, McRobbie and Fisher (1996) and later modified by Aldridge, Fraser and Huang (1999). The last scale, integration, was drawn from the Science Laboratory Environment Inventory (SLEI), which was developed by Fraser, Giddings and McRobbie (1995).

Enjoyment		Strongly Disagree غير موافق بشدة	Disagree غير موافق	Uncertain غير متأكد	Agree موافق	Strongly Agree موافق بشدة
1.	My teacher makes Science fun مدرسي يجعل حصة العلوم ممتعة	1	2	3	4	5
2.	I like to be involved in activities outside my regular classroom at the school أحب أن أكون مشاركا في الأنشطة التي تتمخارج الصفوف الإعتيادية في المدرسة	1	2	3	4	5
3.	Science lessons are fun دروس العلوم ممتعة	1	2	3	4	5
4.	Learning can be fun التعلم يمكن أن يكون ممتعا	1	2	3	4	5
5.	I would enjoy school more if there were more science lessons. سأستمتع في المدرسة أكثر لو كانت حصص العلوم أكثر	1	2	3	4	5
6.	I learn science better when I work in the regular classroom أتعلم مادة العلوم أفضل عندما أعمل في فصول الدراسة الأعتيادية	1	2	3	4	5
7.	I like science because of the topics I learn about. أحب مادة العلوم بسبب المواضيع التي أتعلمها فيها	1	2	3	4	5
8.	I like science because of the teacher. أحب مادة العلوم بسبب معلمي	1	2	3	4	5
9.	School should have more science lessons each week. يجب أن تخصص المدرسة حصص أكثر لمادة العلوم في كل أسبوع	1	2	3	4	5
10.	Science lessons excite me. مواد العلوم تحمسني	1	2	3	4	5
11.	Science is one of the most interesting school subjects. مادة العلوم هي واحدة من أكثر المواد الممتعة في المدرسة	1	2	3	4	5
12.	Science lessons are valuable. حصص العلوم قيمة	1	2	3	4	5

Task value		Strongly Disagree غير موافق بشدة	Disagree غير موافق	Uncertain غير متأكد	Agree موافق	Strongly Agree موافق بشدة
13.	What I learn in science is useful in my daily life. ما أتعلمه من مواد العلوم ينفعني في حياتي اليومية	1	2	3	4	5
14.	What I learn in science is helpful to me. ما أتعلمه من مواد العلوم مفيد بالنسبة لي	1	2	3	4	5
15.	What I learn in science is interesting. ما أتعلمه من مواد العلوم يشوقني	1	2	3	4	5
16.	What I learn in science is useful for me to learn. ما أتعلمه من مواد العلوم مفيد قي عملية التعلم ككل	1	2	3	4	5
17.	What I learn in science allows me to make better choices in my life. يسمح لي ما أتعلمه من مواد العلوم بأن أقومباختيارات أفضل في حياتي	1	2	3	4	5
18.	What I learn in science encourages me to think. يشجعني ما أتعلمه من مواد العلوم في التفكير	1	2	3	4	5
19.	What I learn in science is relevant to me. ما أتعلمه من مواد التعليم متعلق بي	1	2	3	4	5

Appendix 4

ASPIRATIONS TOWARDS GARDENING AND HEALTHY EATING AND NUTRITION (AGHEN)

Aspirations (Healthier Eating and Diet)		Strongly Disagree غير موافق بشدة	Disagree غير موافق	Uncertain غير متأكد	Agree موافق	Strongly Agree موافق بشدة
1.	I want to be healthier أفضل أن أكون أكثر صحة	1	2	3	4	5
2.	I want to eat healthier foods at school أريد أن أتناول الطعام الصحي في المدرسة	1	2	3	4	5
3.	I want to eat healthier foods at home أريد أن أتناول الطعام الصحي في البيت	1	2	3	4	5
4.	I want my family to eat healthier أريد أن تتناول عائلتي طعاماً صحياً	1	2	3	4	5
5.	I am interested in becoming healthier. أنا مهتم بان اكون بصحة أفضل	1	2	3	4	5
6.	I am interested in eating better foods. أنا مهتم بان أكل أطعمة أفضل	1	2	3	4	5
7.	Improving my diet is important to me تحسين نظامي الغذائي هو أمر مهم بالنسبة لي	1	2	3	4	5
8.	I would like to change the types of foods I eat at school أود تغيير نوعية الأطعمة التي أتناولها في المدرسة	1	2	3	4	5
9.	I would like to change the types of foods I eat at home أود تغيير نوعية الأطعمة التبي أتناولها في البيت	1	2	3	4	5
10.	I prefer to eat healthy food than junk food أفضل أن أتناول طعام صحي أكثر من ان اتناول الوجبات السريعة الجاهزة	1	2	3	4	5
11.	I would like more junk food to be sold in the school shop أفضل أن تباع الوجبات الجاهزة السريعة في المدرسة	1	2	3	4	5
12.	I would choose fruits and vegetables ahead of junk food if I had a choice أفضل أختيار الفواكه والخضروات كطعامعن اختيار الوجبات الجاهزة السريعة	1	2	3	4	5

