THE IMPLEMENTATION AND EVALUATION OF A SERVICE-LEARNING COMPONENT IN A SECOND YEAR UNDERGRADUATE ORGANIC CHEMISTRY COURSE

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ABSTRACT

The project describes the action research implementation, and evaluation of learning, of a service-learning component in a second year undergraduate organic chemistry course. The research aims to explore the learning that takes place in a service-learning context while utilizing an action research methodology within the critical theory paradigm. This occurs in response to the world-wide call for Higher Education to produce people with civic competencies and responsiveness to the society in which they live (Boyer 1996). Educating young Chemists to see the importance of their knowledge and their responsibilities in society is an important pedagogical step in the effort to cross boundaries and make connections between people communities (Eyler and Giles 1999). The goal of this project was to explore and categorize the learning that takes place in a service-learning context and discover how these areas of learning impact the awareness of the parties involved with regard to the discipline of chemistry as well as social issues. The project makes use of Kolb‘s (1984) Experiential Learning Theory, and Eyler and Giles‘ (1999) categories of learning in service-learning and results indicate that service-learning can be a powerful pedagogical tool to increase learning in chemistry as well as in the areas of critical thinking, personal and social development, reflection and citizenship. Students‘ perceptions of themselves, their discipline and their responsibility to society were transformed by their experience of service-learning in their undergraduate chemistry course.

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LIST OF ABBREVIATIONS

ACS – American Chemical Society

CHE – Council on Higher Education

CHE 202 – Second semester second year chemistry course

CHERTL – Centre for Higher Education Research, Teaching and Learning

CHESP – Community-Higher Education-Service-Partnerships

DP – Duly Performed

DoE – Department of Education

ELT – Experiential Learning Theory

HEQC – Higher Education Quality Committee

HEI – Higher Education Institution

HET – Higher Education and Training

JET – Joint Education Trust

CHAPTER 1

INTRODUCTION

"You cannot hope to build a better world without improving the individuals."—Marie Curie (1867–1934)

1.1 Rationale for the research

A new challenge facing education institutions today is incorporating learning in activities which not only give the student a mark at the end of the course, but also have a positive influence on the surrounding community (Kenny *et al.* 2002). According to Kraak (2000) whose work is based on the research of Gibbons *et al.* and Scott, there has been a fundamental shift in the operation and structure of higher education institutions world-wide. This paradigmatic shift has involved moving away from ~~"e~~lite and insular institutions" toward systems of teaching and learning that are more ~~"o~~pen and responsive." This movement away from historical academic norms is known as Mode 2 knowledge creation.

World-wide there is a call for Higher Education to produce people with civic competencies and responsiveness to the society in which they live (Boyer 1996). These shifts in societal understanding of what learning and knowledge creation entail, provide a platform for these more ~~"o~~pen and responsive" methods of teaching and learning and a reworking of the intellectual culture of higher education institutions (Kraak 2000). Bernstein (1996) conceptualised this as the merging of vertical (discipline-based) knowledge with horizontal (work or community-based) knowledge.

According to Kraak (2000), Government policy on Higher Education and Training (HET) in South Africa has been heavily influenced by the analytical framework developed by Gibbons *et al.* and Scott and great emphasis has been placed on the transformation of HET from a discipline based, closed system of education to a structure that is engaged

with and open to the society and community in which it finds itself. There has been a gradual shift in focus since 1997, with the release of Education White Paper 3, which explicitly aimed to ―promote and develop social responsibility and awareness amongst students…through community service programmes" (Bender *et al.* 2006, p 4). The perception of community service has moved from a view of community service as one of the three pillars of higher education, along with teaching and research, to a view of community service as the context in which teaching and research take place and an integral and necessary part of the function of an institution in these two areas (Bender *et al.* 2006). Knowledge that is socially useful or socially accountable is highly valued above ‗ivory tower' knowledge that exists in isolation from the rest of the world (Kraak 2000).

Marie Curie's words, quoted by Thomas Lane, American Chemical Society president for 2009, encapsulate the shift in focus from knowledge in isolation from humanity to knowledge for humanity and highlight the reasons for the researcher embarking on this research project. In order to impact the world, individuals need to change. As Lane says,

> ―In this simple statement, Madame Curie summarized a prime responsibility…to reach out and make sure that those who follow us have the opportunities that we were afforded, to actively learn our discipline, and to leverage the power of chemistry to improve peoples' lives."

Lane, in advocating that chemists need to reach out to society and ensure that chemistry, as a discipline, is relevant and engaged with real-world issues and problems, is in line with Mode 2 ideas of socially useful knowledge. Chemistry should be improving and impacting people's lives (Lane 2009).

―Service-learning is a pedagogy based on the principle that course learning goals can be reinforced through meaningful community service" (Esson *et al.* 2005). Since a major concern of educators is the lack of connection between education and how learning is acquired and applied outside of the academic institution – in the community or workplace – service learning provides a hands-on setting in which students become aware of the

challenges and ultimately the rewards of applying knowledge to new situations. This bridges the gap between studying and working, providing a platform where learning takes place in a way that will translate to students' future careers, as well as benefiting the local community (Esson *et al.* 2005).

Service-learning, however, presents many problems because a university's place in the community is defined by community members and not by those intimately involved with the university itself. Kenny *et al.* (2002) say,

> "Arguably, the major challenge facing contemporary higher education is to enhance its relevance and connectedness to the issues and problems faced by the broader society – as these problems are defined by community members, and not by academics, acting independently of the views of non-academic community members."

Perceptions have to be changed both on the side of academics who often see community engagement as a 'soft' option which impinges on the more serious academic content of a course, and students who do not see the point in making any effort outside of what they need to regurgitate at examination time. This is excluding the problem of perception within the communities themselves that see universities as far removed from the reality of life and as contributing little to uplifting the immediate community (Kenny *et al.* 2002).

Service-Learning research has been quite extensive in recent years, especially in the USA, but the focus has mostly been on researching Service-Learning as pedagogy. There has been far less focus on the other types of learning that result from a service-learning experience (Eyler & Billig 2003). In the South African context in particular, there has not been much focus on the learning of civic responsibilities or the effectiveness of the pedagogy in achieving other learning outcomes not directly related to the content of the course. In fact, according to the HEQC guide for Service Learning in the Curriculum, this is an aspect of community engagement that has received little attention and its absence is not just a feature of service-learning research (Bender *et al.* 2006).

Kezar and Rhoads (2001) present a good case for examining the learning that takes place in a service-learning context. They mention that although there are a variety of studies

offering support for the contribution of service learning to course comprehension, generally speaking, more research is needed. As Giles and Eyler (*as cited in* Kezar & Rhoads 2001) noted, "Faculty and administrators are intensely interested in this issue and there is not yet convincing evidence of the importance of service learning to subject matter learning" (p 155). Kezar (2002) also reiterates this view in her article where she discusses how the real outcomes of service-learning are not assessed.

For all these reasons, research exploring the learning in service-learning, particularly in a South African context and within a hard science discipline like chemistry, will greatly enhance the body of knowledge surrounding Mode 2 teaching and learning. It will also enhance the understanding of service-learning both as a pedagogical tool and as a mode of praxis for teaching and learning at HET level, both in a national and international context.

1.2 Research Aims and Objectives

The aim of this research is to explore the learning that takes place in a service-learning context and discover how these areas of learning impact the awareness of the parties involved with regard to the discipline of chemistry as well as social issues. Changes in individuals‘ ideas about themselves and their discipline, as well as the value of the knowledge they gain at university, will be investigated.

1.3 Research Questions

In order to explore the learning and changes taking place on the part of the students the following two Research Questions are formulated:

Question 1: How does service-learning change the way chemistry is learned and perceived by the student and what other (non-discipline-specific) learning takes place due to the service-learning component?

Question 2: How does this change students‘ awareness of social issues and citizens‘ responsibilities?

1.4 Significance of the Research

This research is in the Teaching and Learning field, specifically in the higher education context, but the results of this study will impact on the curriculum in the Chemistry Department at Rhodes University and possibly in other departments as well. With the shift in focus on the role of higher education, there is a call to produce not just scientists or doctors or teachers, but people with civic competencies and responsiveness to the society they live in. (Boyer 1996). South African scientists need to develop the public understanding of science and address issues of inequality that result in poor science take up and even poorer pass rates at both school and university level. Higher Education Institutions need to become engaged in the community that supports them as well as do something to increase student numbers from the local area. This research will speak to all these areas and provide some answers as to both the value and feasibility of service-learning courses in this specific context. The research, however, could provide information that could be useful to practitioners in any context, in highlighting the kinds of learning that take place and how to focus on and extend these possible learning outcomes.

CHAPTER 2

LITERATURE REVIEW

"Tell me, and I will forget. Show me, and I may remember. Involve me, and I will understand." – Confucius, 450 BC *as cited in* Bender *et al. 2006, p 14)*

2.1 Introduction

The literature review aims to outline and discuss the main areas of interest that pertain to this study and seeks to provide an overview of the relevant literature, focusing on important issues which speak to the implementation of service-learning in higher education institutions and in chemistry in particular. Areas where previous research is insubstantial or weak will be noted. This chapter also highlights and discusses the theoretical and practical concepts that undergird chemistry education as well as the service-learning pedagogical approach. Chemistry education and the role of practical work will be discussed and a historical and pedagogical overview of service-learning will be presented with both the motivation for and critique of its value and efficacy.

2.2 Experiential Learning

2.2.1 Historical Roots of Experiential Learning

Experiential learning has its roots in the works of John Dewey, Kurt Lewin, and Jean Piaget, who postulated that learning is through experience and of Lev Vygotsky who with a slightly different approach to Piaget, emphasised human development as the result of learning from experience (Kolb 1984). Experiential learning, according to Kolb, offers the foundation for an approach to education and learning that pursues a framework for ~~"~~examining and strengthening the critical linkages among education, work and personal development" (Kolb 1984, p 4). Experiential learning theory (ELT) uses personal experience as the crucial point for learning because it brings abstract concepts into a context where they can become concrete. Thus, ELT characterizes learning as a continuous process grounded in experience and concepts are derived from and continuously modified by experience throughout human life (Towns 2001).

2.2.2 Kolb"s Theory of Experiential Learning

The definition of learning, as Kolb puts it, is that, –Learning is the process whereby knowledge is created through the transformation of experience" (Kolb 1984, p38). This definition emphasizes several critical features of the learning process as viewed from an experiential perspective. Most importantly, the emphasis is on the process of learning and adaptation and not on the outcomes or content. Secondly, knowledge is considered to be a process of transformation, not an entity in itself to be gained or transmitted from one person to another (Kolb 1984).

Learning and development, as Piaget viewed it, is a linear process where a person simply moves from not knowing to knowing. Instead, Kolb and Dewey proposed that learning could be viewed as a cycle (Kolb 1984), where the learner returns at a higher developmental level to the beginning stages of the process, every time learning and development take place. (See Figure 2.2.2.1) Experiential learning theory is suggested as a holistic integrative perspective on learning that combines experience, perception, cognition and behaviour (Kolb 1984).

The figure can be interpreted as follows: the learner may move from stage to stage in the cycle and is able to enter the cycle at any time depending on the activity being undertaken:

- Concrete experience (feeling): Learning from a specific experience and relating to others.
- Reflective observation (watching): Observing before making a judgement by viewing the environment from different perspectives.
- Abstract conceptualization (thinking): Logical analysis of ideas and acting on intellectual understanding of a situation.
- Active experimentation (doing): Acting on the knowledge gained from the previous stages of learning

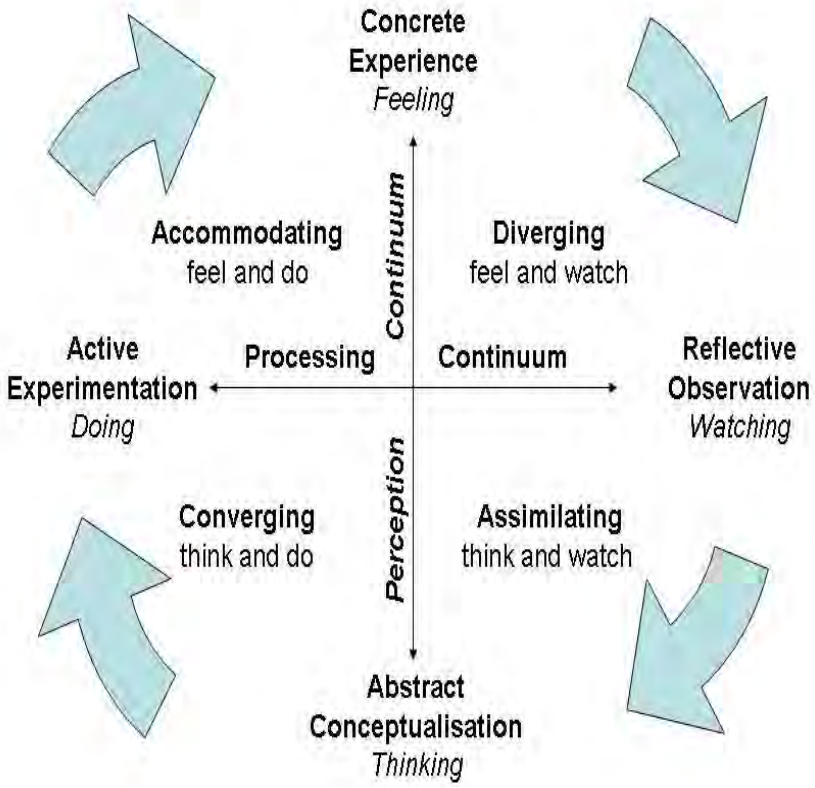


Figure 2.2.2.1 **Adapted from (Kolb 1984)**

The learner then moves to the concrete experience stage again and goes through the cycle at a higher level of understanding. The cycle illustrates the underlying tenet of Kolb‘s theory: that learning is the process whereby knowledge is transformed through experience (Kolb 1984).

These ideas challenge the traditional form that education has taken in Higher Education Institutions, and in contrast embrace the Mode 2 approach to learning. It is obvious then that new pedagogies and theories of knowledge are beginning to incorporate these ideas with more explicit focus on the social context in which learning takes place, espousing Kolb‘s idea that learning is the process of creating knowledge that is the result of the transaction between social knowledge and personal knowledge (Kolb 1984).

2.2.3 Kolb and Constructivism

Kolb talks about learning as *"the* major process of human adaptation," (Kolb 1984, p 32) and goes on to discuss this concept as one which is much broader than the traditional notion of the classroom. Learning occurs in all situations of humanity, from the personal to the workplace, and from the classroom to the street, and happens at all stages of life from childhood to old age. Thus, for Kolb, learning encompasses other adaptive processes which historically might be viewed as more specific and separate processes such as problem solving, decision making and flexibility (Kolb 1984).

> —The cyclical description of the experiential learning process is mirrored in many of the specialized models of the adaptive process…all forms of human adaptation approximate scientific enquiry…" (Kolb 1984, p32)

This comment implies a position not far from the constructivist perspective known as personal or radical constructivism which was articulated by George Kelly in 1955 and was based on the work of Piaget (Kolb 1984 and Bodner *et al.* 2001). This constructivist perspective is also known as *endogenous* constructivism which holds that knowledge comes from previously acquired knowledge and not directly from environmental interactions. Knowledge is seen as developing through "cognitive abstraction" (Schunk 2008, p 238). Kelly however, has a position akin to Kolb's in that, although he emphasizes the role of the individual in the construction of knowledge, he provides a basis for thinking about the kinds of interactions between people that can facilitate this construction (Bodner *et al.* 2001).

It can be tempting to think about radical constructivism and social constructivism as opposite ends of the spectrum. On the one side, learners construct knowledge in isolation, based on their experience of the world in which they live. At the other end, learning is rooted in social and cultural factors. However, intuitively it can be seen that most situations in which learning occurs fall somewhere between these two extremes. Learning is a complex process that occurs within a social context, as the social constructivists point out, but it is ultimately the individual who does the learning, as personal constructivists would argue (Bodner 2004).

According to Bodner (2004), Kelly's 1955 theory thus moves more towards social or cognitive constructivism which holds that constructions reflect the outcomes of mental contradictions that result from interactions with people and the environment. Vygotsky (Kozulin, *et al.* 2003) similarly emphasised the influence of the social environment. Kolb's (1984) theory sees learning occurring as Bodner (2004) argues, somewhere in between the two ends of the spectrum, and this view of social constructivism has been closely associated with many contemporary learning theories such as Bandura's Social Cognitive Theory and many theories of motivation (Schunk 2008).

2.2.4 Experiential learning, constructivism and the implications for teaching and learning in chemistry

With the arguable consensus that science education is not fulfilling the role that it should, the next logical step is to ask: How it can be changed so that it does? Clearly, simply changing the curriculum is not enough since the knowledge itself is not the problem. Rather the transfer of knowledge from the educator to the learner and the fact that knowledge without social context has had its value seriously questioned by the modern thinkers (as discussed earlier) are of greater concern.

> "Changing the curriculum – the topics being taught – is not enough to bring about meaningful change in science education; we also need to rethink the way the curriculum is delivered" (Bodner 1992, p 187).

Bodner's comment highlights the fact that the current problems in science education can only be addressed by a holistic approach. He goes on to discuss the difference between teaching and learning in the same paper:

> "There is a subtle difference between theories of learning and theories of teaching. Theories of learning describe how an organism learns; theories of teaching deal with the ways in which we can influence what the organism learns. It is important to distinguish between the two for the following reason: Teaching and learning are not synonymous; we can teach – and teach well – without having the students learn" (p 187).

Bodner goes on to discuss how active learning is innately better than passive learning, and offers a constructivist epistemology to explain this. Kolb's (1984) ideas also support

the idea that a learner actively engaged with the material, rather than passively being taught it, will learn more, because –learning is the process whereby knowledge is created by the transformation of experience" (Kolb 1984, p 38).

This kind of interactive learning environment where discussion and active involvement are encouraged, is known as cooperative learning. In this situation the role of the teacher or instructor shifts dramatically from "someone who teaches" to "someone who facilitates learning" (Bodner 1992 and Shibley & Zimmaro 2002). The constructivist theory of knowledge offers an explanation for why student achievement is enhanced when students work together in a cooperative learning environment (Bodner 1992 and Bodner *et al.* 2001). Firstly, the general assumption underlying the theory is that the responsibility for learning ultimately rests with the individual learner (Bodner 1992; Bodner *et al.* 2001 and Schunk 2008). According to Bodner (1992):

> –This [learning] can be facilitated by providing a format in which the learner must examine, clarify, describe, compare, and then negotiate with others the implications the individual ascribes to his or her experiences. Although learning occurs within the mind of the learner, anyone with classroom teaching experiences knows the value of being placed in an environment where knowledge has to be explained to others" (p 188).

Providing this kind of format clearly rests on the educator who must employ new pedagogical tools to teach content and to foster positive student attitude towards the content and the discipline. In chemistry, collaborative and experiential learning pedagogy has been shown to both enhance content knowledge and change perceptions of the discipline amongst students. Students respond well to these methods of teaching particularly in courses where the content is traditionally seen as difficult (Bodner 1992; Shibley & Zimmaro 2002; Towns 2001; Draper 2004; Esson *et al*. 2005; LaRiviere *et al.* 2007; Kelly & Finlayson 2009 and Platt *et al*. 2008).

2.3 Chemistry Education

2.3.1 Chemistry Education for Two Purposes

According to Driver *et al*.:

> —Learning science is not a matter of simply extending young people's knowledge of phenomena – a practice perhaps more appropriately called nature study – nor of developing and organizing young people's commonsense reasoning. It requires more than challenging learners' prior ideas through discrepant events. Learning science involves young people entering into a different way of thinking about and explaining the natural world; becoming socialized to a greater or lesser extent into the practices of the scientific community with its particular purposes, ways of seeing, and ways of supporting its knowledge claims."
>
> (as cited in Schunk 2008, p 445)

According to James Treffil (2008), however, there are two processes at work under the name of "science education." One involves the training and education of future scientists and engineers and the other is the education of "the other 98 percent;" the students who are not aiming for careers in science and technology. Treffil states that the education of the engineers, scientists and doctors of our future is in good shape, but the general science education that the masses receive, in the mode that Driver espouses, is outdated and aims to make "miniature scientists" out of all students who cannot be "fully-fledged" scientists. Treffil mentions Dewey's proposal that the proper goal of general science education was to create a "scientific habit of mind," but his main motivation, according to Treffil, for this kind of education, was to produce people who could valuably contribute to society. Treffil extends this idea and calls it "The Argument from Civics:" science education should be adopting goals which support the aim of producing students who are active citizens and can engage in the public discourse that forms the fabric of a healthy democracy (Treffil 2008).

Lippincott and Bodner (1984) agree with this idea that the science curriculum at both school and higher levels has successfully prepared people for scientific careers but has failed to improve the scientific literacy of the general population. In talking about the legacy of chemical education they say:

> —Unfortunately, our record in improving the scientific literacy of the general population is poor. We have shown that we can accommodate to change, but we are neither as bold nor as creative as our best researchers. We have awakened to the needs of our students, but we have not learned how to deal successfully with these needs. We have recognized the need for a humanized science, but we have yet to contribute to creating it" (p 843).

This may be true in developed countries, but in the South African context, not only are we not educating the public, but we are also not producing enough scientists and engineers. Science take-up and pass rates both at school and university level are disappointing to say the least (Pandor 2008). In some way scientists need to be educated and trained and their citizenship developed, while still educating the public and younger audiences about science and its importance. With limited resources and an education system which is only slowly changing to accommodate Mode 2 style scholarship, methods of education that can combine the two goals will be of great use. Experiential methods of education that incorporate engagement with the community have been used to begin to accomplish these goals in the United States (Esson *et al.* 2005), and using these methods in South Africa is in line with the CHE and governmental guidelines for higher education (Bender *et al.* 2006). Chemical education along with all other spheres of education needs to move towards what has been termed ―a scholarship of engagement" (Boyer 1996 *as cited in* Bender *et al.* 2006).

2.3.2 Practical Work in Chemistry Education

Practical work has become an important component of science education over time, however, despite this, its role and functions have been topics of debate amongst science educators (Barton 1998). Despite the debate, there is some consensus in the field of cognitive learning that theoretical knowledge without practical application does not maximise learning. This is especially true if learning is generally defined as

> ―a enduring change in behaviour, or in the capacity to behave in a given fashion, which results from practice or other forms of experience" (Schunk 2008, p 2).

Bodner (1992) generalizes that active students learn more than passive students and qualifies this by saying:

> ―There is no doubt that watching others can provide valuable hints about the skills we should develop, but nothing can replace time spent practicing these skills on our own"(pp 187 – 188).

The relevant literature on the impact of practical work, will be discussed here, in relation to the context of the present study.

Hodson (1990) groups the reasons and rationale for students‘ enquiries during practical work into five sets, namely: to motivate students; to develop students‘ investigative skills; to promote the learning of scientific knowledge; to teach scientific methods and lastly to develop certain „scientific attitudes‘. Bradley and colleagues (1998) point to four similar reasons for practical work in chemistry. Practical work can make chemistry more authentic and appealing, render theoretical concepts more comprehensible, demonstrate the techniques of science and more obviously develop practical skills which are needed for research. They maintain that there is evidence that these objectives can be achieved but that practical work itself does not guarantee these positive outcomes.

Over the years, a number of reviews have been published on the effectiveness of the general chemistry laboratory (Schroeder & Greenbowe 2008). These reviews indicate that there is a lack of evidence to support the idea that traditional laboratories are effective in promoting meaningful learning. Chemistry thus becomes an irrelevance, engaged with methods and systems of the past. (Hawkes 2004 *as cited in* Schroeder & Greenbowe 2008) This has led the traditional laboratory approach to become a cookbook or verification method that does little to help students learn concepts (Bodner *et al*. 2008 and Kalivas 2008). Other researchers also criticize the effectiveness of the current use of practical work for teaching scientific concepts in that it is prescriptive, with students following a recipe and not necessarily thinking about the purpose of the practical work. Thus, strategies for maximising the impact of practical work are vital so that students can be given tasks that are „*minds-on*" as well as „*hands-on*" (Duckworth 1990 and Millar 2004).

Schroeder & Greenbowe (2008) go on to discuss the specific case of organic chemistry practical work which has been criticized for the same general reasons that the general chemistry laboratory has been. They highlight researchers who have argued for the incorporation of an element of discovery in laboratory activities to ensure that student interest and enthusiasm are retained.

In order for practical work to have a positive impact on students‘ learning of scientific concepts, the design and nature of the practical needs to focus on two domains of knowledge: the domain of ideas as well as the domain of objects and observables. For practical work to be effective, experimental design must „*scaffold*‘ students‘ attempts to make a link between these two domains and must be approached in such a way that students‘ thinking is stimulated (Millar 2004 and Tuah 2008). A practical also needs to be appropriately designed and managed because if learners do not see the value in the experience, the enthusiasm of both teachers and learners quickly declines (Bradley *et al.* 1998). It is an obvious conclusion that if the purpose of the exercise is hidden, very little learning will take place. It is necessary to evaluate students‘ learning during the practical under consideration in context of these reasons and conditions for doing practical work (Tuah 2008).

2.4 Service-Learning: an Historical and Pedagogic Perspective

2.4.1 A General Historical Overview

Bringle and Hatcher (1995) define service-learning as a

> „course-based, credit-bearing educational experience that allows students to participate in an organized service activity that meets identified community needs and reflect on the service activity in such a way as to gain further understanding of course content, a broader appreciation of the discipline, and an enhanced sense of civic responsibility"(p 112).

Jacoby (1996) uses a slightly different definition which has the same basic principles but does not insist that the service-learning must be course related.

> „Service-learning is a form of experiential education in which students engage in activities that address human and community needs together with structured opportunities intentionally designed to promote student learning and development. Reflection and reciprocity are key concepts of service learning" (Jacoby 1996, p 5).

There is debate on what exactly service-learning is, even within the research fraternity (Jacoby 1996). Billig and Eyler (2003) also discuss this particular aspect of the debate –

Does service-learning by definition have to include the acquisition of academic knowledge and skills? They maintain that the answer in Higher Education is ~~"m~~aybe." For the purposes of this project, however, the Bringle and Hatcher definition will be used.

Service-learning is one of many trends in pedagogy that together mark a change in undergraduate education from an emphasis on teaching to one on learning (Jacoby 1996). The roots of service-learning are found in experiential education, internships, volunteerism and other forms of project-based learning. What is different about service-learning, however, is ~~"th~~e unique way in which service and learning have been combined and way in which service-learning are being discussed as a pedagogy in K-12 and higher education institutions" (Billig & Eyler 2003, p 225).

Even the way that ~~"s~~ervice-learning" is written has been discussed and debated, and both Kraft (2002) and Jacoby (1996) refer to Sigmon's (Sigmon *as cited* in Jacoby 1996, p 5) explanations of four typologies of service-learning. Service-LEARNING refers to a context where learning goals are given primary importance and service outcomes are secondary. SERVICE-learning refers to the situation where the opposite is true. Service learning, with no hyphen, implies that learning goals and service outcomes are not connected, and service-learning implies to the contrary that service goals and learning outcomes are of equal weight. According to Sigmon the hyphen is ~~"e~~ssential" (Sigmon *as cited* in Jacoby 1996, p 5). Jacoby goes on to say that the ~~"h~~yphen in service-learning is critical in that it symbolises the symbiotic relationship between service and learning" (Jacoby, 1996, p 5).

According to Eyler and Giles (1999), ~~"s~~ervice-learning...suffers from the lack of a well-articulated conceptual framework." The closest service-learning comes to having its own theory is Dewey's educational theory and Kolb's (1984) experiential learning theory which is based on Dewey's work (Bringle 2003). Service-learning began to come into being in the 1930s as a direct response to Dewey's theories of experiential learning, but it appeared in the applied and professional disciplines. For social workers, nurses, teachers and many other professions practical training was mandated by the regulatory bodies and

organisations responsible for the fields. This was in conjunction with the theoretical training received at school. This practical training was in many instances what we would call service-learning, but until recently Higher Education in the general or liberal arts, has remained ―largely immune" to service-learning (Erlich 1996, p xiv).

From the 1960s Kennedy's campaign, ―ask what you can do for your country," his 1961 formation of the Peace Corp. and the 1965 formation of the Volunteers in Service to America (VISTA) programme, the idea of social justice and work for the greater good began to take off amongst college students and young graduates (Erlich 1996). Jacoby (1996) adds to this that the shift came in the 1960s from a focus on teaching to a focus on learning.

The 1980s brought about the formation of Campus Compact: The project for Public and Community service. While college presidents formed Campus Compact to combat the ―me" generation and involve students in service projects, a group of recent college graduates formed the Campus Outreach Opportunity League (COOL) and began a student driven initiative of service and outreach projects. The 1990s saw Clinton bringing in the Learn and Serve America programme and from then, service-learning has gained in popularity and begun to establish a strong theoretical base, both in the United States and internationally (Erlich 1996 and Eyler & Billig 2003).

Eyler and Giles (1999) in their book, ―Where's the learning in Service-learning?" begin to articulate the many areas in which service-learning can enhance and facilitate learning. They define six areas of learning which will be used in this study as a foundation on which to describe and outline the kinds of learning taking place in service-learning. They are:

- Personal and Interpersonal Development
- Understanding and Applying Knowledge
- Engagement, Curiosity and Reflective Practice
- Critical Thinking
- Perspective Transformation

- Citizenship

2.4.2 A South African Background to Service-Learning and Community Engagement

Community engagement and service-learning are entrenched in a number of South African policy documents. These include the Green Paper on Higher Education Transformation (1996) and The White Paper on Higher Education (1997), which is mentioned in the introduction to this thesis. Explicit goals are articulated in the White Paper to transform Higher Education by

- **Increasing and expanding participation** in Higher Education to accommodate a student population that is larger and more diverse. This will be achieved by policy that overcomes historical barriers and fragmentation and by generating new curricula and new models of teaching and learning with increased flexibility.
- **Increasing sensitivity to social needs and community interests** by implementing policy that restructures HEIs to meet the needs of an emerging technologically reliant economy.
- **Promoting cooperation and partnerships in governance.** Successful policy must remodel the relationships that exist between HEIs and state, civil society, stakeholders and other institutions.

Social responsibility is affirmed as a goal of higher education and the paper states the aim to "promote and develop social responsibility and awareness among students of the role of higher education in social and economic development through community service programmes" (Department of Education 1997, p 10) at a national level. At an institutional level, the goal is identified as making expertise and infrastructure available for community service programmes and in so doing demonstrate the social responsibility of institutions and their commitment to the common good (Department of Education 1997).

The White Paper on Higher Education (Department of Education 1997) laid the foundation for making community engagement an integral part of higher education in South Africa and as a result of this, the Joint Education Trust, now known as JET Education Services and the Higher Education Quality Committee (HEQC) were formed (van Schalkwyk 2009). On the back of the release of the White Paper, in July 2000, the JET Community – Higher Education – Service Partnerships (CHESP) held a meeting of vice chancellors of various HEIs and other stakeholders to discuss the direction for community service in higher education. Some of the major decisions that were reached at this meeting can be found in the report. The consensus was that community service in South African HEIs should take on an eclectic and multi-faceted form.

Some of the concepts discussed were:

- **Education for Citizenship:** where HEIs should ~~"re~~vive the notion of civic responsibility through their teaching, research and service programmes"(JET Report 2000, p 3)
- **Add on vs. Integrated Approach:** It was agreed that community service in South African Higher education should not be an ~~"a~~dd on" or solely philanthropic exercise. Rather it should be a central part of the mainstream teaching and research business of South African HEIs (JET Report 2000).
- **Scholarship of Engagement:** The focus on teaching and learning as the dominant paradigm needs to be changed and restructured so that a scholarship of engagement can be rewarded and promoted through the merger of teaching, research and service (JET Report 2000).

The report also articulates the next steps for growth and good practice and advocates the development of guidelines and support systems to speak to community service in Higher Education, in its various forms (JET Report 2000).

The HEQC guide to Service-Learning in the Curriculum (Bender *et al.* 2006) was subsequently developed to summarise the background to service-learning and articulate

how to apply it to the curriculum. This resource focuses on one aspect of community engagement, namely service-learning, and includes contributions from South African specialists in the field which explain and expand on the practice of and approaches to service-learning in higher education (Singh 2006).

2.4.3 Service-Learning as Pedagogy: a Theoretical and Conceptual Summary

The JET/HEQC Guide states that service-learning is based on the pedagogical foundation of experiential learning and embedded in theories of constructivism and that to ensure that service promotes substantive learning, service-learning connects students' experience to reflection and analysis in the curriculum (Bender *et al.* 2006).

There are numerous theorists on whom service-learning relies to explain its pedagogical foundations and practice (Bender *et al.* 2006), and the two main theorists on whose work in experiential learning we draw, are John Dewey and David Kolb (*Ibid*). Their ideas, as discussed earlier, form the basis for learning through experience and reflection.

Conceptually, service-learning, as previously discussed, has many different forms and the term itself has been debated. Figure 2.4.3.1 shows the different categories of community engagement that service-learning brings together. All these forms of community engagement have their roots in experiential learning. Although these different forms have separate definitions, the boundaries between these categories are not fixed, and at any stage learning activities integrated in academic programmes may shift either way on the continuum (Bender *et al.* 2006).

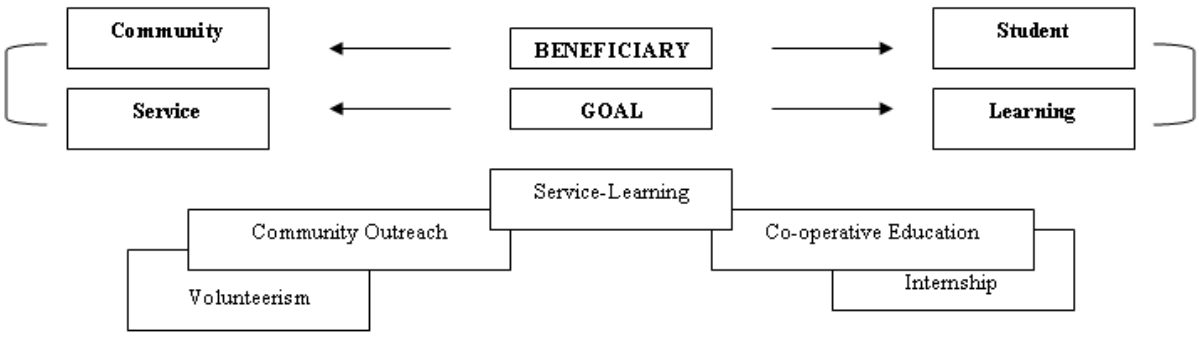


Figure 2.4.3.1 *The service-learning continuum* *(Adapted from Bender et al. 2006)*

On the community and service focused end of the continuum, Volunteerism and Community Outreach are both forms of engagement where the primary goal of the activity is to provide a service that benefits the community, the recipient of that service. Typically, community engagement involves more structure and commitment from the students than volunteerism, and as students begin to engage in formal academic discourse around service issues, the activity moves more towards the centre of the continuum and closer towards service-learning. On the other end of the continuum, internships engage students in activities where their learning is the primary goal and the main beneficiaries are the students themselves. In general, internships are fully integrated with the curriculum. Similarly, in co-operative education, the goal is learning and the student is the primary beneficiary. These activities are usually co-curricular in nature and related to, but not fully integrated with the curriculum (Bender *et al.* 2006).

In order for an activity to be classified as service-learning, the Bringle and Hatcher definition must be kept in mind and service-learning should characteristically involve the following:

- **Relevant and meaningful service to the community (Reciprocity):** the community should need and want the service that the students are offering. The students‘ skills and interests should be valued by the community who see the activity as worthwhile.
- **Enhanced academic learning:** Clear connections must exist between the course objectives and service activity. Student learning must be strengthened by the service-learning experience.
- **Purposeful civic learning (social responsibility):** Knowledge, skills and values making a clear and purposeful contribution to the preparation of students for active participation in civic affairs and therefore developing social responsibility.
- **Structured opportunities for reflection:** As discussed earlier in the chapter, experiential learning theorists see reflection as crucial for the transformation of knowledge through experience. Reflection assists in gaining a deeper

understanding of module content and a broader appreciation for the discipline as well as an enhanced sense of personal values and social responsibility (Bringle & Hatcher 1995; Eyler and Giles 1999; Eyler 2001; Kolb 1984 and Bender *et al.* 2006).

Existing programmes for student volunteers, like the Rhodes University Community Engagement Centre Student Volunteer Programme, do much good for the community, but the service goals are placed high above any learning outcomes that may result from the volunteering. The volunteer work has no academic credit and there is very little recognition of students‘ efforts in relation to their coursework. Much of the work the students do has no relation to what they are studying and is rather an act of giving during which little academic learning takes place. The service is, in other words, developing the person without developing the student. It is volunteer work, without the benefits of service-learning.

Some of the problems in developing service-learning opportunities are that when departments do develop service learning course components, the work that is done by the academics and lecturers is seldom seen as research, and often has little to do with the research direction of the parties involved. Faculty may spend a large amount of time developing service learning components for courses, but these efforts are often not linked to their research and are thus not highly rewarded in terms of university promotion and tenure (Kenny *et al.* 2002). Kenny *et al.* (2002) state that, ―Service Learning curricula are sometimes viewed as promoting affective development, at the expense of more rigorous academic content" (p 5).

However, while these are the real problems in both practicality and perception, there is world-wide, increasing pressure from politicians, university trustees and alumni, as well as communities and already volunteering students, to use the research and education resources of universities and colleges to add value to the communities in which they are situated. The drive to merge education and outreach is gaining momentum (Kenny *et al.* 2002).

Most colleges and universities do seek to create successful alumni, —people who will contribute positively to their own lives and to the lives of their families and communities" (Kenny *et al.* 2002, p1). However Kenny *et al.* (2002) maintain that there is in fact much more that colleges and universities can, and hopefully will, contribute to the well-being and positive functioning of the communities within which they are embedded,

> —...than only the education of students who will occupy jobs associated with the knowledge and skills inculcated through curricula offerings. Most higher education institutions are beginning to aspire to reach out to communities, and to use their research and educational programmes to add value to civil society" (p 1).

2.4.4 Service-Learning in Chemistry Higher Education

In South Africa today, there is a dearth of skills in the sciences and a severe lack of money and resources to teach science properly in impoverished communities. Science faculties in universities thus have an added responsibility to engage with the community in making resources and teachers available to bring skills and services to those without access to them. It is very important that chemistry is given its place in this endeavour. At the meeting of the American Chemical Society in autumn 2000, the ACS Education Division's Experiential Programs in Chemistry (EPiC) activity and the Pew Charitable Trust sponsored a Service Learning Blueprint Meeting. In their report they observed that,

> —Chemistry, as the central science, is uniquely positioned to serve needs in the community. Roles for chemistry students include supporting K–12 education, improving science literacy among the general public, and investigating scientific issues that impact society" (Wiegand and Strait. 2000, p1538).

2.4.5 Service Learning in Chemistry – improving teaching and learning

According to Sutheimer (2008), service-learning in the sciences has been very successful in chemistry courses with an environmental or analytical focus, as well as in programmes that provide tutoring or chemistry demonstrations for junior and high school learners. An example of a programme such as this is the Grahamstown Khanya Maths and Science Club. Here students, under the supervision of lecturers from Rhodes University, have the

opportunity to tutor school children from impoverished local schools in mathematics and physical sciences, doing demonstrations and helping learners improve their chances of a good matric result by supplementing the school syllabus (*Khanya Maths and Science Club* 2007). However, this programme has no academic credit attached to it, and the volunteers are recognized only through the ―service" pillar of academia and not in terms of their academic results.

―Integrating service activities into chemistry courses has become increasingly popular as a teaching and learning tool" (Sutheimer 2008, p 231). Recent research has shown that service-learning which is curriculum-based has manifold benefits for the student, including entrenching of skills learned in course-work, as well as generally improving thinking skills and application of learned concepts to real-life situations (Esson *et al.* 2005). In fact, American college students who participated in a tutoring project for secondary school students in science achieved higher results on standardized tests than those who did not participate (Lee 2006 *as cited in* Sutheimer 2008).

2.4.6 Incorporating Service-Learning

Improving the public perception of chemistry and increasing the number of qualified high school chemistry teachers were put forward as goals for the discipline by the president of the American Chemical Society (Carroll 2005). University service-learning courses can promote both of these objectives at the same time. The service- learning process connects students with the community while simultaneously achieving learning outcomes (Wiegand & Strait 2000). For example, students may conduct chemical analysis to assess water quality (Draper 2004), participate in screening for lead paint (Kesner & Eyring 1999), or develop chemistry projects or demonstrations for local elementary schools (Esson *et al.* 2005). Many of these initiatives are in the context of a larger course, with the service-learning component encompassing a part of the laboratory curriculum (LaRiviere *et al.* 2007).