Diet and Healthy Eating - Preferences		Strongly Disagree غير موافق بشدة	Disagree غير موافق	Uncertain غير متأكد	Agree موافق	Strongly Agree موافق بشدة
13.	Junk food tastes better than healthy food طعم الوجبات السريعة الجاهزة أفضل من الطعام الصحي	1	2	3	4	5
14.	Working in a garden can help me change the foods I eat يمكن أن يساعدني العمل في المزرعة في تغيير نوعية الأطعمة التي أتناولها	1	2	3	4	5
15.	I like to eat junk food at **school** أفضل أن أتناول الوجبات السريعة الجاهزة في المدرسة	1	2	3	4	5
16.	I like to eat fruit and vegetables at **school** أحب أن أتناول الفواكه والخضروات في المدرسة	1	2	3	4	5
17.	I like to eat junk food at **home** أحب أن أتناول الوجبات السريعة الجاهزة في البيت	1	2	3	4	5
18.	I like to eat fruit and vegetables at **home** أحب أن أتناول الفواكه و الخضروات في البيت	1	2	3	4	5
19.	Eating junk food makes me unhealthy تناول الوجبات السريعة الجاهزة يجعلني بصحة غير جيدة	1	2	3	4	5
20.	Eating fruit and vegetables is better for my health تناول الفواكه والخضروات هو الأفضل لصحتي	1	2	3	4	5
21.	Growing my own food can help to improve my health إنبات طعامي بنفسي يساعدني على تحسين صحتي	1	2	3	4	5
22.	I like the taste of most fruits أحب طعم أغلب الفواكه	1	2	3	4	5
23.	I like the taste of most vegetables أحب طعم أغلب الخضروات	1	2	3	4	5
24.	I would like more fruits and vegetables to be sold in the school shop أفضل أن تباع الفواكه والخضروات بشكل أكبر في المدرسة	1	2	3	4	5
25.	I am interested to learn more about growing fruits and vegetables إنني مهتم لاتعلم أكثر حول كيفية زراعة وإنبات الفواكه والخضروات	1	2	3	4	5

Aspirations (Gardens)		Strongly Disagree غير موافق بشدة	Disagree غير موافق	Uncertain غير متأكد	Agree موافق	Strongly Agree موافق بشدة
26.	I want to learn about growing my own food. أريد أن أتعلم حول كيفية زراعة وإنبات طعامي	1	2	3	4	5
27.	I want to have a garden in my home. أريد أن يكون في منزلي حديقة	1	2	3	4	5
28.	I want to grow my own food because it is healthier. أريد أن أزرع بنفسي طعامي لأنه صحي أكثر	1	2	3	4	5
29.	I want to grow my own food because it is fun. أريد أن أزرع طعامي بنفسي لأنه أكثر متعة	1	2	3	4	5
30.	I want to grow food so that I can make money by selling them. أريد أن أزرع وأنبتالطعام حتى أتمكن من جني المال من خلال بيعه	1	2	3	4	5

Appendix 5

KNOWLEDGE OF HEALTHY EATING AND NUTRITION TEST

Name: _____ الإسم: Class: _____الصف:

Science Teacher: _____ إسم مدرس العلوم:

TEST- Health and Nutrition

Circle the best answer (a, b, c or d) for each question. ضع دائرة حول أفضل إجابة لكل سؤال

1. Which of the following can be grown in a garden: 1- أي من الآتي يمكن زراعته في الحديقة:

(a) Chocolates الشوكولاتة
(b) Tomatoes الطماطم
(c) Hamburger برجر اللحم
(d) Pizza البيتزا

2. Which of the following foods would be the healthiest choice to eat at school?
أي من الطعام التالي تختاره ليكون طعاماً صحياً في المدرسة؟

(a) Chocolate الشوكولاتة
(b) Potato chips بطاطا الشرائح (شيبسي)
(c) Pizza البيتزا
(d) Salad السلطة

3. If eaten too much, which of the following foods is bad for our health?
في حالة تناول أطعمة بكثرة، أي من الأطعمة التالية تعتبر مضرة للصحة؟

(a) Chocolate الشوكولاتة
(b) Lettuce الخس
(c) Cucumber الخيار
(d) Tomato الطماطم

4. What is one of the main causes of obesity and weight gain?
أذكر واحد من الأسباب الرئيسية للبدانة وزيادة الوزن؟

(a) Eating too much salad تناول الكثيرمن السلطة
(b) Eating one piece of fruit every day تناول قطعة فاكهة يومياً
(c) Going to the gym and exercising الذهاب للصالة الرياضية والتدريب
(d) Eating too much chocolate and chipsتناول الكثير من الشوكولاتة والشيبسي

5. Which of the following are important for keeping your weight within normal limits?
أي من التالي هام للإبقاء على وزنك ضمن الوزن الطبيعي؟

(a) Eating junk foods at school تناول أطعمة سريعة في المدرسة
(b) Exercising regularly التدريب بإنتظام
(c) Sitting down for long periods الجلوس لفترات طويلة
(d) Watching television daily مشاهدة التلفاز يومياً

6. Fruits and vegetables are important for us because:
تعد الخضروات والفواكه مهمة لنا بسبب:

(a) They are components of a healthy diet تعد من مكونات التغذية الصحية
(b) They contain lots of sugars تحتوي على العديد من السكريات
(c) They make us fat تجعلنا بدناء (نعاني السمنة)
(d) They are difficult to eat من الصعب تناولهم

7. Which statement below is TRUE?
أي من البيانات التالية **حقيقية؟**

(a) Fruits and vegetables are difficult to grow تنمو الفواكه والخضروات بصعوبة
(b) Fruits and vegetables are not healthy to eat تناول الفواكه والخضروات غير صحي
(c) Eating fruits and vegetables are better for our health than eating chocolate and chips
تناول الفواكه والخضروات أفضل صحياً عن تناول الشوكولاتة والشيبسي

(d) Eating chocolates and chips are better for our health than eating fruits and vegetables
تناول الشوكولاتة والشيبسي أفضل صحياً من تناول الفواكه والخضروات

8. Which food provides us with the best amount of good vitamins for our bodies?
أي من الطعام يمد جسمنا بأفضل كمية من الفيتامينات الجيدة؟

(a) Soft drinks المشروبات الغازية
(b) Popcorn الفوشار
(c) Green salad السلطة الخضراء
(d) Chocolate الشوكولاتة

9. Which of the following would be difficult to grow in a garden at home in the UAE?
أي من التالي يصعب نموه في حديقة المنزل في دولة الإمارات؟

(a) Tomatoes الطماطم
(b) Lettuce الخس
(c) Parsley البقدونس
(d) Apples التفاح

10. Growing my own food in a garden could be good for my health because:
زراعة غذائي بنفسي في الحديقة يحسن صحتي بسبب:

(a) It is fun أنه ممتع
(b) It will be good for the environment لأنه يحسن البيئة
(c) I can grow and eat more fruits and vegetables يمكنني من زراعة وتناول المزيد من الفواكه والخضروات
(d) I can learn more about science أتعلم المزيد حول مادة العلوم

11.The main problem with growing fruits and vegetables in a garden in the UAE would be:
المشكلة الأساسية لزراعة الفواكه والخضروات في الحديقة داخل دولة الإمارات هي:

(a) The hot weather الطقس الحار
(b) It is a waste of time أنها مضيعة للوقت
(c) Not enough space available to have a garden عدم وجود مساحة كافية لعمل حديقة
(d) Other foods are better for our health أفضلية أطعمة أخرى لحصتنا

12.Eating health foods can… تناول أطعمة صحية يمكنه.....
(a) Help me to lose weight مساعدتي على تخفيف وزني
(b) Make me feel better يجعلني أشعر بتحسن
(c) Provide me with important vitamins يمدني بالفيتامينات الهامة
(d) All of the above كل ماسبق ذكره