Sutheimer advocates using the Higher Education Institution itself as a community partner. In many instances the kind of service opportunities that are available in this context may be more suited to the course content than off-campus community service. She opines, "While many strict service-learning advocates may find this to be problematic, rural and sometimes urban colleges often find a paucity of nearby community partners with course related needs" (Sutheimer 2008, p232). However, many colleges and universities have large grounds and chemistry classes can contribute to building databases with long-term benefit by, for example, "monitoring the water quality of campus ponds or determining soil chemistries in college gardens, farms and forests" (Sutheimer 2008, p232).

2.4.7 Using Schools as a Community Partner

The benefit of service-learning programmes that specialize in tutoring or providing chemistry demonstrations for school-going learners cannot be underestimated. The advantages for the community and the students are manifold, as working together on special projects and demonstrations for schools enhances the course experience of students. Tutoring and projects like these are relatively easily negotiated with local schools that are often desperate for resources and skills in these areas. Here flexibility is again very important as both staff and students "may have to adjust their schedules as well as their ideas of what a chemistry class 'must' entail," to enable such programmes to be feasible (Sutheimer 2008, p 233).

These kinds of programmes are usually longer term, comprising of anything from a few weeks to an entire semester. LaRiveire *et al.* (2007) developed a service-learning course to be offered over 4 weeks at Colby College. Their goal was "for students to apply the chemical principles they had learned in prior courses in new settings and contexts to benefit the community" (p 1636). This was to be achieved by creating a programme of hands-on activities for children from Grade 1 to 5 level that would illustrate chemistry's place in society. The students themselves developed these activities and demonstrations

during laboratory periods, after being lectured on key concepts required for science at this school level. Before each laboratory period, each student was required to submit a proposal detailing two activities to investigate key concepts (LaRiviere *et al.* 2007).

Students were assessed on all aspects of the work they had done over the four weeks, they had a laboratory notebook which was marked weekly – this formed the bulk of the mark – as well as being marked on the teacher kits, the classroom visits, the children's visits to the college and their final multimedia presentations. Students had a very positive response to the course with unanimous agreement that the course had been effective (LaRiviere 2007).

Teachers whose classes were visited by the students or who brought their classes to the college were equally enthusiastic, saying the visits really made the children excited about science and the possibilities open to them through science education. "It makes (college) seem like a less far off, scary unrealistic place and goal" (LaRiviere 2007, p1639). Chemistry students can help combat scientific illiteracy by making chemistry accessible for young school children and build their own confidence in the process. Through service-learning researchers and practising scientists are able to "share the excitement of (their) discipline with the college students of tomorrow" (LaRiviere 2007, p 1639).

A similar kind of programme was developed by Esson *et al.* (2005) at Kalamazoo College. In this first year chemistry programme, students completed a service-learning project in which they used topics learned in the course to propose and implement chemistry projects with the students of a local elementary school. Every class at the school from Kindergarten to Grade 6 was involved in the programme. Seventy-nine percent (79%) of the students in the school come from disadvantaged socioeconomic backgrounds and so the programme aimed to introduce chemistry in a fun and supportive way which would enhance and supplement the curriculum and encourage more disadvantaged students to pursue scientific careers (Esson *et al.* 2005).

This service learning course ran over an eight week period and the students were split into small groups assigned to a specific grade. The project ideas were put forward by the chemistry department at the college and the school teachers chose the project ideas that were suitable for their classes.

Students were not enthusiastic about the positive effect the project had on their understanding of course material. They felt the projects were too simplistic to help them with the chemistry, although the project had really been worthwhile in that it had helped to increase their interpersonal and communication skills as well as really benefiting the community. Students did agree though, that their ability to design and optimize an experiment was improved, as their usual practical sessions involved following a step by step procedure with very rare experimental difficulties (Esson *et al.* 2005).

Interestingly, Esson and colleagues also looked at the effect that service-learning had on the number of chemistry majors at Kalamazoo College. In comparison to the eight years prior to the introduction of the service-learning component of the course, the size of the chemistry major class has increased significantly since the project‘s inception. While service-learning cannot be attributed to be the sole cause of this increase, the finding is very interesting as there has been little research into the impact of service-learning in attracting students towards majoring in a subject (Esson *et al.* 2005).

Overall, the service-learning project at Kalamazoo College has proven to be very successful with goals of improved problem solving and communication being met for the students. There has been a good response from the community partner, as well as some evidence to suggest that service-learning improves enjoyment and perception of chemistry to the point that more students will choose to continue with the subject to a higher level (Esson *et al.* 2005).

2.4.8 Service-Learning at Museums and Science Centres

Another way that service-learning can take place in chemistry is to have chemistry displays and interactive workshops at places like museums and science centres. The Sciencenter in Ithaca, New York is a science museum with the mission to ~~"in~~spire people of all ages and backgrounds to discover the excitement of science through programmes and exhibits that promote learning through interaction" (Silberman *et al.* 2004). This presents the perfect opportunity for exhibits and activities that can be developed and supervised by students at local colleges and geared towards children from 4 to 10 years of age.

Cornell University in Ithaca developed a fun programme of activities to be run by college and high school student volunteers, but the students themselves could easily design the simple experiments as well as research the safety aspects of each activity. The programme was a great success involving various simple colour-changing and noise-making exciting experiments with non-hazardous reagents that young children would find both absorbing and fun (Silberman *et al.* 2004).

Ten activities were developed and each was presented as a challenge. Each activity involves relatively simple chemistry so that student volunteers with a single high school or college chemistry course can easily be taught to do these activities with visitors. The ten activities range from making up solutions from various substances and discovering which conduct electricity to make a buzzer buzz, to discovering the difference between genuine fruit juice and artificial juice made of sugar, water and food colouring. The activities, while developed for a museum venue, could easily be used for chemistry outreach or an enrichment programme (Silberman *et al.* 2004).

Besides tutoring and providing enrichment programmes for school-going children, service-learning in chemistry can also form a platform for very important community work with a wider effect, benefiting the community by collecting data over a long period of time to add to databases of important information, to analyzing water supplies, soil contamination, and lead paint analysis (Wiegand & Strait 2000).

2.4.9 Contributions to Larger Projects

Alison Draper at Bucknell University integrated project-based service learning into an advanced environmental chemistry course. She maintains that

> —whenlearning is measured not only by the quantity of information students gain, but by how much they can transfer to new problems in new situations, evidence is mounting that more active approaches, particularly involving projects that can benefit others, are especially effective as an approach to teaching" (Draper 2004, p 221).

This service-learning effort is unique compared to the ones already discussed in that it is for third and fourth year as well as masters students. A variety of project ideas were discussed with the class, all stemming from community requests Draper had received over the previous two years. The final five projects were:

- Analysis for gasoline contamination in soil in a local neighbourhood
- Exposure to environmental tobacco smoke in local restaurants and bars
- Assessment of water quality in the Nueva Vida, Nicaragua medical clinic
- Analysis of drinking water quality in a local neighbourhood
- Assessment of particulate matter sources in a local neighbourhood

(Draper 2004).

Students discussed ethical issues surrounding community based research and they developed sampling plans by using methods derived from published studies on the subject. Since it was a semester long project, students were encouraged to think carefully about how many samples they could collect and analyze in the time provided (Draper 2004).

Student response was very positive. A better understanding of the course work in relation to real-world chemistry was evident, and since the project was performing a service, students were concerned that their results and findings were accurate to report back to the community in which they were doing the research. One student said, —Doing our individual research...gave me an idea of how relevant and helpful environmental

chemistry can be to the community. My favourite part of the research was actually presenting something worthwhile" (Draper 2004, p 223).

In summary Draper believes the service-learning approach was a great success, with students really engaging with the subject matter and gaining insight into how environmental chemists work. She believes more could have been done to emphasize the community benefits of the project and more time could have been allowed for discussion and reflection, both by the students in relation to their projects, but also with the communities who were being helped by the information gathered (Draper 2004).

Another helpful community project analyzing the lead in the paint of houses in a certain area was conducted by the students of Kesner and Eyring (1999). At the University of Utah, students analysed the paint of houses in an old neighbourhood.

> "The service-learning guidelines of the university require that the project be useful to a particular nonprofit agency and since The City/County Health Department had an interest in assessing the extent of the lead-paint problem in older neighbourhoods and educating the public about the hazards of lead paint it was decided to marry service-learning with student experiments examining lead-based paints" (Kesner & Eyring 1999, p 920).

The students were required to research and write an essay on lead poisoning as an introduction to the project. In addition, each student kept a long-hand journal of the service-learning experience. After attending a lead-hazard lecture, the students, armed with flyers went to their assigned neighbourhood. Small samples were collected from the exterior of the houses, encompassing as many layers of paint as possible. Kesner and Eyring believe that the educational value of the sample collection exercise was in itself significant. In a typical first year practical,

> "students receive and treat samples with no consideration of their source or representative nature. In the service-learning course, students experienced the difficulty of extracting a small sample that would be representative of the site as a whole" (Kesner & Eyring 1999, p 921).

The course fired enthusiasm for all aspects of the required learning. Analysis was particularly rewarding; students learned new techniques of analysis and were careful to be as accurate and precise as possible. They seemed to view the lead paint sample

preparation and analysis as more important than analyzing the previously analyzed _unknown' sample as in other practical sessions (Kesner & Eyring 1999).

2.4.10 The Simple Short Project

2.4.10.1 Water Sample Collection

Sutheimer maintains that "flexibility of the teacher, curriculum, and institution is the key to integrating service-learning into the course." (Sutheimer 2008) Simplifying strategies, coupled with this flexibility should enable successful incorporation of service-learning into course-work. One of Sutheimer's simplifying strategies is the "Simple Short Project" or SSP which moves away from the idea that service-learning has to include a long term commitment to a particular community partner, which can prove problematic when coordinating practical and lecture times. The idea behind an SSP is to use a simple project to illustrate the main point of a course. An example of a successful project of this nature was one undertaken by the general chemistry class at Green Mountain College, Poultney. At the request of the director of the local watershed district, the class was involved in collecting water samples for analysis at a number of collection sites.

Using only one practical period of 4 hours and two short lecture periods, the class learned of the importance of quality and representative sampling for the validity of the final results of the analysis as well as sampling techniques, labelling and the handling of surface water at a river or lakeside location. They then used the practical period to drive to the collection sites off-campus to collect the river water samples using the techniques that they had learned. While a relatively simple project, the contribution of the class was meaningful to the students, who felt that they had achieved something worthwhile and applied their knowledge to "real-world chemistry," and to the community partner who felt that the value of the work they were doing increased enormously when the students, "not only help gather data, but then learn from it and share their knowledge" (Sutheimer 2008, p 232).

2.4.10.2 Dyes

Another project undertaken by the same college but with a class of first year organic chemistry students was similarly successful. One of the set practical projects was investigating the chemistry of colours, astringents, dyes and dyeing. Students had to collect natural materials to make the dyes and they usually dyed swatches of cloth or wool in the laboratory. Service-learning was incorporated into this practical by dyeing one-piece baby clothing for a local non-profit organisation that serves children and families in the local community of Green Mountain College in Vermont. According to Sutheimer, while the ~~–b~~asics and theory of the experiment did not vary much from previous iterations, the focus of the lab became completely different" (Sutheimer 2008, p 232).

Rather than rushing to get through the basics of the experiment and leave, the students made colourful, patterned clothes for the Vermont Achievement Centre to distribute to families in the area, feeling that the experiment ~~–f~~elt more purposeful than most of the other labs" they had previously performed, since what they had done had ~~–e~~nded up benefiting children in a rather important way – clothing them" (Sutheimer 2008, p 232).

2.4.11 Conclusion

From all these applications of service-learning to chemistry, it can be seen that not only is service-learning a viable way for students to learn about chemistry in a real-world environment, but also it is a way of bringing a deeper appreciation for the discipline of chemistry and its place in the world as a whole.

Important skills can be learned such as accurate and well-documented sample collecting and preparation, and opportunities for analytical skills to be learned are endless. The personal satisfaction gained by the student when completing a project that is for the greater good and has some use besides allowing him or her to pass or fail is also immeasurable. Possibly more important than the chemistry itself, is the knowledge of

how to use skills and information wisely and what a scientist‘s obligations are both towards communities and the education system.

Reflection sessions after service-learning projects have the distinct possibility of introducing important questions to science students. ―Is it moral for scientists to divorce themselves from the uses of their findings? Will moral concerns about uses undermine scientific objectivity?” A deeper understanding of the scientific aspects of the project can be gained with students coming to the realization that they can understand a scientific question and can collect data, analyze it and make sense of it in order to answer that question (Kesner & Eyring 1999, p 923). It is in reflection that the real opportunities for enhanced learning take place, as this is the heart of experiential learning, where knowledge is transformed by and through the experience of the learner and new knowledge is created as a result of the cooperative experience (Kolb 1984 and Schunk 2008).

Kesner and Eyring maintain that ―it is the connection between classroom learning and the service that differentiates service-learning from other volunteer activity” (p 920). This connection may yield a variety of important and desirable results:

> ―A student who recognizes an immediate use for the knowledge may become a more motivated learner and may voluntarily acquire advanced skills in the performance of his or her service...The student may be evaluated on an activity more directly connected to future employment than the typical undergraduate exams...The student may receive personal satisfaction from performing useful service...The elements in the community benefiting from a service-learning project may be inclined more favourably toward the academic institution and toward advanced learning in general”(Kesner & Eyring 1999, p 920).

If successful service-learning projects are implemented at tertiary institutions, all these benefits ensure that there is the distinct possibility of all round upliftment: the students benefit from an improved learning experience, the community benefits from the service provided and the institution creates a positive public image, enabling future work to take place. This ultimately ensures that future students are made aware of the opportunities available through tertiary study (Esson *et al.* 2005), and the goals of the Education White Paper (1997) can begin to be achieved.

CHAPTER 3

RESEARCH METHODOLOGY

"Action research improves practice and understanding of practice, as well as alters the circumstances under which educational practice occurs." – (Marilyn Cochran-Smith & Susan L. Lytle, 1995, p vii)

3.1 Introduction

This chapter outlines the research design decisions made and the paradigm in which the research was undertaken, as well as the process of data collection, describing instruments used and reasons for choosing the critical action research and qualitative methodological approach. The first part of this chapter briefly summarizes the Action Research Methodology as understood from a Critical Theory perspective and presents the reasons for approaching the research in this way, as well as a critique of the methodology. The second part presents the sample selection and the ethical considerations as these were paramount in terms of how the study was designed. The third section outlines the research process. The development of the curriculum is discussed, as well as development of the research instruments, methods of data collection and data analysis. The chapter concludes with a summary of the research methodology.

3.2 Research Design

3.2.1 Critical Theory

The orientation most suited to the research questions is the Critical Research Paradigm or Transformative Paradigm because the research questions have an implicit change agenda (Connole 1998). The ontological perspective inherent in Critical Theory is that reality is shaped by social injustice and inequalities and that power structures influence the reality of the individual (Popkewitz 1995). The epistemological perspective is that interaction between people determines the *status quo* and to some extent individuals create their own reality by how they respond to the structures in place and interact with others. Some of

these structures can be viewed, as Carr and Kemmis (1986) elaborate, as _objective' over which the person has no control whatsoever, and others can be viewed as _subjective,' where the actor has the opportunity to change the way he or she sees and responds to his or her environment. How people are positioned by (in this case) access to education, is investigated. As Carr and Kemmis (1986) note, in this way, the epistemology of critical theory is essentially constructivist in nature. Constructivism is discussed in some detail with respect to learning in the previous chapter.

The goal of the research is to understand the other types of learning that take place in a service-learning context and to change students' awareness of the inherent structures and inequalities that determine their experience of chemistry education (Janse van Rensburg 2001). Since the purpose of my research is to affect change, and bring in a new pedagogical intervention which will improve practice and enhance learning, the Action Research methodology was implemented.

3.2.2 Action Research

Action Research, as viewed from a critical theory perspective, is the methodology in which the research agenda is well accommodated. Carr and Kemmis point out that for research to be called _action research,' it must be educational research which is not –research *about* education but research *for* education" (1986, p155). The Lewinian model for action research as extrapolated by Carr and Kemmis (1986) and Cochran-Smith and Lytle (1995), is seen as a non-linear, cyclical pattern of planning, acting, observing and reflecting. Carr and Kemmis call this a –spiral of circles" (p 164), where analysis, fact-finding and conceptualization of problems precedes the planning of action programmes, after which they are executed and more fact-finding or evaluation takes place, and the cycle begins again.

The National Invitational Seminar on Action Research held in 1981 at Deakin University, Victoria, agreed on the following definition of educational action research:

> —Educational action research is a term used to describe a family of activities in curriculum development, professional development, school improvement programs, and systems planning and policy development. These activities have in common the identification of strategies of planned action which are implemented, and then systematically submitted to observation, reflection and change. Participants in the action being considered are integrally involved in all of these activities" (Carr & Kemmis 1986, pp 164-165).

The idea of the spiral is preserved in this definition, as is the importance of participation which was an essential feature of Lewin's action research process (Carr & Kemmis, 1986). Lewin focused on understanding and changing human action, often around issues of reducing prejudice and increasing democratic behaviours, and so it can be seen that the origins of action research were often intertwined with social action towards increased social justice, although this was not always the case (Noffke 1995).

Carr and Kemmis divide "action research" into three types, the first emphasizing the technical aspects, the second the practical aspects (or moral/ethical aspects), and third the emancipatory aspects. Their treatment of the three types appears to move towards the idea that unless the research is emancipatory in nature, whether it is actually "action research" is debatable. Carr and Kemmis, for the purposes of critical enquiry, see emancipatory action research as the only option because the practitioner and group of stakeholders take joint responsibility for the development of practice and see understanding and educational situations as socially-constructed in the process of educational life (which is interactive by nature). In contrast, technical action research simply seeks effectiveness of practice, judged according to criteria which are not analyzed. Practical action research opens these criteria to analysis and participants monitor their own actions, learning more about the reasons for those actions through self-reflection, but the practitioner group does not become a self-reflexive community as it does in emancipatory action research (Carr & Kemmis 1986).

Noffke (1995), however, states that although these categories can be useful in understanding action research, they hide the ways in which interests interconnect and overlap and are all essential to educational practice.

While there is disagreement in some circles as to what is "allowed" as action research, there is consensus that action research improves practice and the understanding of practice as well as changes the circumstances under which educational practice occurs (Cochran-Smith & Lytle 1995). Carr and Kemmis explain this further, saying that

> "There are two essential aims of action research: to *improve* and to *involve*. Action research aims at improvement in three areas: firstly, the improvement of a *practice;* secondly, the improvement of the *understanding* of practice by its practitioners; and thirdly, the improvement of the *situation* in which the practice takes place. The aim of *involvement* stands shoulder to shoulder with the aim of *improvement*. Those involved in the practice being considered are to be involved in the action research process in all its phases of planning, acting, observing and reflecting. As an action research project develops, it is expected that a widening circle of those affected by the practice will become involved in the research process" (Carr and Kemmis 1986, p 165).

Action research is a deliberately social process. In embracing a view of truth and action as socially constructed and historically embedded, action research is not unique: research in the interpretive tradition embraces a similar view. However, action researchers, rather than trying to understand the significance of the past to the present, aim to change the present to produce a different future. Action researchers are thus deliberately activist in their approach (Carr & Kemmis 1986).

Carr and Kemmis (1986) explain that critical theory, and by extension educational action research, stands in opposition to the positivistic world view which sees knowledge as value-neutral and independent of the observer and aims to be 'objective' in research. It is also in opposition to interpretivist thinking which could be described as 'subjective' where the personal understandings of a participant form the basis for understanding reality. In contrast, critical researchers see reality as dialectical. There are some 'objective' aspects of social life which cannot be influenced by certain individuals at a particular time and in order to change the way that people act, it may be necessary to change the way these structures limit their action. Simultaneously the critical researcher recognizes that people's personal and therefore 'subjective' understanding of a situation can also act as constraints on their action and these understandings can be changed.

> "Action research recognizes that thought and action arise from practices in particular situations, and that situations themselves can be transformed by

> transforming the practices that constitute them and the understandings that make them meaningful. This involves transformations in *individual* practices, understandings and situations, and transformations in the practices, understandings and situations which *groups* of people constitute through their interaction. The double dialectic of thought and action and individual and society is resolved, for action research, in the notion of a *self-critical community* of action researchers who are committed to the improvement of education, who are researchers *for* education" (Carr & Kemmis 1986).

Thus an integral part of action research is its participatory nature and the idea of collaboration with all the people whom the research and the practice being researched affect (Whyte 1991). However, critical theory has also been condemned for these very reasons, the same reasons that its adherents claim makes it praiseworthy (Lincoln 1995).