13.Eating junk food is bad because:
تناول الأطعمة السريعة سيء بسبب:
(a) It can lead to diseases such as diabetes قد تؤدي إلى أمراض مثل السكري
(b) It costs too much تكلف كثيراً
(c) It takes too long to grow junk food in a garden زراعة الأطعمة السريعة تستهلك وقتاً كبيراً في الحديقة
(d) It tastes good طعمها طيب

Appendix 6

FORM C- CURTIN UNIVERSITY APPLICATION FOR APPROVAL OF RESEARCH WITH LOW RISK (ETHICAL REQUIREMENTS)

Curtin University

Memorandum

To	William Baini, SMEC
From	Mun Yin Cheong, Form C Ethics Co-ordinator Faculty of Science and Engineering
Subject	Protocol Approval **SMEC-03-14**
Date	3 March 2014
Copy	Jill Aldridge, SMEC

Office of Research and Development

Human Research Ethics Committee

Telephone 9266 2784
Facsimile 9266 3793
Email hrec@curtin.edu.au

Thank you for your "Form C Application for Approval of Research with Low Risk (Ethical Requirements)" for the project titled *"Evaluating the Impacts on Learning, Health and Nutrition of a School Greenhouse and Garden"*. On behalf of the Human Research Ethics Committee, I am authorised to inform you that the project is approved.

Approval of this project is for a period of 4 years **28th February 2014** to **27th February 2018**.

Your approval has the following conditions:

(i) Annual progress reports on the project must be submitted to the Ethics Office.

(ii) It is your responsibility, as the researcher, to meet the conditions outlined above and to retain the necessary records demonstrating that these have been completed.

The approval number for your project is **SMEC-03-14**. Please quote this number in any future correspondence. If at any time during the approval term changes/amendments occur, or if a serious or unexpected adverse event occurs, please advise me immediately.

Regards,

[redacted]

MUN YIN CHEONG
Form C Ethics Co-ordinator
Faculty of Science and Engineering

Appendix 7

EVIDENCE OF APPROVAL TO CONDUCT RESEARCH FROM ADEC

مجلس أبوظبي للتعليم
Abu Dhabi Education Council
Education First التعليم أولاً

Date: 14th May 2014		التاريخ: 14 مايو 2014
Ref:		الرقم:
To: Public Schools Principals, and other deprtments		**السادة/مديري المدارس الحكومية والإدارات المختلفة**
Subject: Letter of Permission		**الموضوع: تسهيل مهمة باحثين**
Dear Principals,		**تحية طيبة وبعد،،،**
The Abu Dhabi Education Council would like to express its gratitude for your generous efforts & sincere cooperation in serving our dear students.		يطيبُ لمجلس أبوظبي للتعليم أن يتوجه لكم بخالص الشكر والتقدير لجهودكم الكريمة والتعاون الصادق لخدمة أبنائنا الطلبة.
You are kindly requested to allow the researcher/**Wiliam Baini**, to complete his research on: **Evaluating the Impacts of an on-site School Greenhouse on Students' Perceptions of the Learning Environment, Attitudes and Understanding of Healthy Eating and Nutrition**		ونود إعلامكم بموافقة مجلس أبو ظبي للتعليم على موضوع الدراسة التي سيجريها الباحث/**ويليام بايني** **Evaluating the Impacts of an on-site School Greenhouse on Students' Perceptions of the Learning Environment, Attitudes and Understanding of Healthy Eating and Nutrition**
Please indicate your approval of this permission by facilitating his meetings with the sample groups at your respected schools.		لذا، يرجى التكرم بتسهيل مهمة الباحث ومساعدته على إجراء الدراسة المشار إليها.
For further information: please contact **Mr Helmy Seada** on 02/6150140		للاستفسار: يرجى الاتصال بالسيد/ **حلمي سعدة** على الهاتف 02/6150140
Thank you for your cooperation.		شاكرين لكم حسن تعاونكم
Sincerely yours,		وتفضلوا بقبول فائق الاحترام والتقدير،،،
[redacted] **محمد سالم محمد الظاهري** **المدير التنفيذي لقطاع العمليات المدرسية**		