Critical theory in its many forms is attacked for being —a subversion of the political neutrality and ideological disinterestedness that...the enterprise of education is all about" (McLaren & Giarelli 1995, p3) and the charge is often made that action research is always biased (Carr & Kemmis 1986). Since action research involves the researcher analyzing his or her own practice, the assumption is made that the findings of action research will always be unreliable and the result of —self-deception" or ideological distortion" (*Ibid,* p 192). This approach to the notion of bias suggests that there must be a value-free medium to describe praxis, unrelated to the values and interests of the observers (*Ibid*). Silverman (2001) cites Weber's (1946) argument refuting this idea, when he states that we must recognize that there is simply no neutral or value-free position possible in social science. According to Silverman (2001), paraphrasing Weber, all research is contaminated by the values of the researcher to some extent, and it is only through these values that certain problems are identified and studied.

> —Even the commitment to scientific (or rigorous) method is itself, as Weber emphasizes, a value. Finally, the conclusions and implications to be drawn from the study are, Weber stresses, largely grounded in the moral and political beliefs of the researcher" (Silverman 2001, p 260).

Thus, if _praxis' is defined as informed, committed action, then the *study* of praxis can only be *through* praxis (action with and for the critical development of understanding and commitment). Furthermore, construing this bias as a _problem' fails to understand that it is the purpose of critical science to expose and identify self-interests and ideological

distortions. Without this critical element, the researcher would, as Silverman (2001) puts it, ―look and inevitably find" examples which can be used to support their preconceived ideas. Action research as a methodology within the critical tradition aims to provide an escape from this unfortunate possibility because the researcher is not outside the process, looking in with a specific agenda, but rather within the process acting out an agenda which aims to address issues as seen from the researcher's perspective. In summary, action research is a deliberate process for emancipation ―from the often unseen constraints of assumptions, habit, precedent, coercion and ideology" (Carr & Kemmis p 192). Obviously any particular project only accomplishes these results in a very limited way, but this is the aim of critical action research.

Bloor (1997) discusses in some depth the various arguments both for and against using research to address problems and offer solutions to those problems by participatory action or action research. He posits that social researchers may address social problems by influencing practitioner practice. This can be done on two levels, firstly changing and influencing one's own practice as in the case of action research and secondly, with the rich qualitative descriptions available using the action research methodology, making the research accessible to other practitioners who were not the subject of the research itself.

Therefore, the research methodology, being action research, where the research itself will bring about a change, and participatory research where students will have the opportunity to contribute to the teaching and learning transformation process, lends itself to working in the critical or transformative paradigm, and suits the goal of the research project. As Lather (1986) describes, the lines between research, education and development become blurred in critical research projects, as critical research is in itself a form of praxis.

The project was thus arranged around the Lewinian action research cycle of strategic planning; implemented action; observation, analysis and reflection. This cycle overlaps to a certain extent with the Kolb learning cycle discussed in the previous chapter (Figure 2.2.2.1), and since the learning of the students was to be understood in terms of this theory, the project itself was planned in a similar way. Figure 3.2.2.2 schematises this

overlap. Reflection was incorporated at every stage which fed into the planning and action for the next stage. (See Figure 3.2.2.1) These stages are not discrete, however. In fact in many instances, the plans for a particular activity were changed during the activity because of what was observed. In this case observation, reflection and change can all happen simultaneously but also because of each other.

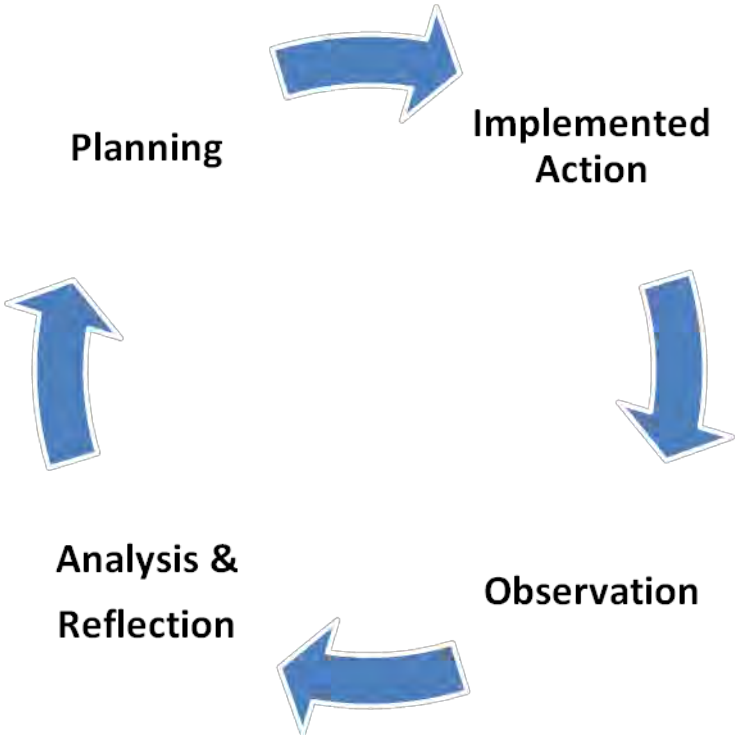


Figure 3.2.2.1 *A schematic representation of the Lewinian Cycle as explained by Carr & Kemmis*

In Figure 3.2.2.2, the possible overlap of the Kolb cycle and the Lewinian action research cycle are shown. One Lewinian cycle could contain an infinite number of Kolb learning cycles depending on how the research is undertaken and what activities constitute the planning, action, observation and reflection. Action research could itself be seen as a cycle of experiential learning, because knowledge about practice comes from the action that is taken and then reflected upon. In action research, by the systematic observation and reflection on practice, practice is transformed and knowledge created. This fits in with the definition of experiential learning; ~~"l~~earning is the process whereby knowledge is created by the transformation of experience" (Kolb 1984, p 38).

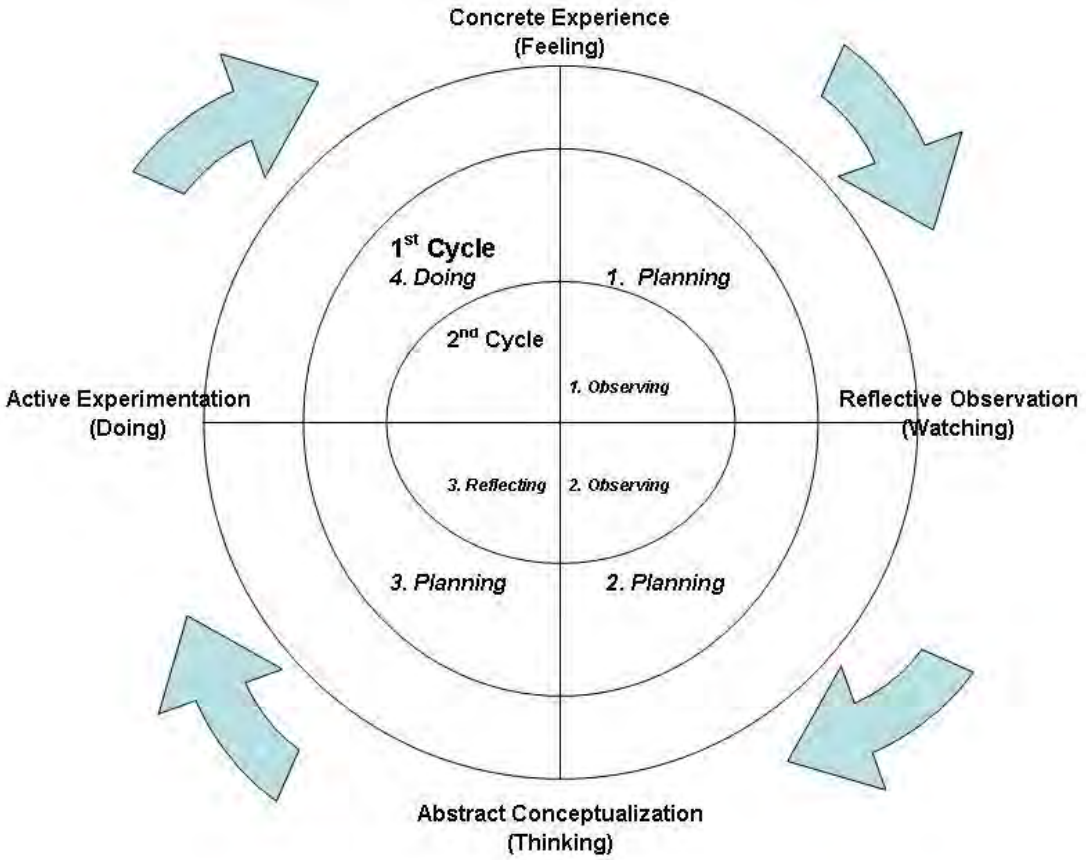


Figure 3.2.2.2 *A schematic representation of the possible overlap of the Kolb learning Cycle with the Lewinian Action research cycle.*

(Adapted from Kolb, 1984 and Carr & Kemmis, 1986)

Figure 3.2.2.2 shows how within the planning stage of the Lewinian cycle there could be Reflective Observation, Abstract Conceptualization and Active Experimentation. In other words, one stage of the Lewinian Cycle contains three stages of the Kolb Cycle. From there, the Lewinian cycle moves to ―Doing" in which Active Experimentation and Concrete Experience fit in. One Kolb Cycle is now complete. Moving into the second Kolb cycle, the Lewinian cycle can then be completed.

3.2.3 The Project Design

Due to the self-reflexive nature of the action research process and the precedent set by many critical researchers (Whyte 1991), the sections that follow are presented in the first person. This is a very brief overview of the background to this project, as this fed into

how the research was conceptualized. The research design decisions made and the process followed will be explained in detail in Section 3.4.

The idea for this project was conceived in 2008 after my Honours Review Essay focused on Service-Learning in University Chemistry courses. I had always been interested in chemistry education, and to me this presented a unique opportunity to connect the outreach activities of the Rhodes University Department of Chemistry, with the academic goals. After an oral presentation of my essay topic to the Department, there was palpable excitement and interest on the part of the Head of Department and various other lecturers on the potential presented by some of the examples presented in the essay to improve the alignment of outreach in the Department of Chemistry with practical organic chemistry. Some principles of service-learning had been included in one second year organic practical in 2008 entitled: "The Combinatorial Synthesis of Azo Dyes (Gung & Taylor 2004)." Instead of dyeing swatches of material which would simply be thrown away after the practical, t-shirts were tie-dyed by the students using dyes prepared in the practical session and these were donated to a local shelter for street children. The idea of dyeing clothing articles came from a Journal of Chemical Education article on service-learning in chemistry (Sutheimer 2008).

While this was a good start, some issues and problems arose from this practical experience which I observed in 2008 prior to beginning this research project:

- The practical was chaotic and messy and two practical periods were used, where the sole purpose of the second practical was dyeing t-shirts. Was this time well spent?
- The practical was time-consuming to organize and difficult to run
- The practical could not be termed 'service-learning' in terms of the Bringle and Hatcher (1995) definition because it included no reflection and the community was not a partner in the exercise.
- While students thoroughly enjoyed the practical, and seemed to enjoy dyeing the t-shirts, learning was limited to the usual recipe book style practical situation.

There was no accountability for the students to understand more deeply or to use the knowledge gained for a greater purpose than the practical itself. This had to do with the fact that no community members were involved, and the way that the practical was assessed (a normal _prac report').

- The dyes were not colourfast.
- The practical was not embedded in the curriculum, in the sense that connections were not made to coursework or lectures. (This is a problem inherent in the chemistry practical syllabus due to timetable constraints among other factors.)

As a result, the opportunity to research service-learning in chemistry became available as a Masters research project. In discussion with my supervisors and some university service-learning practitioners, the aforementioned issues were to be addressed by instituting curriculum changes and making service-learning a focus of a component of the practical syllabus in the second year organic chemistry course. Achieving this was considered to be easier if a separate person (the action researcher) was in charge of the practical and could organize the logistics as well as evaluate the success or otherwise of the project. This was how by both necessity and design, the project became an action research project. Rather than researching someone else's practice, I was provided with the opportunity to develop the practice and research its implementation.

At the outset it was decided that:
The service-learning component needed to fully embrace service-learning as defined by Bringle and Hatcher (1995) and not simply be viewed as a charitable _add-on' masked as outreach work. To fulfill these criteria, we needed to involve the community partner directly in the activity and in its planning.

- We needed to change the way learning was approached and evaluated in the context of this practical.
- We needed to find a way to embed the practical within the curriculum and link the lectures to the practical.
- We needed to prepare the students for this practical in a different way in order for them to gain the most from the experience.

- We needed to evaluate and understand the impact of service-learning on the students and their learning and discover what other areas of learning could be brought into the chemistry laboratory because of this experience. Our aim in this was not only to enhance the learning of science concepts, but to see if service-learning could change student attitudes towards the discipline and change their view of their own responsibilities in society and how this could be achieved.

The first Lewin cycle of action research was thus completed before the 2009 second year organic course began. This research project focuses on the second cycle as developed for the course of 2009. (See Figure 3.2.3.1) A third cycle will take place in 2010 based on the recommendations of this study.

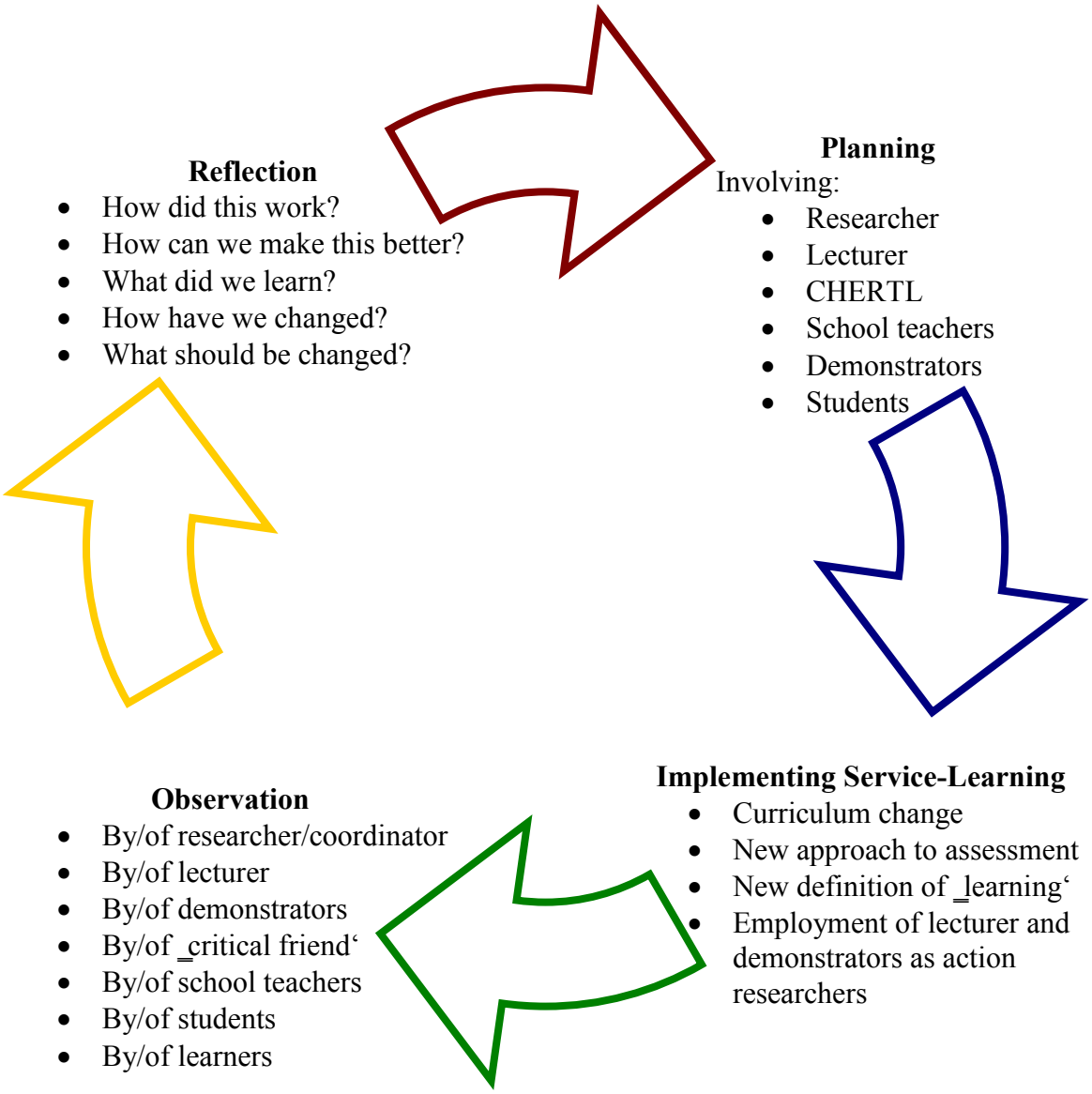


Figure 3.2.3.1 *The Lewinian Cycle for the 2009 Implementation of Service-Learning*

Since a curriculum change was needed, much of the first semester was devoted to curriculum planning and negotiation with the Head of Department (who was also the lecturer for the second year course and my supervisor). These curriculum changes and revisions will be discussed in detail in Section 3.4. Thus the first stage of planning could be termed ―Improvement." The component was tweaked and changed to improve learning. The changes were also vetted by a service-learning expert from Rhodes University's Centre for Higher Education Research, Teaching and Learning (CHERTL).

The expert became my ‗critical friend' and her suggestions and revisions were most helpful in ensuring that the service-learning outcomes were preserved, while liaison with the course lecturer ensured that his experience in lecturing in chemistry and wisdom with regard to how to approach undergraduates were kept in mind.

Issues of practicality and resistance on the part of the Department were minimal because of the researcher's relationship with the Head of Department. The project could be designed so that I, as a passionate activist for experiential learning and social justice issues as well as education for citizenship, could develop a curriculum which I believed would begin to accomplish these aims, while still fulfilling the mandate of the department to educate its students in chemistry. Involving the CHERTL also meant that the institutional aims for transformation and incorporation of service-learning could be kept in mind and the process illustrated the Carr and Kemmis' (1986) widening circles of participation beginning to come into effect. (See Figure 3.2.3.1 ‗Planning'.)

The second stage of planning could be termed ―Involvement." Because the Department of Chemistry already has links with a number of science teachers through weekly teacher training workshops that it runs for high school chemistry teachers, we were able to communicate with teachers about getting their classes involved in the project. In fact, the two teachers, who are deeply committed to education, were very excited about the prospect of their learners coming into the university laboratory to work with the students. These teachers who are passionate and excellent in their own practice, despite the limiting circumstances of their educational institutions wanted to motivate their classes to think further than just school science. In planning the activity the teachers were consulted about what dates would suit their classes, as well as the form that the activity should take. The teachers also decided which grade would be best suited for the dye activity. We had various ideas about what the learners could dye, but in the end the teachers felt that the t-shirts would be the best option.

In terms of obtaining data, observations on the part of the lecturer, demonstrators and the researcher were all collected and member checked. A pre- and a post-questionnaire were

administered to the students to track changes to thought processes, and the written reflections of the students provided more information on their experiences. An informal semi-structured interview was conducted with the demonstrators.

Figure 3.2.3.2 is a schematic representation of the whole process, from planning to implementation. A careful reading will elucidate the process discussed above and described in Section 3.4.