صندوق بريد:٣٦٠٠٥، أبوظبي – إ.ع.م، هاتف: ٦١٥ ٢ ٩٧١+ ٠٠٠٠، فاكس: ٦١٥ ٢ ٩٧١+ ٠٦٠٢، البريد الإلكتروني: info@adec.ac.ae
P.O.Box. 36005, Abu Dhabi - U.A.E., Tel: +971 2 615 0000, Fax: +971 2 615 0602, Email: info@adec.ac.ae

Appendix 8

TEACHERS' INFORMATION SHEET AND CONSENT FORM

Curtin University
School of Science
Science and Mathematics Education Centre

Teacher Information Sheet

Evaluating the impacts of an on-site school greenhouse on Students' Perceptions of the Learning Environment, Attitudes and Understanding of Healthy Eating and Nutrition

My name is William Baini. I am currently conducting research for my Master of Philosophy degree at Curtin University, Australia.

Purpose of Research
I am investigating the impacts of an on-site greenhouse and garden on teaching, learning, and on health and nutrition of students and their families in public schools in Abu Dhabi.

Your Role
Throughout this coming school year, students from your school will be involved in the setting up and use of a school garden and greenhouse. This will mostly occur during allocated time slots during science and other classes, as well as some times outside of class. They will be asked to complete a questionnaire prior to using the garden and greenhouse, then again after several weeks of use once the garden has been set up and used to grow vegetables and plants. Some students will also be selected to take part in a focus group interview with other students during class time.

Consent to Participate
The student's involvement in the research is entirely voluntary. You have the right to choose for any student not to participate or to be withdrawn from the study after they have completed the questionnaires. If you agree for your students to participate, please complete and sign the consent form attached.

Confidentiality
The names of the school and any student will not be used for any individual data collection and no other personal details will be collected apart from the grade and class so that results can be compared between the two surveys. The purpose of this study is not to evaluate students or your school, but to investigate the total impacts that a greenhouse and garden may have on the school as a whole, in terms of learning, teaching styles, thinking, perceptions of science, food choice and eating habits. The individual responses will not be shared with anyone. The questionnaires will be kept securely until my research is finished, and then they will be destroyed. Electronic copies of the data will be kept under password-protection for 5 years and then they

will be destroyed. Only myself and my supervisor will have access to the questionnaires and data.

Further Information

This research has been reviewed and given approval by Curtin University Human Research Ethics Committee (Approval Number) and by the Abu Dhabi Education Council Research Office. If you would like further information about the study, please feel free to contact me on 0562792999 or by email william.baini@adec.ac.ae.If you wish to speak with an independent person about the conduct of the project, please contact Curtin University's Human Research Ethics department by email: hrec@curtin.edu.au. You can also contact the Abu Dhabi Education Council Research Office on 02 615 0000.

Thank you very much for your involvement in this research.
Your participation is greatly appreciated.

Curtin University

Curtin University
School of Science
Science and Mathematics Education Centre

Teacher Consent Form

Evaluating the impacts of an on-site school greenhouse on Students' Perceptions of the Learning Environment, Attitudes and Understanding of Healthy Eating and Nutrition

I have been informed of and understand the purposes of this research study.

I have been given an opportunity to ask questions about the study.

I understand that my participation in this study involves students from my school completing two written questionnaires and possibly a focus group interview.

I understand that I can withdraw any students from this study at any time without prejudice.

Any information that might potentially identify me, the school and any student will not be used in published material.

I agree to allow the school to participate in the above study as outlined to me.

Name: _____

Signature: _____

Date: _____

Appendix 9

STUDENTS' INFORMATION SHEET AND CONSENT FORM

Curtin University
School of Science
Science and Mathematics Education Centre

Student Information Sheet

Evaluating the impacts of an on-site school greenhouse on Students' Perceptions of the Learning Environment, Attitudes and Understanding of Healthy Eating and Nutrition

My name is William Baini. I am currently conducting research for my Master of Philosophy degree at Curtin University, Australia.

Purpose of Research
I am investigating the impacts of an on-site greenhouse and garden on teaching, learning, and on health and nutrition of students and their families in public schools in Abu Dhabi.

Your Role
Throughout this coming school year, you will be involved in the setting up and use of a school garden and greenhouse. This will mostly occur during allocated time slots during science and other classes, as well as some times outside of class. You will be asked to complete a questionnaire prior to using the garden and greenhouse, then again after several weeks of use once the garden has been set up and used to grow vegetables and plants. You might also be selected to take part in a focus group interview with other students during class time.

Consent to Participate
Your involvement in the research is entirely voluntary. You have the right to choose not to participate or to ask to withdraw from the study after you have completed the questionnaires. If you agree to participate, please complete and sign the consent form attached and submit it with your questionnaires.

Confidentiality
Your name will not be used for any individual data collection and no other personal details will be collected apart from your grade and class so that results can be compared between the two surveys. The purpose of this study is not to evaluate you or your school, but to investigate the total impacts that a greenhouse and garden may have on the school as a whole, in terms of learning, teaching styles, thinking, perceptions of science, food choice and eating habits. Your individual responses will not be shared with your principal or advisors. The questionnaires will be kept securely until my research is finished, and then they will be destroyed. Electronic copies of the data will be kept under password-protection for 5 years and then they will be destroyed. Only myself and my supervisor will have access to the questionnaires and data.

Further Information

This research has been reviewed and given approval by Curtin University Human Research Ethics Committee (Approval Number) and by the Abu Dhabi Education Council Research Office. If you would like further information about the study, please feel free to contact me on 0562792999 or by email william.baini@adec.ac.ae.If you wish to speak with an independent person about the conduct of the project, please contact Curtin University's Human Research Ethics department by email: hrec@curtin.edu.au. You can also contact the Abu Dhabi Education Council Research Office on 02 615 0000.

Thank you very much for your involvement in this research.
Your participation is greatly appreciated.

Curtin University
School of Science
Science and Mathematics Education Centre

Participant Consent Form

Evaluating the impacts of an on-site school greenhouse on Students' Perceptions of the Learning Environment, Attitudes and Understanding of Healthy Eating and Nutrition

I have been informed of and understand the purposes of this research study.

I have been given an opportunity to ask questions about the study.

I understand that my participation in this study involves me completing two written questionnaires and possibly a focus group interview during class time.

I understand that I can withdraw from this study at any time without prejudice.

Any information that might potentially identify me will not be used in published material.

I agree to participate in the above study as outlined to me.

Name: _____

Signature: _____

Date: _____

Appendix 10

PRINCIPAL'S INFORMATION SHEET AND CONSENT FORM

Curtin University
School of Science
Science and Mathematics Education Centre

Principal Information Sheet

Evaluating the impacts of an on-site school greenhouse on Students' Perceptions of the Learning Environment, Attitudes and Understanding of Healthy Eating and Nutrition

My name is William Baini. I am currently conducting research for my Master of Philosophy degree at Curtin University, Australia.

Purpose of Research
I am investigating the impacts of an on-site greenhouse and garden on teaching, learning, and on health and nutrition of students and their families in public schools in Abu Dhabi.

Your Role
Throughout this coming school year, students from your school will be involved in the setting up and use of a school garden and greenhouse. This will mostly occur during allocated time slots during science and other classes, as well as some times outside of class. They will be asked to complete a questionnaire prior to using the garden and greenhouse, then again after several weeks of use once the garden has been set up and used to grow vegetables and plants. Some students will also be selected to take part in a focus group interview with other students during class time.

Consent to Participate
The student's involvement in the research is entirely voluntary. You have the right to choose for any student not to participate or to be withdrawn from the study after they have completed the questionnaires. If you agree for your students to participate, please complete and sign the consent form attached.

Confidentiality
The names of the school and any student will not be used for any individual data collection and no other personal details will be collected apart from the grade and class so that results can be compared between the two surveys. The purpose of this study is not to evaluate students or your school, but to investigate the total impacts that a greenhouse and garden may have on the school as a whole, in terms of learning, teaching styles, thinking, perceptions of science, food choice and eating habits. The individual responses will not be shared with anyone. The questionnaires will be kept securely until my research is finished, and then they will be destroyed. Electronic copies of the data will be kept under password-protection for 5 years and then they

will be destroyed. Only myself and my supervisor will have access to the questionnaires and data.

Further Information

This research has been reviewed and given approval by Curtin University Human Research Ethics Committee (Approval Number) and by the Abu Dhabi Education Council Research Office. If you would like further information about the study, please feel free to contact me on 0562792999 or by email william.baini@adec.ac.ae.If you wish to speak with an independent person about the conduct of the project, please contact Curtin University's Human Research Ethics department by email: hrec@curtin.edu.au. You can also contact the Abu Dhabi Education Council Research Office on 02 615 0000.