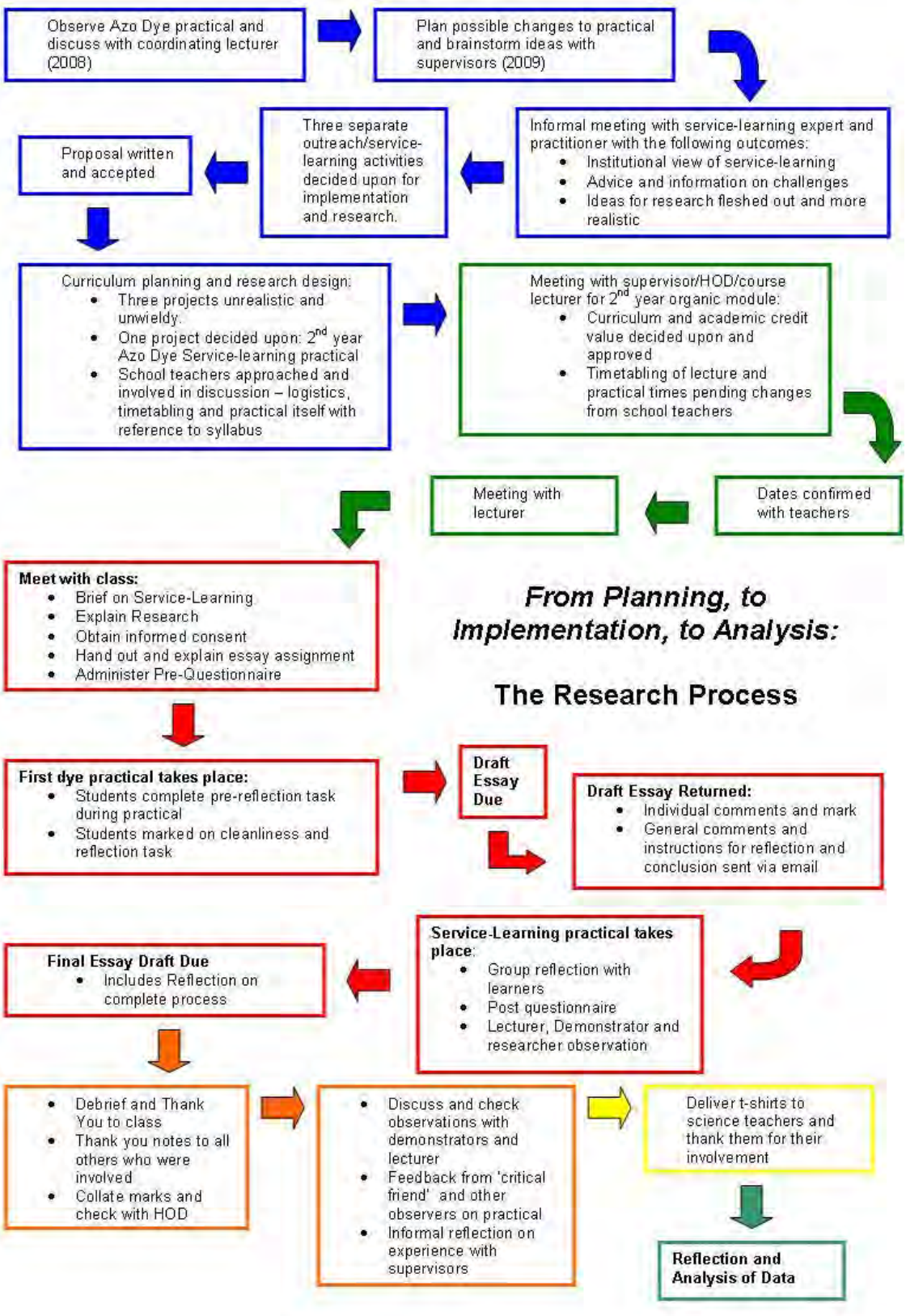


Figure 3.2.3.2 *A schematic representation of the stages of the research and design process*

3.3 Sample Selection

3.3.1 Ethical Considerations

Ethical considerations were of paramount importance when designing this study and deciding what exactly would be evaluated and explored. Silverman (2001) indicates that all social science research involves the consideration of ethics because people and their behaviour are being studied. He goes on to state that when studying people‘s behaviour and asking them questions, it is not just the values of the researcher that come into question, but the researcher‘s responsibilities to those being studied that need to be faced. With the need for ethical conduct and informed consent in mind, the project was designed.

Because of the nature of the project which involved dealing with university students (in second year and all over the age of 18), and school learners (probably under the age of 18), the decision was taken to focus the research on the students‘ experience of the service-learning course component. This negated the negotiation of perceived difficulties in obtaining permission from guardians of school learners in situations where there may be no parents or guardians, or where English is not the home language. Funding and time constraints did not allow for the lengthy process of translation and editing of consent forms. This decision simplified the informed consent procedure, as access to the class of students was part of implementing the course in the first place. Students were given an introductory lecture on service-learning and on the research project, where the reasons for doing the research were explained.

Students were forced by their course commitment to take part in the service-learning component of the course, and complete all the assignments associated with it, but the research aspect was voluntary. Letters detailing the research information and contact details were distributed at the lecture, along with informed consent forms which were signed by the whole class, apart from one absentee, on the day of the introductory lecture. Examples of this letter and form can be found in Appendices A and B. The letter faxed to

the two school teachers regarding their Grade 12 learners‘ involvement can be found in Appendix C.

3.3.2 Sample Description

The sample selected was a sample of convenience and proximity as well as a strategic sample, because the students involved in the project were in the Chemistry Department at the university where I was a student. The sample was strategic because within the curriculum there was already an opportunity to change and tweak an existing practical to incorporate service-learning, rather than to begin from scratch and design something entirely new. This allowed for minimal disruption to the timetable and less inconvenience to the course coordinator and lecturer.

As discussed in the previous section, the ethical considerations that would have become an issue had the focus of the research been the school learners, were not a problem when dealing with adult subjects. At second year level, students are ideally placed to be involved in something new, the classes are smaller than in first year, and the students are settled into university life and more mature. However, responsibilities and stress are minimal compared with third year, where students are completing their degrees, stressed for time and often not interested in activities that they perceive as not being examinable.

The second year class was also an ideal sample because the lecturer of the organic course and practical coordinator is also one of the supervisors of the research project and the Head of Department. This made it easier to change the practical component. This was very convenient and embraced the aim of inclusive and participatory action for research, as there were no obstacles to contact with the lecturer.

The class consisted of 37 students, both male and female and was representative of a diverse mix of races and socioeconomic backgrounds.

The learners involved in the service-learning practical came from two schools in the Grahamstown township areas. These schools are impoverished and under-resourced and draw their students from the township. The language of instruction in Physical Science at these schools is English, but the learners are all first-language Xhosa-speaking Grade 12 learners. The Grade 12 class was chosen by their teachers, as they felt these learners would benefit the most from such an experience, since organic chemistry and an introduction to light and spectroscopy is dealt with in the Grade 12 curriculum. A lower grade would not benefit as much from the practical because they would not have the chemistry background to understand what was being done.

3.4 The Research Process

The aim of this research is to explore the learning that takes place in a service-learning context and discover how these areas of learning impact the awareness of the parties involved with regard to the discipline of chemistry as well as social issues. We wanted to track changes in individuals‘ ideas about themselves and their discipline, and investigate the value of the knowledge they gain at university.

In order to explore the learning and changes taking place on the part of the students the following two research questions were formulated:

Question 1: How does service-learning change the way chemistry is learned and perceived by the student and what other (non-discipline-specific) learning takes place due to the service-learning component?

Question 2: How does this change students‘ awareness of social issues and their responsibilities as citizens of the society in which they live?

3.4.1. Background to the Second Year Organic Chemistry Course

Chemistry 202 is a second semester course and the organic module entitled "Strategic Organic Resources" is the first module lectured in the semester. The module consists of twenty lectures, during the third term. The course content forms the bulk of one of the two November examination papers, and is generally considered to be quite challenging by the students. The course covers organic chemistry from a practical and applied perspective, covering the theoretical concepts as relevant to the chemical industry, especially in South Africa (Chemistry 2 course outline 2009).

The course "Fossil fuels and organic chemicals" contains the following sections:

- Sources of organic chemicals: coal, petroleum, synthesis gas and primary refinery processes
- Alkenes and alkynes: applications and reactions as chemical feedstocks
- Cycloalkanes: structure, stereochemistry and synthesis
- Benzenoid aromatics: electrophilic substitution-reactions and orientation effects; nucleophilic substitution mechanisms; diazonium salts
- Heterocycles: structure and reactivity of basic systems

(Chemistry 2 course outline 2009)

The practical component of the course aims to support the course work, but consists mainly of organic synthesis and follows the practical manual which uses a 'recipe book' style.

Like most other courses at the university, CHE 202, the general chemistry course of which the organic chemistry module forms a part, has certain criteria that must be fulfilled in order for a Duly Performed (DP) certificate to be obtained from the university. The DP certificate allows the student to write the exam at the end of the course. In the case of CHE 202, the DP requirements for each student are:

- Attendance at ninety percent of all lectures (a register is taken)
- Satisfactorily perform all assigned tutorials, essays and practical work
- Any absence must be explained in writing with a Leave of Absence form

Thus each student was required to perform all the assignments and tasks set for them in the service-learning component. The marks for the course are heavily weighted towards the end of semester exam, which counts for 70% of the mark. The practical component over the course of the whole semester counts for 20% of the mark and the mid-semester departmental test counts 10%.

3.4.2 The Development of the Curriculum

According to Bender *et al.* (2006), curriculum is ~~a~~n explicitly and implicitly intentional set of interactions designed to facilitate learning and development and to impose meaning on the experience" (p33). Thus the curriculum design process involves formulating learning outcomes and designing activities that will create the environment for those outcomes to be achieved.

Curriculum development follows a cycle very similar to that of the Lewinian model for the cycle of action research. The HEQC Guide to Service-Learning in the curriculum (Bender *et al.* 2006) advocates a four step process for the ongoing development of a service-learning curriculum.

The four stages are (with the corresponding Lewin stage in brackets):

- Development and Design (Planning)
- Implementation (Action)
- Reflection and Assessment (Observation and Reflection)
- Evaluation (Reflection)

3.4.2.1 Design of the Service-Learning Module

To fulfil the Bringle and Hatcher (1995) definition of service-learning, the component needed to be course-related, for academic credit and include a reflection component. The HEQC guide provides a summary of the value of reflection:

> —Ctical reflection provides students with the opportunity to examine and question their beliefs, opinions and values; it involves observation, asking questions, and putting together facts, ideas and experiences to derive new meaning" (Bender *et al.* 2006, p 58).

The HEQC guide gives six principles for designing reflection. Reflection, whether it is structured or free, must

- Connect with the module content
- Be continuous with multiple opportunities for reflection, before, during and after the experience
- Challenge the student
- Coach: Provide support for the aspects of the module that are challenging
- Be contextualised: appropriate for the context of the module
- Enhance communication: reflection should provide opportunities for reflection with peers, staff and the community members

The reflection components were thus designed with these principles in mind. The reflection components were also useful to me because, aside from being a requisite part of the service-learning module they could provide a rich data source. Thus I wanted to ensure that the reflection times were productive and gave opportunity for both structured and free reflection.

As both a researcher and educator in this component, developing the course in collaboration with the lecturer was essential both to maintain the quality of the course and to ensure the quality of the research. The aim for the lecturer was to increase the students' knowledge in chemistry whereas my main aim was changing the curriculum and researching the effect that this had on the students' learning. Hence our different approaches were complementary in terms of curriculum development.

The HEQC guide provides a typology of learning outcomes which is in line with the outcomes-based education critical cross-field outcomes stipulated for South African education. These types of learning outcomes are listed below:

- Knowledge/understanding
- Cognitive skills beyond information acquisition
- Procedural skills
- Social skills
- Attitudes/Values/Self-confidence
- Personal growth

(Bender *et al*. 2006, pp 45-46)

The student learning outcomes desired for the organic chemistry service-learning module are listed below with the HEQC outcome type in brackets:

- A deep understanding of dye chemistry and its social context (Knowledge/Understanding and cognitive Skills)
- Ability to use the written communication medium effectively (Procedural skills)
- An understanding of academic writing, the conventions thereof and the acquisition of such skills (Procedural skills)
- Ability to draw chemical structures using computer software programmes (Procedural skills)
- Ability to reference correctly using the American Chemical Society numbered system according to the Style Guide (Procedural Skills)
- Ability to verbally communicate chemistry to both experts (lecturer and demonstrators) and novices (Grade 12 learners) (Social, cognitive and procedural skills)
- Knowledge of azo dyes and how to synthesize them (Knowledge/Understanding and cognitive skills)
- Understanding of safety hazards and safety protocol in the laboratory (Knowledge/Understanding)

- Working tidily and cleanly in the laboratory. Dyes are readily transferred to objects and people in the laboratory and tidiness and cleanliness can be easily monitored (Procedural skills)
- Ability to communicate and work effectively as a team (Social skills and Attitudes/Values/Self-confidence)
- Ability to plan, reflect and think critically about their experience to facilitate learning and future improvement (Cognitive skills)
- A deeper appreciation for the discipline of chemistry (Attitudes/Values/Self-confidence)
- An understanding of their own usefulness and the value of the knowledge that they have gained (Personal Growth)
- A sense of responsibility towards the community (Attitudes/Values/Self confidence)

3.4.2.2 The Introductory Lecture

The introductory lecture was used as a time to introduce myself to the class and elucidate for them the aim of service-learning and the goals of my research project. The ethics were explained to them as well as the issue of confidentiality vs. anonymity. It was explained that due to the nature of the research being based in the university, people might be able to find out who was involved in the study, but nothing that they said or wrote would ever be able to be traced back to them personally. The letters and informed consent forms were handed out, and the consent forms signed. The lecturer was also present while I talked to them and he interjected and added his own support and enthusiasm during my presentation.

Here the essay assignment was explained and handed out. The pre-questionnaires were also handed out and completed during the period. The completion of the pre-questionnaires (Appendix G. 1) concluded the lesson and provided the opportunity for pre-reflection on the part of the students.

3.4.2.3 The Essay: "The Chemistry of My Favourite Colour"

Kesner & Eyring (1999) suggested the use of an essay as an introduction to a service-learning project. This appeared to work well in these practitioners' situation and I felt that this would be a valuable exercise for our students as well. For these students this essay was the first time they had been required to write an academic paper within the discipline of chemistry. Thus the writing of the academic essay required the use of many skills which the students had never needed before. For this reason, a comprehensive handout detailing what was expected, as well as tips and hints for finding information, using both computer-based academic search engines and specified reference texts; drawing chemical structures and using accepted international protocols to reference their work. (See Appendix C.)

To prevent the students from all choosing the same colour, or the colour on which there was the most information, the students were first asked to write down their favourite colour before they were informed about the essay.

The aim of the essay was to provide the students with a background in dyes and dyeing and the chemistry related to that industry before they came into the laboratory to do the practical.

The essay required them to:

- research the general background of dyes and dyeing as well as more specific chemical information regarding the colour that they had chosen as their favourite
- to find a mechanism for the manufacture of the dye and thus they were introduced to understanding and drawing mechanisms from papers and sometimes very advanced texts.
- start thinking about the significance of dyes and dyeing and what the cultural implications are for colour chemistry.

Below is an excerpt from the assignment sheet they received, detailing what was required:

Your Essay Must Include:

- A general introduction to dyes, dyeing and the textile industry with reference to the importance of dyes in everyday life
- At least one industrial process (including the reaction scheme and mechanism) used to manufacture a synthetic dye of your chosen colour.
- A natural source of your colour dye and some background information with reference to when and where it was used and how it was discovered. You must find its chemical structure and try to find the social significance of the colour in the culture(s) which used it.
- General information on mordants/fixatives and how and why they are used.
- Information on how the dye binds to different textiles.
- A **minimum of 6 references** of which at least ***3 references must be from the books placed on short loan*** and at least ***2 journal/periodical articles*** as well as any other sources you might like to use, all referenced correctly in the ACS style.

A NOTE ON STRUCTURES:
Your structures must not be copied and pasted from the literature. All structures must be drawn in Symyx Draw using ACS Settings.

Symyx Draw is available for free download from www.symyx.com/downloads/ where you register for free and download the Symyx No Fee zip file.

Once downloaded, choose "Open a new document using a template" and load the ACS template from the File menu.

At between 2000 and 3000 words, the essay was a "big" assignment at the second year undergraduate level, which required them to hand in a draft. They had just over three weeks to write the first draft, and a further ten days to edit and improve the essay before the final hand in date. The first drafts were marked and returned to the students with suggestions for improvement and encouragement in the areas where they had done well. The students were also encouraged to contact me about the essay if there were any problems.

While serving as an introduction to the service-learning practical, the essay also tackled new learning areas and honed research skills. Students learnt how to summarize and recontextualise information from different sources, how to write in the academic style, how to reference and how to draw chemical structures using a computer software drawing

programme. Writing the draft essay enabled better quality work on the part of the students who could change and edit their essays to better fulfill the criteria on the assignment sheet, as well as improve their general writing skills. The draft essay also ensured that the students made a start on the essay at least 10 days before the final essay was due, and shoddy, last-minute work became less of a problem. Issues of plagiarism could also be sorted out before the formal submission.

As Bressette and Breton (2001) point out, writing is a particularly powerful tool to encourage active learning in chemistry and that through writing assignments students become familiar with the stylistic requirements of scientific writing. They state that drafts that are evaluated by staff members and returned to the students with comments and suggestions for review, lead to better final papers and increased student comprehension.

The drafts were formatively assessed, with many comments and suggestions for improvement, but given a mark according to the rubric found in Appendix D. I emailed the class once the draft essays were marked with general concerns and information on how to conclude the essay with a reflection. The reflection offered the students the opportunity to reflect on the whole experience (the final essay submission was after the service-learning practical had taken place) and gave them a chance to see their own growth process over the course of the term. The reflections also formed part of my data. The email can also be found in Appendix D.

The final draft was due on the Monday following the Thursday afternoon practical with the Grade 12 learners.

3.4.2.4 The Azo Dye Practical: "Parallel Combinatorial Synthesis of Azo Dyes"

The practical is based on the laboratory experiment of the same name that appeared in the Journal of Chemical Education, devised by Gung and Taylor (2004). The practical lends itself well to a collaborative and cooperative learning experience. To quote from Gung and Taylor:

> —The paradigm of combinatorial chemistry is a powerful research technique that also readily accommodates other desirable educational outcomes. A suitably designed laboratory experience in combinatorial chemistry emphasizes the relationship of structure to molecular properties. It reinforces the concept that data acquisition must often precede a theoretical framework. Finally, it allows each student to work independently, yet leads them to share data and interact collaboratively to reach conclusions" (Gung &Taylor, 2004, p1630).

Since the aim of service-learning is to work collaboratively and interact with others to reach conclusions, this kind of practical, where there was space for both individual and group work was ideal. This dye practical was done over two weeks. During the first week each pair of students made a different colour dye and planned for the Grade 12 learners who were coming the following week

The practical had been slightly altered and adapted already, by the organic practical coordinator, for the previous year's class and so few changes were needed for the practical manual. What did need to be changed, however, was the fact that since the azo dyes made the previous year were not colourfast, a fixative was needed. After some experiments with different fixatives, I decided upon ferrous sulphate as the fixative for this practical. The adapted manual for this practical, along with the lab report sheet can be found in Appendix E.

The second year undergraduate chemistry students generally do their laboratory practicals in pairs, although they usually submit their own work for assessment. Since their work was done jointly, they were given the option to hand in joint practical reports.

In the practical, the principle of combinatorial chemistry is shown by generating a number of brightly coloured dyes using only one common reaction, the diazo coupling, and two common reactants with small variations in their substituents. Each student bench is turned into an individual —well" in terms of combinatorial chemistry. At the conclusion of this experiment, students were asked to discuss the relationship between chemical structure and function when comparing the dye chemical structures and the cotton strips dyed with their azo dyes. The pedagogical value of this experiment lies in that the structure – function relationship is demonstrated in bright colours, and so there is a

tangible way to see the effect that a small chemical structure change can have (Gung & Taylor, 2004). Figure 3.4.2.4.1 shows the generalized diazo coupling reaction, and Figure 3.4.2.4.2 shows the laboratory layout with the twenty different combinatorial wells A1-D5 and the different substituents and the names of the resulting dyes. For a complete table, with all the molecules, including the probable resultant dye molecules, see Appendix E.

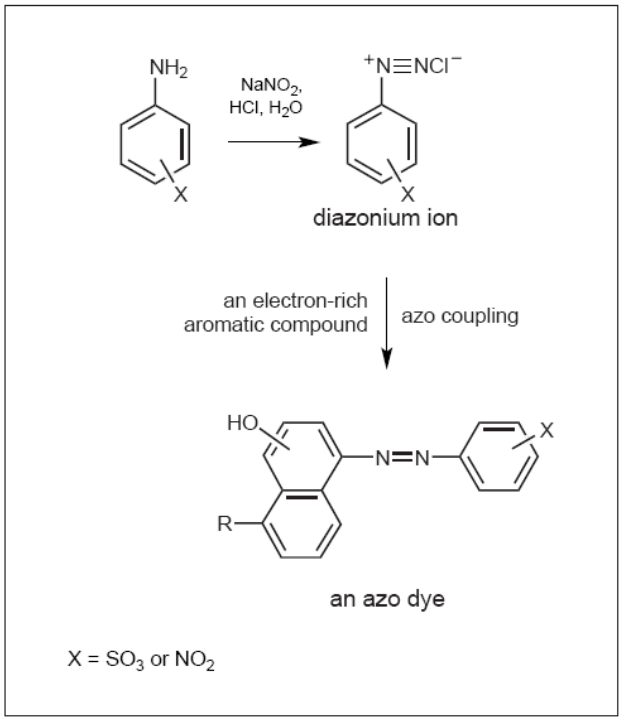


Figure 3.4.2.4.1 *The generalized reaction scheme of a diazo coupling (Gung & Taylor 2004, p 1630).*

The practical report or write-up in this case required the student to draw the mechanism of the azo coupling reaction and discuss the relationship between, colour, chemical structure and the ultraviolet spectra of the compounds.