Thank you very much for your involvement in this research.
Your participation is greatly appreciated.

Curtin University
School of Science
Science and Mathematics Education Centre

Principal Consent Form

Evaluating the impacts of an on-site school greenhouse on Students' Perceptions of the Learning Environment, Attitudes and Understanding of Healthy Eating and Nutrition

I have been informed of and understand the purposes of this research study.

I have been given an opportunity to ask questions about the study.

I understand that my participation in this study involves students from my school completing two written questionnaires and possibly a focus group interview.

I understand that I can withdraw any students from this study at any time without prejudice.

Any information that might potentially identify me, the school and any student will not be used in published material.

I agree to allow the school to participate in the above study as outlined to me.

Name: _____

Signature: _____

Date: _____

Appendix 11

PARENTS' INFORMATION SHEET AND CONSENT FORM

Curtin University
School of Science
Science and Mathematics Education Centre

Parent Information Sheet

Evaluating the impacts of an on-site school greenhouse on Students' Perceptions of the Learning Environment, Attitudes and Understanding of Healthy Eating and Nutrition

My name is William Baini. I am currently conducting research for my Master of Philosophy degree at Curtin University, Australia.

Purpose of Research
I am investigating the impacts of an on-site greenhouse and garden on teaching, learning, and on health and nutrition of students and their families in public schools in Abu Dhabi.

Your Role
Throughout this coming school year, your child will be involved in the setting up and use of a school garden and greenhouse. This will mostly occur during allocated time slots during science and other classes, as well as some times outside of class. Your child will be asked to complete a questionnaire prior to using the garden and greenhouse, then again after several weeks of use once the garden has been set up and used to grow vegetables and plants. They may also be involved in a focus group interview.

Consent to Participate
Your child's involvement in the research is entirely voluntary and at your discretion. You have the right to choose for your child not to participate or to be to withdrawn from the study after he/she has completed the questionnaires. If you agree for your child to participate, please complete and sign the consent form attached.

Confidentiality
The names of your child will not be used for any individual data collection and no other personal details will be collected apart from your child's grade and class. The purpose of this study is not to evaluate your child or the school, but to investigate the total impacts that a greenhouse and garden may have on the school as a whole, in terms of learning, teaching styles, thinking, perceptions of science, food choice and eating habits. Your child's individual responses will not be shared with the principal or advisors. The questionnaires will be kept securely until my research is finished, and then they will be destroyed. Electronic copies of the data will be kept under password-

protection for 5 years and then they will be destroyed. Only myself and my supervisor will have access to the questionnaires and data.

Further Information

This research has been reviewed and given approval by Curtin University Human Research Ethics Committee (Approval Number) and by the Abu Dhabi Education Council Research Office. If you would like further information about the study, please feel free to contact me on 0562792999 or by email william.baini@adec.ac.ae.If you wish to speak with an independent person about the conduct of the project, please contact Curtin University's Human Research Ethics department by email: hrec@curtin.edu.au. You can also contact the Abu Dhabi Education Council Research Office on 02 615 0000.

Thank you very much for your involvement in this research.
Your participation is greatly appreciated.

Curtin University
School of Science
Science and Mathematics Education Centre

Parent Consent Form

Evaluating the impacts of an on-site school greenhouse on Students' Perceptions of the Learning Environment, Attitudes and Understanding of Healthy Eating and Nutrition

I have been informed of and understand the purposes of this research study.

I have been given an opportunity to ask questions about the study.

I understand that my child's participation in this study involves me completing two written questionnaires and possibly a focus group interview.

I understand that I can withdraw my child from this study at any time without prejudice.

Any information that might potentially identify my child will not be used in published material.

I agree to participate in the above study as outlined to me.

Name: _____

Signature: _____

Date: _____

Appendix 12

SKEWNESS AND KURTOSIS RESULTS FOR EACH CONSTRUCT

Scale	Skewness	Kurtosis
Relevance	1.74	6.25
Student Negotiation	-.58	-.07
Collaboration	-1.11	1.34
Integration	-.91	.51
Shared Control	-.55	.03
Enjoyment	-.61	-.31
Task Value	-.79	.49
Aspirations (Gardening)	-1.06	.52
Aspirations (Healthy Eating	-.73	3.53