As part of the preparation for the service-learning component the students completed a pre-reflection and planning task while they were busy with the initial dye preparation. This task was based on a simplified version of Kolb‘s Learning Cycle (Kolb 1984) which has been used as a model for reflection by the Campus Outreach Opportunity League (Eyler and Giles 1999).

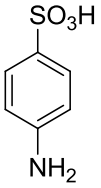
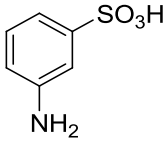
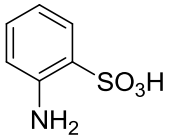
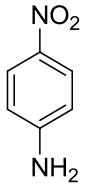
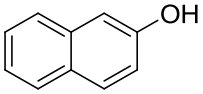
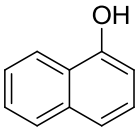
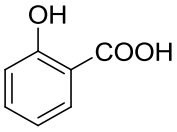
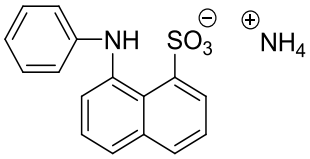
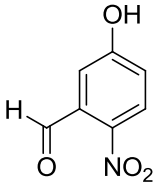
				
	A1	B1	C1	D1
	A2	B2	C2	D2
	A3	B3	C3	D3
	A4	B4	C4	D4
	A5	B5	C5	D5

Figure 3.4.2.4.2 *Table showing layout of combinatorial practical and each possible combination (adapted from Gung and Taylor 2004).*

The ―What? So what? Now what?" model shown in Table 3.2.4.2.1 prompts the students to think about the concrete experience of doing the practical for the first time (What am I doing?). Understanding the reasons why these skills or concepts are important (So what?), a critical thinking step; and then extending this to plan for the future, in this case the second practical with the Grade 12 learners (Now What?), a decision making step. The ―Now what?" section was the most important in terms of forcing the students to plan for and think about the service activity and think of ways to incorporate the learners into the experience. This model is recommended by the HEQC Guide for undergraduate

service-learning and particularly for students with very little knowledge and experience of reflection. This was a successful model to use due to its ease of application (Bender *et al.* 2006).

This exercise had the added effect of stimulating interesting dialogue with the students about the specifics of azo-dye making. Each section of the practical was divided into a grid format with space for the students to write their plans and comments (See Table 3.4.2.4.1 and Appendix E.3 for the full-size version). Each student was led from a superficial ~~"d~~doing" approach, where a recipe is followed, a learning approach heavily weighted on the Active Experimentation side of Kolb's learning continuum, to a more in-depth approach which incorporates Abstract Conceptualization and Reflective Observation within Active Experimentation and contributes to effectiveness of learning (Kolb 1984).

Table 3.4.2.4.1 *Grid that each student completed as a pre-reflection and planning task*

WHAT? • Information/concept • Synthesis Step	**SO WHAT?** • Reasons for doing this, challenges, difficulties • Importance for me and Grade 12 learner	**NOW WHAT?** • How will we do this and include the learners next week?
Safety: Lab rules, chemicals		
Background to Combinatorial Chemistry, Dyes, Dyeing and Fixatives		
Preparation of Diazonium Salt		
Coupling Reaction		
Dyeing of Fabric		
UV Spectra Discussion and Comparison		

This table was completed on an individual basis for each student, but since the practical was done in pairs, the students discussed their plans with their partners and with the other students at their laboratory benches. Demonstrators and students all commented on how this activity encouraged them to think about the synthesis in a new way, and students commented that they understood the chemistry of the practical much more thoroughly

than they usually did. As a direct result of having to fill the grid in and ask specific questions about each reaction in the reaction sequence, conceptual understanding was reinforced. For example, demonstrators commented numerous times that students had never asked questions like, "Why is this reaction done in ice and not heated up?" This points towards the fact that students had never before engaged with the practical at the level with which they were required to in this case.

At the end of the first practical, the students had to stick their dyed cotton strips onto the board at the front of the laboratory in the position corresponding to their combinatorial well." They also ran a UV spectrum of their dye product. These dye swatches were then photographed and the photograph of the dye, the UV spectrum and the drawing of the structure were all incorporated into a poster for use as a pedagogical aid the following week and for future classes. (See Figure 3.4.2.4.4).

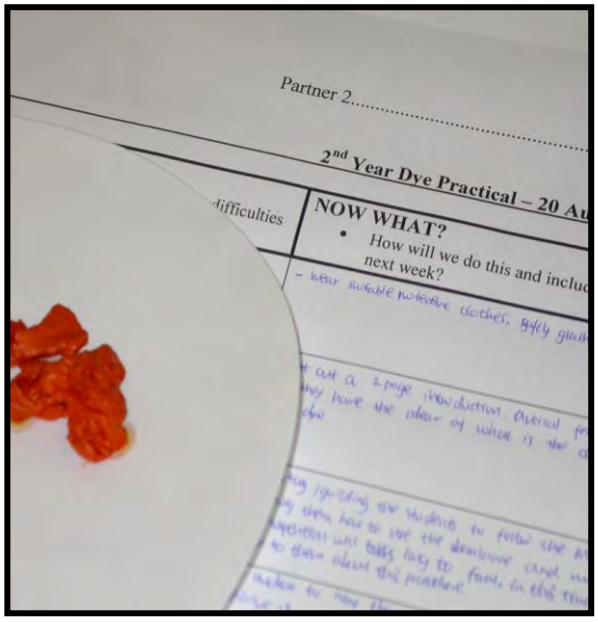


Figure 3.4.2.4.3 *A student's completed dye and „Pre-reflection and Planning Task"*

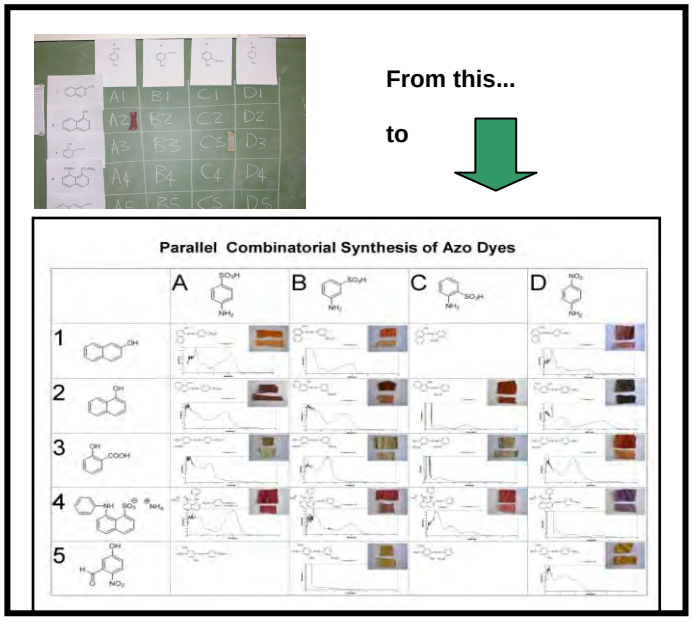


Figure 3.4.2.4.4 *The poster created from the results of every student pair's practical*

The students were given a mark for the planning and reflection task as a pair by the demonstrators according to the rubric which can be found in Appendix E. They were also marked on the cleanliness of their desk area, again the rubric can be found in the same Appendix. I marked the practical report for academic credit.

The first practical was thus developed in such a way as to prepare the students for the following week with the Grade 12 learners. The coursework knowledge they had gained in the lecture course was related to the practical by the lecturer and the demonstrators during the practical session in response to students‘ questions.

For the second week of practical the lecturer and I agreed, that the practical would be far more structured if everyone made the same dye. Thus everyone made D4, a purple dye which was chosen by student consensus. The second year students had to decide how they would involve the learner in the practical. This was not prescribed to them at all. Learners were divided amongst benches, and once introduced to each other, learners and students were simply left to interact on their own terms. This was intended to give the students and learners ownership of the service aspect of the practical. We did not want to be too prescriptive feeling that doing so would rob the experience of its authenticity. Howard, as paraphrased in Bender *et al.* (2006), articulates that the pedagogy of service-learning seeks to ―give students control over their learning by allowing them to make decisions in directing their own learning" (p 31). By leaving the floor open for the students, communication between them and the learners had to happen because they could not just follow a set of predefined steps. This was another reason why doing the practical twice was such a good idea. Once the learners joined them, the students knew what was expected of them in terms of involving the learners and they knew how to make the dyes. They could also manage their practical time more efficiently therefore allowing more time for communication with the learners.

Students were marked on their safety knowledge concerning the reagents used in the practical and the procedures of the synthesis which was assessed by the demonstrators using the rubric in Appendix F. They had been warned of this the week before. Assessment was carried out by the demonstrators using a rubric which can be found in Appendix F.

The students were also given a mark for their level of engagement with the learners and their general performance, communication skills and enthusiasm for the practical and teaching the learners. See Appendix F for the rubric and the observer sheets that the demonstrators used to write down the marks and justify the marks awarded. The demonstrators also recorded general observations about the practical on these sheets. For this purpose, each demonstrator and the lecturer were assigned a group consisting of students and learners. They observed and worked with this group for the whole practical.

The t-shirts were dyed using tie-dye methods and each Grade 12 learner received their own t-shirt to dye. Tie-dye information, including pictures of how to tie material to get certain patterns, string and elastic bands were all provided. The tie-dye t-shirts were presented to each of the learners at a later date.

While the dyed t-shirts were drying, the groups that had worked together during the practical met to do a group reflection. Similarly to the pre-reflection and planning task this reflection was based on the "What? So What? Now What?" model. This time, however, the students and learners were asked to focus on what they learned and how the experience was useful, and also how it could be improved for future courses. This group reflection was recorded in writing and fulfilled the requirement that peers, community and staff should all be involved in reflection and discussion (Appendix F). The demonstrators were also involved with their group in this activity, facilitated the discussion and kept the reflection on track time wise.

Once this was complete, the learners left the laboratory to go home and the students filled in the post-questionnaire, Appendix G.2. This research instrument will be discussed further in Section 3.6.

3.5 Logistics

This section aims to highlight and clarify some logistical issues that may not be apparent from the previous section.

3.5.1 Transport and refreshment for the learners

The practical took place in the Chemistry Department Laboratory during the time of the usual Thursday afternoon practical. Therefore the school learners needed transport from their schools to the department and then back to school after the experience. A university bus was hired for this purpose out of the research budget allocated to this project. Since the practical started at lunchtime, the learners needed to be given food. Sandwiches were made and juices bought for them which they ate on the bus on the way to the university. This also came from the research budget allocated to the project.

3.5.2 T-shirts and safety gear

The t-shirts were bought from a local clothing store, in sizes that were given by the teachers. This also came from the budget allocated to the project. Due to the fact that the Department of Chemistry has an active community engagement and outreach programme, the department has a store of laboratory coats and safety glasses used for these initiatives, and so safety gear was available for each learner.

3.6 Development of the Research Instruments

As is evident from the above discussion, much of the data for this project came from the tasks and reflections that the students completed. Thus the development of the reflection components, the essay and reflection and the practical report are all discussed in the previous section. The other source of data was observation by the researcher, lecturer, demonstrators and other outsiders who were present on the day of the practical. This section will therefore just give a brief overview of the design and development of the pre- and post-questionnaires.

It is clear from the previous section that the large number of observers and research instruments contribute largely to the quality of the research. In terms of validity, triangulation emerges as the method by which a more accurate view of the subject is obtained. Silverman (2001) challenges the notion that _simple minded' triangulation is of any use in determining validity of data. This is because he rejects the idea on which triangulation rests: that there is a single underlying reality of which we obtain different views. In the critical paradigm however, validity is not an issue of reality, but rather of the critical process employed in coming to understand the source of different representations of that reality (Phillips 2000).

Thus, as Gibbs (2007) points out, while triangulation cannot be used in any ultimate sense to create a single, valid and accurate interpretation of reality (which critical theory would reject in any case), there are still practical uses for it:

- Different data and different observers of the same phenomena can illuminate limitations or mistakes in interpretation, reinforce conclusions and suggest successful lines of enquiry.

- There is always the possibility that research subjects are inconsistent in what they say and do. Forms of data triangulation that include as this study does, observation and written questionnaire or interview data are useful because they reveal new facets of social reality where people do not always act consistently. They also help to eliminate data collection issues due to problems inherent in some types of data collection, such as questionnaire fatigue as could be a problem in this case.

The questionnaires were based on the pre and post implementation questionnaires that are given in the HEQC Guide to Service learning in the Curriculum, which are based on the 2005 CHESP model (Bender *et al*. 2006). These questionnaires combine Likert scale type questions and longer open ended questions.

As a result of the nature of the research questions, the questionnaires were altered quite considerably. Most of the questions which focussed on the community were removed, and the questions which focussed on the students‘ personal experience and their perceptions of the experience were retained. More questions were added about previous community engagement and service, as well as questions focusing specifically on the discipline of chemistry and the way that students viewed themselves, their education and their possible contributions to society. Piloting of the questionnaire was also done, which resulted in the removal of two demographic questions and some other editorial changes (see section 3.6.2). The original questionnaires, pre- and post- as well as the edited instruments that were used in the project can be found in Appendix G.

3.6.1 Pre-Questionnaire

The questionnaire consisted of 7 sections:

Section 1 – Student information

Three questions were piloted of which one was retained.

- 1 nominal fixed response question: Gender

Section 2 – Student Understanding of Service-Learning

- 1 open ended question

Section 3 – Student Expectations of Service-Learning

- 7 agreement scaled fixed response questions (5-point Likert scale)

Section 4 – Learning Outcomes

- 1 fixed response question with open-ended contingency explanatory question
- 3 Open ended questions

Section 5 – Student View and Experience of Chemistry

- 6 agreement scaled fixed response questions (5 point Likert scale)
- 1 open ended explanatory question

Section 6 – Previous Service and Citizenship

- 2 nominal fixed response questions
- 1 open ended question

Section 7 – Student Opinion on the value of community service and social responsibility

- 5 agreement scaled fixed response questions (5 point Likert scale)

Because this was an action research project, aiming to emancipate students from their old ways of thinking about themselves and their discipline and make them aware of their social responsibilities, these types of questions helped to position each student in terms of how they saw themselves and the discipline and also gave some background on their previous service experience. This was necessary to track any change in opinion from the pre-service questionnaire to the post-questionnaire.

Despite the fact that this project is a qualitative one, the Likert scale questions were retained for a number of reasons:

a) The nature of the respondents: Chemistry students have not been taught to write down their opinions or describe their feelings. This is not part of their course content at all. I felt that having ~~"e~~asy" questions which were quick to answer would help to ease them into the questionnaire and improve the quality of the responses to the few open ended questions.

b) The nature of the study: There are so many rich data sources in a project like this. Thus the main purpose of the questionnaire was to track change and to give background on a respondent's opinions and previous experience. This can be done by comparison of answers, and a Likert scale type question is easier to compare than a free response question.

c) The potential audience: Although for the purposes of the thesis quantitative data were not needed, the Department of Chemistry or the university may want

descriptive statistics to assess the success of the module. These could be processed at a later stage and/or used for illustrative purposes in this project.

3.6.2. Piloting

Since the sample size was limited as this was a case study, the questionnaire was not piloted in the conventional way. Rather, the questionnaire was checked by my supervisor and _critical friend' from CHERTL, as well as _piloted' on a group of ten chemistry postgraduate students. These students were evenly split between male and female and there was a mix of first language English speakers and those who were not mother tongue English speakers. They were asked to comment on ease of comprehension and the time it took them to complete the questions. This was a useful exercise, as _questionnaire fatigue' could be lessened, and misunderstood or difficult questions could be altered. The pilot questionnaire can be found in Appendix G.5.

The postgraduates were ideal people to use for the pilot, as, even though they are older than the second years, they also have no experience of service-learning and also have little knowledge of education and social science jargon. Thus questions where these issues arose as problems would be identified by the postgraduates. Since the postgraduates are people that I know really well, they were also able to comment freely on the questionnaire.

From the piloting exercise and after discussion with my _critical friend,' we decided that two of the demographic questions asked at the beginning of the questionnaire were unnecessary, as they had nothing to do with what I was researching. They also took up a lot of space on the page and made the questionnaire feel much longer. This was also something that the postgraduates had pointed out – even though it did not take them long to complete the questionnaire, their first response to it was that it looked really long. This was obviously not ideal and so the layout was also changed slightly. Below are two

examples of how the layout of questions were changed to take up less space and cut page space out of the questionnaire so that it _felt' shorter.

In the pilot questionnaire, questions 1 and 4 looked like this:

1. Student information

1.1 Gender

Male	1
Female	2

1.2 Home language

Afrikaans	1
English	2
isiXhosa	3
Sesotho	4
Setswana	5
IsiZulu	6
Other	7

1.3 Age

<= 18	1
19	2
20	3
21	4
22-24	5
25+	6

4. Previous Service and Citizenship

4.1 Have you been involved in any community engagement or outreach activities in the past 4 years?

No	1
Yes, while at school.	2
Yes, while at university.	3
Yes, at both school and university	4

In the final questionnaire, they were laid out like this (see below) instead. Clearly, with the demographic questions removed and the layout changed, the questionnaire appears to be much shorter and more user friendly. The order of the questions was changed which resulted in changes to the numbering, for example, question 4 became question 9.

1. Student information

1.4 Gender (Tick the number that applies)

Male	1	Female	2

9. Previous Service and Citizenship

9.1 Have you been involved in any community engagement or outreach activities in the past 4 years?

No	1	Yes, while at school.	2
Yes, while at university.	3	Yes, at both school and university	4

A few typographical errors were picked up and changed, and the questions were reordered so that all the long, open response questions were in the middle and not at the end.

Another question that was altered as a result a postgraduate‘s comments was the one below. In the pilot it appeared like this:

4.2 If yes, was any of this service or outreach related to the direction of your academic studies?

Yes, it was directly related to the subjects I am studying.	1
Yes, but only generally science related.	2
No, it was totally unrelated to science.	3

One of the postgraduate students commented that he had been involved in more than one type of outreach, and so the question was altered in the final questionnaire to look like this:

9.2 If yes, was any of this service or outreach related to the direction of your academic studies? **Tick all those that apply.**

Yes, it was directly related to the subjects I am studying.	1
Yes, but only generally science related.	2
No, it was totally unrelated to science.	3

The wording on another question was changed due to its ambiguity, from

I believe that community engagement experience will affect me in the following ways:

4.4.2 Change my level of awareness of my **social** context within the greater community.

1	2	3	4	5

to

I believe that community engagement experience will affect me in the following ways:

9.4.2 Change my level of awareness of my immediate world **in relation to** the wider community.

1	2	3	4	5

One more change was made to the questionnaire after the pilot, not as a result of piloting the questionnaire, but as a result of discussions with my _critical friend.' In the pilot, Question 8 appeared like this:

8. What do you regard as the module's intended outcomes for the researcher?

_____

_____

_____

Immediately, by calling myself _the researcher' I was distancing myself from the process and establishing a power relationship over the students which could have been construed that I was simply using the students for my own purposes. This is contrary to the paradigm of critical action research and contrary to my aims and purposes with regard to the project. Thus the question was reworded, and became Question 6, and the focus of the question was also changed slightly to be angled towards the student and not towards the researcher.

6. How do you think your learning experience will be changed by having Sarah research this course?

_____

_____

In summary, the pilot questionnaire was useful for the following reasons:

- Identification of misunderstood, ambiguous or badly laid out questions
- Checking the time taken to complete the questionnaire
- Checking response to and impression of questionnaire and feasibility of questionnaire layout.
- Removing questions which have undesired ideological bias

3.6.3 Post-Questionnaire

The post-questionnaire was very similar to the pre-questionnaire in both content and layout; all the questions were simply rephrased to the past tense. For this reason the questionnaire was not piloted with the postgraduate students as it was not necessary. It was simply checked by my supervisor and ‗critical friend.'

A number of extra open ended questions were added in the fourth section where learning was being investigated, but these were very similar to the questions in the original CHESP questionnaires. These focused on learning from others and the personal experience of the service-learning component and asked about development of social skills and social responsibility. This section was also marked and used as a post-service-learning reflection tool.

3.7 Methods of Data Collection and Data Analysis

3.7.1 The Pre-Questionnaire

On the 3rd of August, two and a half weeks before the first practical, the pre-questionnaire was administered by me after the introductory talk about service-learning and the research project that I gave to the second years. Hence all the students answered and returned the questionnaire to me timeously. All the students at the lecture had signed informed consent forms and therefore every questionnaire received in that session was used for research purposes.

The first three sections of the questionnaire focused on student demographics, student understanding of service-learning and student expectations of the course. These sections were used to provide background information in answering Research Question 1 (See Appendix G). The question about student understanding of service-learning in particular, was also used as a check for me, to see if students understood what the aims of service-learning were, and the variations in how service-learning was understood would help to elucidate why some students seemed to value some types of learning above others.

Questions 4 and 5 concern the student understanding of learning outcomes, both for them and for the community. Question 6 asks what effect researching the course will have on the students. Question 7 invites comment, opinion or feelings on the prospect of doing the service-learning course component. These questions all centre on answering Research Question 1. Question 8 will also help to answer Research Question 1, since the question covers student perception of and view of chemistry as well as student view of themselves in terms of their field and in relation to society. Question 9 which focuses on previous community service and citizenship will, in conjunction with Question 8, answer Research Question 2.

The questionnaire was explained and introduced before it was handed out and students were encouraged to give their own opinions and write as much as they could. It was stressed that there were no _right' or _wrong' answers.

3.7.2 Observation

3.7.2.1 Researcher Participant Observation

Observation formed a large part of the data collection methods. This was necessary especially in the light of Research Question 1, where learning needed to be explored. Thus my observation started with the introductory lecture and ended with the lecture at the end of the term where I thanked the class. In terms of my own observation, I was mostly looking for indications of attitude and enthusiasm, as well as growth and changes taking place in these attitudes. I was looking at the class as a group and wanting to get a

sense of the collective feeling towards and participation in the activity, as well as collective understanding of the chemistry content.

During the first practical, I was specifically looking for sigs of understanding and enjoyment of the practical experience as well as the types of questions students were asking, as this would give an indication of the depth of engagement and depth of understanding of the academic material. I was also looking for indications that the students were taking responsibility for their own learning. For example, changes in interaction with demonstrators, changes in behaviour in the laboratory, improved efficiency and cleanliness.

For the service-learning practical I was interested in the interactions between students and learners, and how this developed through the course of the afternoon. I wanted to see how the students organised themselves, how they involved the learners in the practical, and how their reaction to and interaction with their fellow students and demonstrators changed to accommodate the learners.

3.7.2.2 Demonstrator (and lecturer) Participant Observation

In order to answer both research questions more fully, and because I was focused on the whole group dynamics, I needed the demonstrators, who deal individually with the students to observe smaller groups of people and give detailed observations on how individuals interacted.

In the first practical this was not so much of an issue, and the demonstrators gave their general impressions of the practical and the student response in informal conversations during the afternoon.

During the second practical, however, with so many people (students and learners) in the laboratory, demonstrators were assigned to a group of students and learners and they formally observed and assessed each student‘s interaction according to the rubric that I

had given them. This sheet and rubric are discussed in Section 3.4.2.4 and can be accessed in Appendix F.

The four demonstrators and the lecturer were ideal participant observers because they are present in every practical session with the students. Thus they know the students relatively well and have a rapport with them. They could also compare student behaviour, the types of questions they asked and their comments in comparison to other practical sessions.

3.7.2.3 Observation by „critical friend"

The observation by an external observer with no vested interest in the success of the project was paramount to ensure validity of the observation data generated. As a Xhosa speaker, she was also ideally placed to talk to and gather data from the learners. Her observations, like mine, were focused on the interaction taking place between learners and students and the evidence of learning on the part of the learners. This was important, because although the focus of the research is student learning, in terms of evaluating whether a service-learning effort has been successful, the mutually beneficial concept cannot be ignored. Thus if the learners were not enthusiastic and learning something, then the students, firstly had not managed to fulfil the requirement of the service-learning practical, and secondly would learn less themselves. This information was very important to answering both research questions.

3.7.3 The Essay (draft) and Essay and Reflection

The essay along with how it was introduced and administered is discussed in Section 3.4.2.4. The essay itself in terms of the comparison between the drafts and the final copies was a wonderful indication of learning and understanding, and the change that had taken place over the whole organic chemistry course. Since the essay was developed to introduce and prepare the students for the service-learning component, this information on learning was very important in answering Research Question 1.

The final essay which had as its conclusion a reflection section, was a rich resource. Students gave their opinions and feelings regarding chemistry, themselves and their place in society and within the discipline, the community, and how their own capabilities and social responsibility had changed as a result of the course. This was essential in answering both research questions, but particularly for answering research question 2.

The students handed in their essays as both a hard copy and electronic version. The electronic format helped me greatly with data gathering.

3.7.4 The pre-planning and reflection and the group post-reflection tasks

As with the essay, these have been discussed in some detail in previous sections and the grids can be found in Appendix E.3 (pre) and Appendix F.3 (post). These were both administered during the practical periods and filled in and completed during this time. Since these were for marks and were part of the syllabus, similarly to the essay, these were not administered as research instruments as such. However these provide evidence of the cognitive process that each student underwent in order to plan for the service-learning task. The post-group reflection gives a good indication of what things could have been changed or done differently to make the experience more beneficial which shows evidence of both critical thinking and personal growth. Thus these were used to answer question 1.

3.7.5 The Post-Questionnaire

This questionnaire was administered at the end of the whole experience, but during the practical time. This research instrument was designed to be used and viewed in conjunction with and comparison to the pre-questionnaire. All the corresponding questions were formulated in the past tense in order to see if students‘ ideas and opinions had changed over the course of the component. Added to this was a much longer open ended question section for students to communicate what they felt they had learned, in terms of personal skills, chemistry and values and social responsibility. Thus in conjunction with the first questionnaire, this information gathered was useful in answering both research questions.

3.7.6 Focus Group Interview with demonstrators

This interview was held very informally after lunch in the Department of Chemistry tea room. The interview was used as an opportunity for the demonstrators to read the comments that they had made over the course of the service-learning practical, and add anything they felt they may have forgotten, or alter the things they had said which they felt were not a true reflection of what happened. Incidentally none of them did this. They were all happy with what had been written.

The interview was interrupted on a number of occasions by people walking in, using the microwave and other distractions. As a result of this, much of the taped interview is completely inaudible. However, since I took notes on what people said at the time and wrote up my impressions of the interview afterwards, this was still a valuable exercise. The information gained here was used to answer research question 1, as it had to do with student attitude and skills learnt as well as their depth of understanding of the subject material in comparison to other practicals. The list of Interview questions can be found in Appendix G.6.

3.8 Data Analysis

All the data were categorized into common themes and organised in such a way as to answer the two research questions. This was necessary because the data was of such a nature that the answers to the research questions were not neatly separated, but rather the whole picture began to emerge after looking at the data as a whole.

In terms of the critical paradigm, true „open coding" is not possible, because open coding requires the researcher to remove their own preconceived ideas and approach the data with an open mind and let the data speak, such as in a grounded theory approach (Gibbs 2007). Since the ideological standpoint has been made explicit in this study, and the whole purpose of the study is to cause changes in the curriculum and changes in the students' perceptions and in their learning, the themes which are expected to emerge in the data come from the service-learning literature. Since the practice is being evaluated and the aims for learning were incorporated into the curriculum, the curriculum-based data will reflect the aims and goals of the service-learning process.

Thus the thematic coding of the data, while striving to be data driven, will to a large extent also be concept driven. In the examination of data, I was looking for evidence of learning in the six areas mentioned in Chapter 2 and articulated by Eyler and Giles (1999). Gibbs (2007) summarizes the views of King (1998) and Ritchie (2003), where a collection of codes and themes are constructed from literature, previous research and a preliminary read of some or all of the data. However, Gibbs states that both authors recognize that the researcher will need to amend the list of codes, as new ideas and new themes emerge from the data.

The answers to the Likert Scale questions of the two questionnaires were coded into tables so that the frequency of responses could be recorded, but these results are used to give background information on the beliefs and attitudes of the chemistry class to begin with. Some of the questions are used for illustrative purposes, but the focus of the study is

on the data generated from the observations and written reflections and practical report. The Likert scale questions are used in a comparative fashion simply to assess change from responses in the pre-questionnaire to responses in the post-questionnaire.

CHAPTER 4

FINDINGS, ANALYSIS AND DISCUSSION OF RESULTS

"I now am aware of my scientific knowledge, and how to pass it on to others." – (S_{32}, post-questionnaire, p 5)

4.1 Introduction

This chapter provides a detailed description and discussion of the results of this study with reference to the research questions which guided the enquiry. As stated in Chapter 1, the main aim of the present study is to investigate the learning that takes place in a service-learning context and discover how these areas of learning impact the awareness of the students involved with regard to the discipline of chemistry as well as social issues. Changes in individuals' ideas about themselves and their discipline, as well as the value of the knowledge they gain at university are investigated. This chapter also examines and discusses the results of the data collected from the questionnaires (pre- and post-), observations of the demonstrators and the researcher, the practical report and all the reflections including the essay reflection. Due to the nature of this study and the methods of data collection, the answers to each research question come from different data. Thus, the data description and some analysis and discussion will be presented together, organized chronologically by the two practicals and secondarily by data collection tool (Wolcott 1994).

The data are described and in some cases tabulated, but details of some of the findings are presented in Appendices H and I. The open-ended questionnaire responses and reflections, as well as the observations are grouped into common themes for the purpose of analysis and interpretation (Appendices H and I) while extracts from the data gathered from all these tools will also be presented in full to support the arguments and discussion. The findings from the observations of and conversations had with the Grade 12 learners, are also presented to support the argument for student learning, and provide pointers towards avenues for further research.

The last part of the chapter presents the synthesis and discussion of the findings, in which the interrelationship between the responses made by the students in the questionnaires and reflections and their observed behaviour are explained. The last section will also synthesise the findings in relation to the literature discussed in Chapter 2, and present the results in answer to the two research questions. Similarly, data gathered from the learner observation and informal conversations are supplemented to support the discussion.

4.2 Results, Analysis and Discussion

4.2.1 The Pre-Practical Lecture

During the pre-practical lecture, as discussed in Chapter 3, I introduced the class of 35 students to my research project and the concept of service-learning. Responses from the class to the idea of service-learning were very positive, but when the essay handouts were sent around, the class was palpably upset about the extra work. In my notes I wrote, "...the class listened and was very receptive to me," and I felt from the atmosphere and the response from the class that they were very excited about the prospect of being able to contribute to research that would directly affect them and other students who might repeat this exercise in the later years.

The lecturer was present during the lecture and he supported and confirmed everything that I said, as well as giving me a very complimentary introduction to the class. I believe that this really set the tone for the whole project, because the class could see that he trusted me and had faith in both my abilities and the project, they therefore felt that they were in safe hands too. During the whole lecture, there were only a few questions and most of them related to whether time outside of lectures and practicals would be required. All the members of the class signed the consent forms and there was an excitement surrounding the research and their involvement in it. However, concern was expressed about the workload associated with the essay.

I wrote in my journal that I was concerned that I had not put the community learning goals across very well, and had focussed too much on the students and what they were going to get out of the process. In general I kept the learning goals quite vague and this probably compromised the effectiveness of the service-learning, but at the same time, the vagueness of the learning goals made the results obtained all the more exciting as students learned and grew in many areas other than chemistry without being told explicitly about possible learning outcomes.

The pre-questionnaire was distributed during this lecture and the results are described in the next section.

4.2.1.1 Pre-Questionnaire (See Appendix G.1)

The pre-questionnaire was designed in conjunction with the post-questionnaire to evaluate the attitudes and experience of the students towards chemistry, community service and the prospect of the service-learning component to which they had been given a brief introduction. This pre- and post- design was chosen to see if there was a change in the perception of the students as a result of their participation in the service-learning component of the practical.

The response from the students was very positive with regard to the way that they viewed chemistry and with regard to what they expected from the service-learning component. The results for the students‘ expectation of service-learning can be found in Figure 4.2.1.1.1. As can be seen, for most of the questions asked the students answered ―agree" or ―strongly agree," showing a general understanding of the service-learning component as a beneficial and useful component. Students mostly answered ‗neutral‘ to the statement about the component requiring more work. This uncertainty could be because of the vague learning outcomes that they were given at the beginning of the course. The students were less enthusiastic in their perception of what they would gain from the community members themselves, showing their perception that the community members

were the ones with something to learn, and they were the ones with a service to provide. This is a common initial perspective among students, and is what Mitchell (2008) along with many other practitioners (Cooks *et al.* 2004 and Pollack 2009) see as the possible downfall of traditional service-learning which takes, as Remen (2000) articulates a ―helping" or ―fixing" approach rather than one of service.

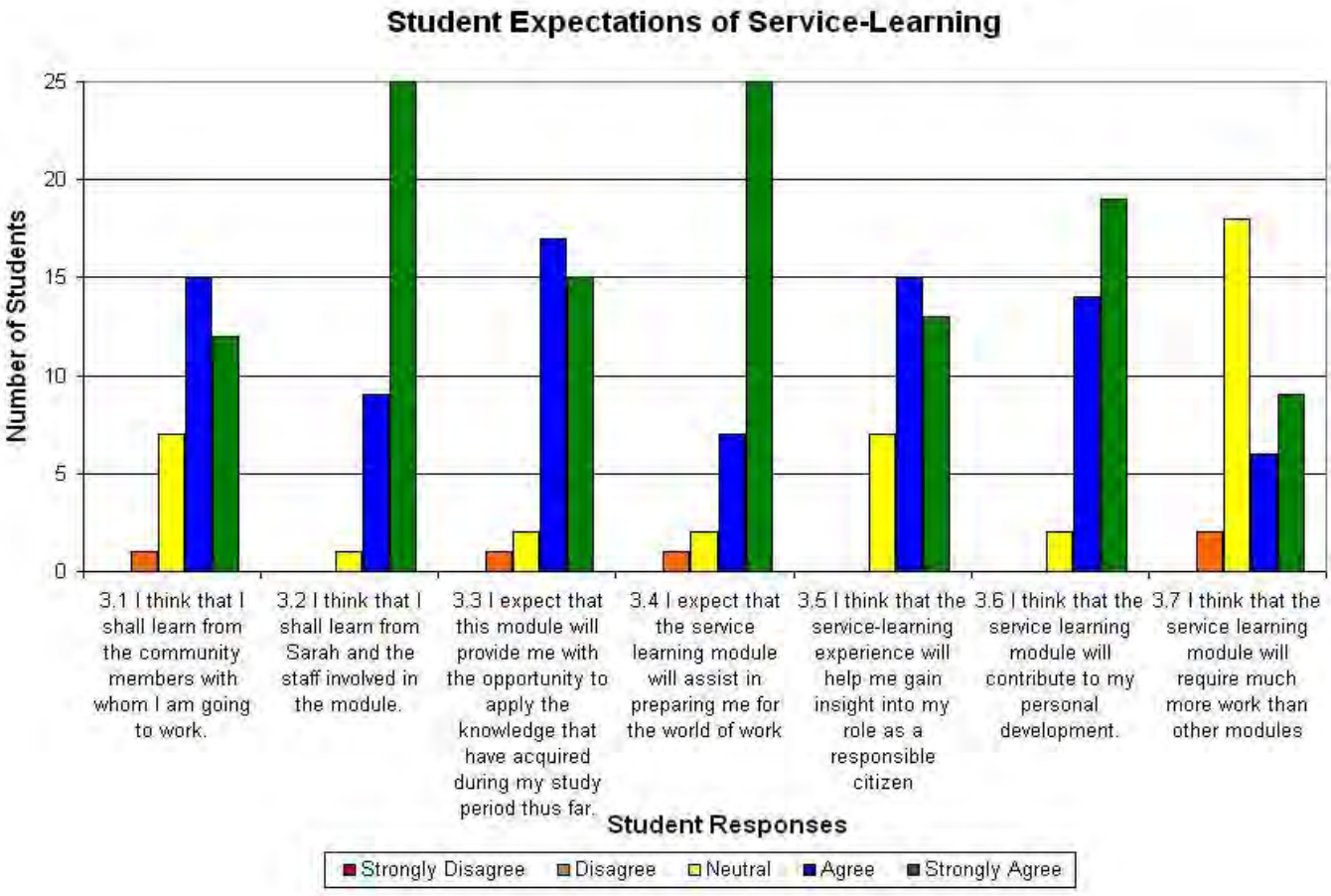


Figure 4.2.1.1.1 *Bar graph showing student responses to Likert scale statements about their expectations of the service-learning component*

In Figure 4.2.1.1.2, the student responses are summarized for the questions dealing with their view of chemistry. It is encouraging to see that no one answered ‗strongly disagree' except in response to Question 8.5 which calls chemistry a theoretical subject with no application to real life. Students, in terms of their response to this section of the questionnaire, have a positive image of chemistry and many students felt that they could, with the knowledge they had gained at university, make a contribution to society.

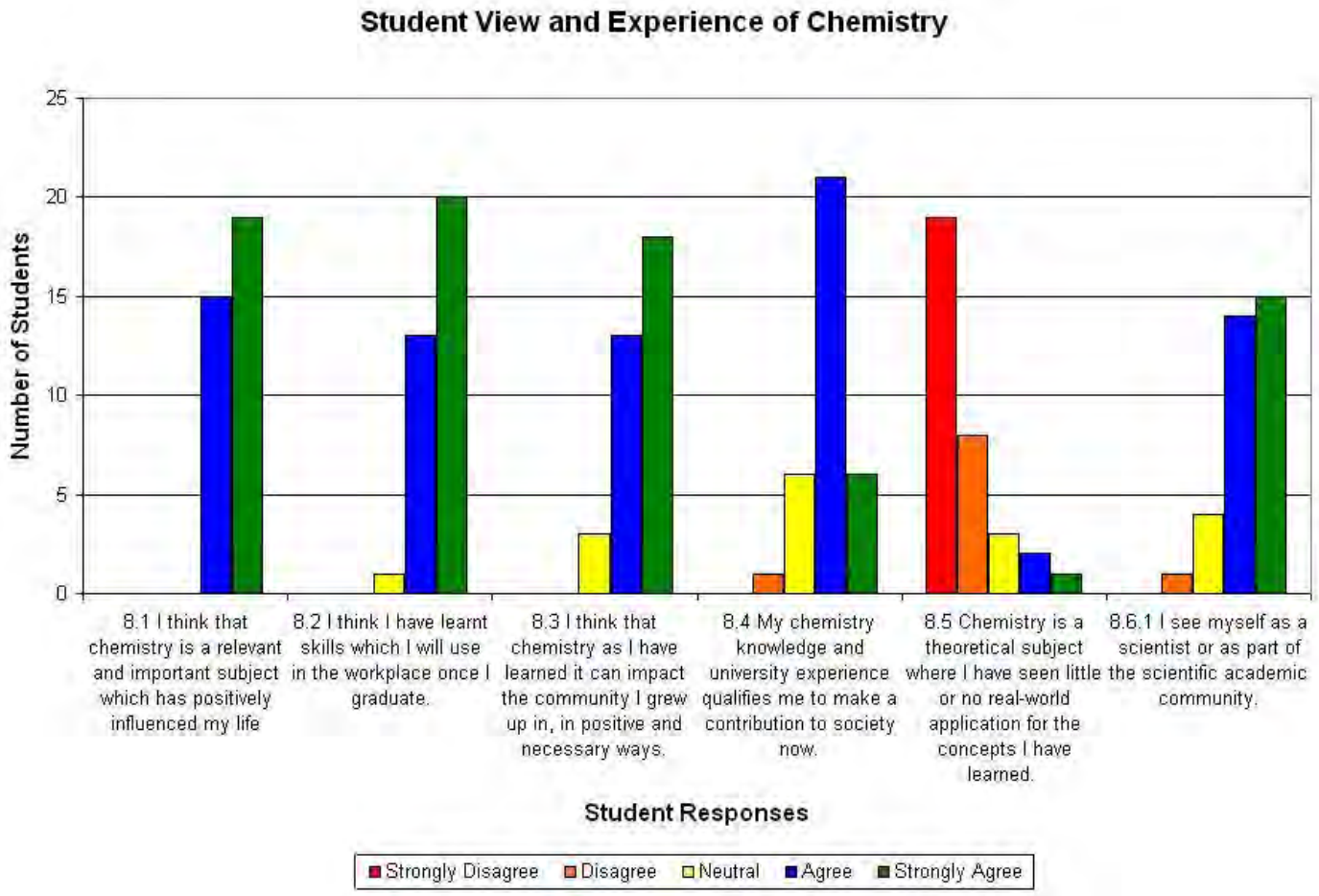


Figure 4.2.1.1.2 ***Bar graph showing student responses to Likert scale statements on their view and experience of chemistry***

The pre-questionnaire contained in its second section, an open ended response question asking for student understanding of service-learning. My initial concern that I had not brought the community learning goals across well enough is not really reflected in the student response to this question. Although there were responses that were dismissive of the community contribution towards any service-learning project, most mentioned the community in a positive way, clearly stating that the learning of the server was facilitated by the one who was served.

The responses of the students to this question could broadly be divided into two categories. Either the students saw service-learning in its broad definition or defined it as only applicable to chemistry. There were only seven students who failed to see service-learning in its broader context, and even their responses encompassed the spirit of

service-learning although defined specifically for chemistry. A fairly typical example of this kind of response came from student S_{32},

> ―Service learning is a process by which we carry out experiments in [sic] the same time as our course while doing community service. Helping ourselves as well as other people."

On the other hand, with the majority of the class seeing service-learning in a more broad way, there were a three subcategories of response:

1) The students saw their own learning as the most important and sidelined the community (student-focussed), or

2) they saw the process as joint (mutual), or

3) they emphasised the charitable aspect and saw the community as gaining the most from the experience (charity).

There was only one response that spoke of ―empowering others while you gain experience" (S_{17}), which did not fit into any of the three categories.

The differences mentioned were, however, quite subtle as students sometimes gave responses that overlapped into all three quite different paradigms. This could well be a language issue, rather than an issue of the way the students actually saw service-learning, because as science students they probably do not understand the nuances of meaning inherent in using words like ―charity" rather than community engagement. Nevertheless, in my pre-lecture, the word ―charity" was never used, and so this was their interpretation of the process as they understood it from my lecture. I did, however, use words like, ―community engagement," and ―learning," and many of the responses include these words which may or may not be part of the students' everyday understanding. I also used the word ―empower," and ―mutually beneficial" but only one response picked up on these two concepts.

I quote an example of the student-focussed response from S_5,

> —Service-learning is the use of an academic project which involves the teaching of a specific subject/topic to students, while at the same time allowing the students to apply the knowledge they have learned to help the community."

S_{13} gave one of the very few responses that explicitly emphasises the joint aspect, –Service-learning is a joint learning experience for both the aspiring scientists and the community. It involves using science to benefit the community." There were many examples of charity focussed responses,

> —Service-learning is a form of charity that benefits the underprivileged in both an educational form and receive a tangible service by the end of it – charitable education" (S_{36}).

See Appendix H for further examples.

What is surprising though, and which lends credence to the idea that this is an ignorance of value-laden language rather than an issue of paradigms, is the fact that the student (S_{36}) who wrote the last response quoted above, which really puts the community into a very passive, receiving role, did not disagree with the statement –I think that I shall learn from the community members with whom I am going to work," she answered –neutral." Another student (S_{35}) who responded with a much more holistic view of service-learning, although still using language which puts the community into a passive role, said, –Service-learning is obtaining skills and knowledge through providing services and community outreach projects while providing the community with skills as well," and answered –Agree" to learning from the community members. Incidentally, this student was also one of the most enthusiastic and involved students when it came to the service-practical, and thoroughly enjoyed the whole experience, and felt she had learned a lot from working with the learners as can be seen from her reflections and from the observations of the demonstrators. The first student mentioned (S_{36}), contrary to what her response implies, was also very enthusiastic and caring during the practical, interacted well with the learners and stated how much she had enjoyed and gained from the practical experience.

Thus, the student understanding of service-learning, while it may be thought to be an indicator of behaviour or attitude towards the practical cannot necessarily be taken as such, especially in this context, where science students are not at all aware of the prejudices and power struggles that lie beneath the words that they use. However, in the case of the only student (S_{30}) who failed the component (by 0.5%) it seems that the understanding of service-learning was an indicator for his poor performance. His understanding of service-learning was quite vague, he defined it as, "a wider perspective of education which can benefit a person both academically and as a person." While he did agree with the statement that he thought he would learn from the community members with whom he worked, he was unprepared for the practical, did not understand the chemistry and was withdrawn and according to the demonstrator assigned to his group, "scared of" the learners. It cannot be unequivocally stated that his poor performance was as a result of his poor understanding of service-learning - there are too many other factors to consider – but it does raise the point that if his understanding of service-learning lacked reference to the community at all, then it is not surprising that interacting with community was not a priority during the service activity.

Along with student understanding of service-learning, we need to know what the student understanding of the learning outcomes for the module was. As discussed in Chapter 3, the learning outcomes were kept quite vague in order not to influence the study in any way. Thus it is not surprising that, as Figure 4.2.1.1.3 shows, the majority of the class only had a partial knowledge of the learning outcomes of the module. Students identified personal and academic development, the application of chemistry in the real world, helping people, and being prepared for the world of work, as the most important outcomes for the course.

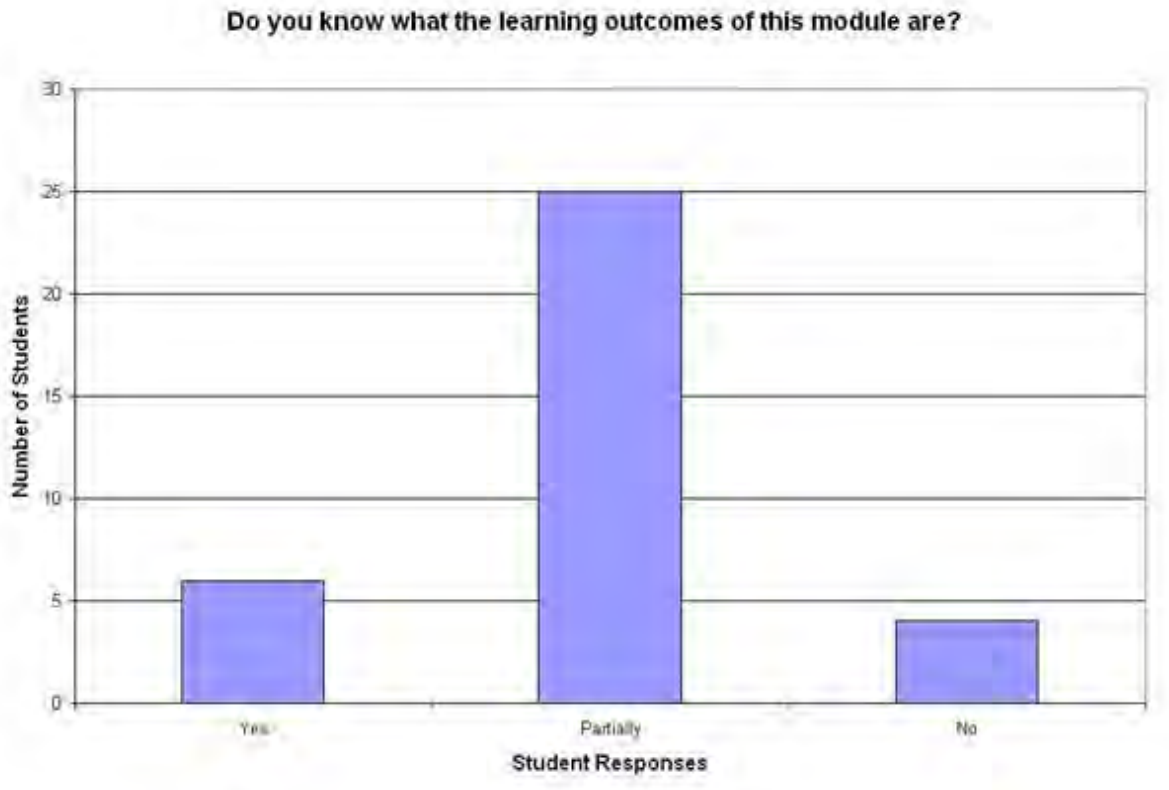


Figure 4.2.1.1.3 *Graph showing knowledge of learning outcomes for the module*

By far, student centred outcomes were the most common, with those who mentioned community outcomes also mentioning the student outcomes. Many however, just mentioned student-outcomes as opposed to community-centred ones. This may have been as a result of the way I introduced service-learning to them, where I felt that I had not expressed the community's role clearly enough. Most students answered that they were looking forward to the module, although some did express concerns about the workload.

In terms of the section that dealt with previous service and citizenship, just over 60% of the class had been involved in some form of community service over the preceding four years, see Figure 4.2.1.1.4.

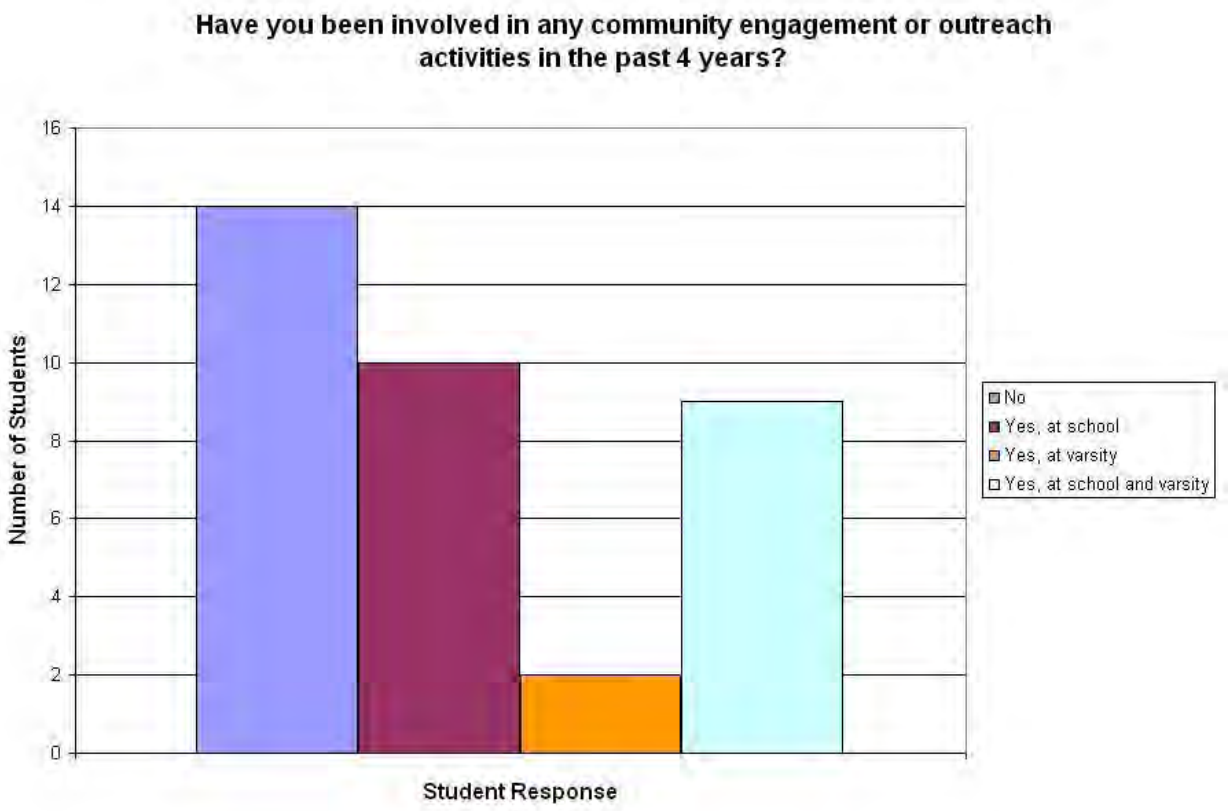


Figure 4.2.1.1.4 *Graph showing when students had recently been involved in community engagement*.

Of these students, very few had done community engagement that was subject related. Some had done some work that was generally science related, but not specific to any subject they were studying. Some students had done a variety of different community engagement activities. Over 50% of the service opportunities that the students had been involved in, were not related to science at all. Only one service opportunity was directly related to the academic studies of the student who was involved. See Figure 4.2.1.1.5.

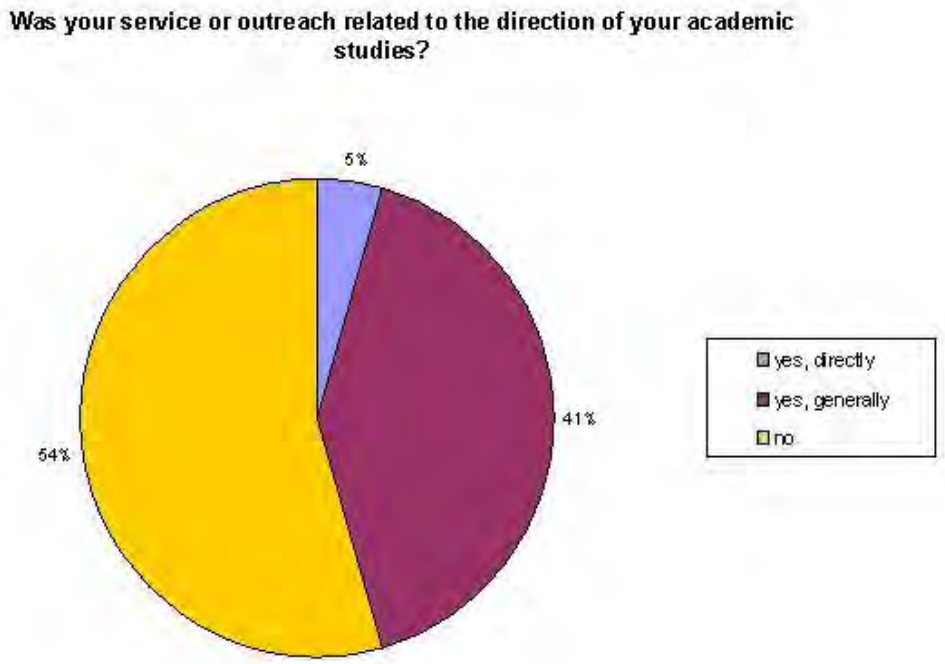


Figure 4.2.1.1.5 *A pie chart showing the percentages of the total service opportunities taken by the students prior to the practical which were directly related to their academic course of study, not related or only generally related.*

As the figure above demonstrates, more than half of the community service opportunities available to the students at undergraduate level were not related to their academic work at all. Thus students who had partaken in outreach work had not had their view of themselves as useful chemists affected, but only the view of themselves as useful citizens. Student background in service seemed to be an indicator of the way the students responded to the service-learning practical as well as the ease with which the students interacted with the learners in the second practical. Many students who naturally began to interact with and engage with the learners had done some form of community service either at school or university.

What was unusual was that some of the students who had done community service, and very often community service which was related to their academic studies, did not seem to be able to easily interact with the learners. Students who had done other forms of community service however seemed to interact with the learners easily. There is no direct

evidence to support this claim, but it would be remiss not to postulate that the discomfort the students felt with the learners could have been because in this case the students were interacting with learners over complicated scientific concepts, in their own situation where they felt they had to be in control. If they struggled with the chemistry themselves, they found it hard to simplify it and thus interact with the learners meaningfully. The other students, who had done community service not related to their academic study, may have been more used to the personal interaction that the service-learning required. What was very evident, however, was that those who interacted well with the learners had completed the planning and reflection task in such a way that demonstrated that they had thought about and planned the service practical from both a logistical and chemical point of view. There is more of this discussed in section 4.2.2.2.

What is also possible, is that some students, since there were only two or three learners between eight students, allowed the more outgoing and confident members of their group to take over and did not actively try to involve themselves with the learners as it was not necessary in their view. They had been told that they were going to be assessed on their interaction with the learners and a rubric was given to them to see how this would be assessed however, so there must also be other factors that influenced these students. These factors are, however, beyond the scope of this project, and were not investigated, but present an opportunity for further research.

The questionnaire also asked questions about community engagement in order to position students in terms of their citizenship and social responsibility awareness. Figure 4.2.1.1.6 shows the students‘ responses. The students were very positive that community engagement would affect them in ways that would enhance the value of their education and change the way they saw their responsibilities both as citizens and scientists. The only statement to which there was any disagreement was the one dealing with students becoming more aware of inequality in their society. This is understandable, because those who were already aware of the severe inequalities in society would not necessarily discover more about it due to doing community engagement activities. However, those who come from very privileged backgrounds, or those who had not been engaged in

community activities before, would feel that they could learn more about inequality in society through doing community engagement.

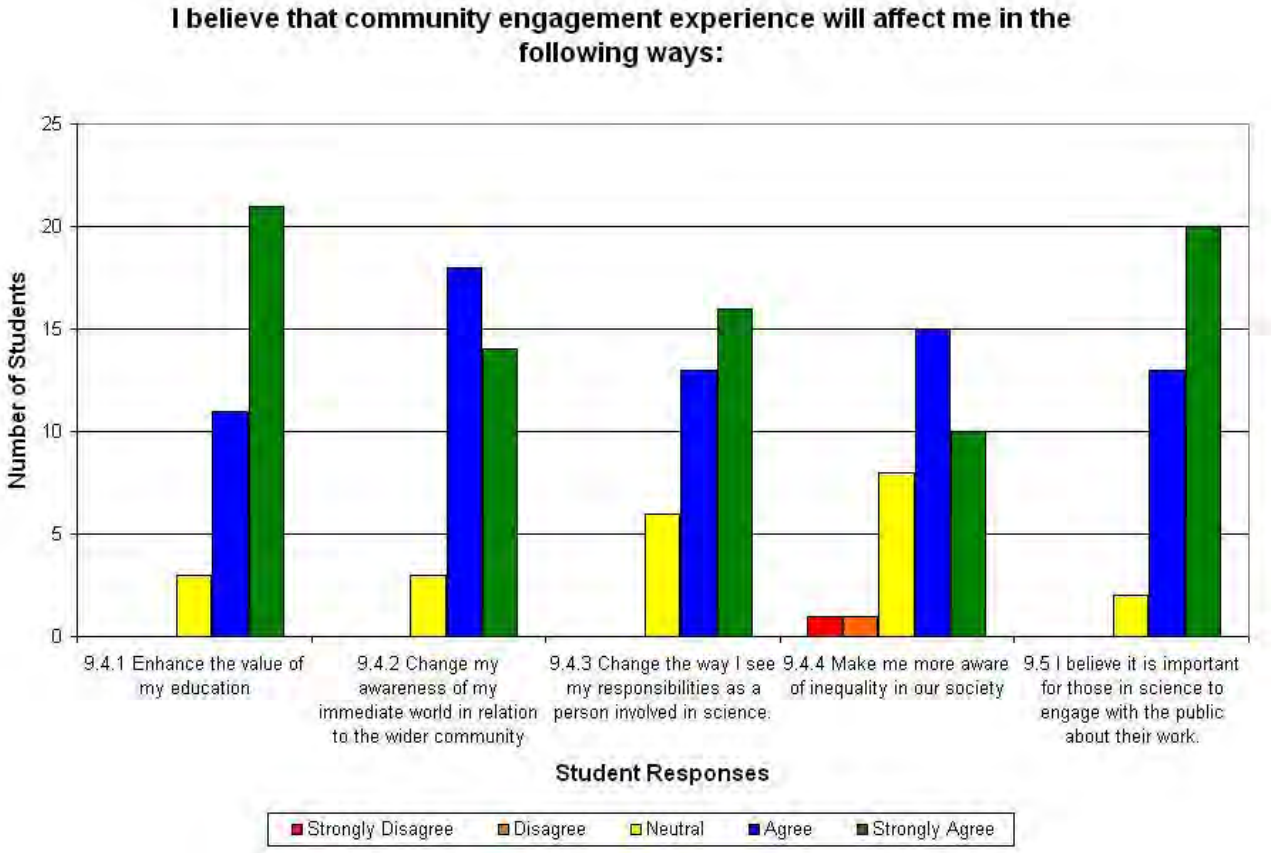


Figure 4.2.1.1.6 *Bar graph showing students"responses to statements about the effect of community engagement experience.*

4.2.2 The First Practical

4.2.2.1 Observations

Observations were made at both the first and second practical, but the second practical was under more strategic focus, with each demonstrator and the lecturer assigned to a group of 6 to 8 students and the learners who were allocated to them. I, as the researcher observed both the practicals with a more general goal in mind, but since I was facilitating the first practical, my observations were drawn to particular circumstances where the students needed help with the chemistry or clarification on how to do the planning and

reflection task, for example. This is consistent with Silverman's (2001) claim that observation data must be selective, and focus on the behaviour of interest. In this case, because reflection and questionnaire data provided insight into what the students were thinking, I was more interested in observing what the students were doing and using this as an indicator, together with the other data, of how they were thinking and feeling about the practical and what they were learning. During the course of the practical I informally interviewed the other demonstrators and the lecturer, taking notes of their responses and their general feel for the practical, especially in comparison to other organic practicals, as they were involved with the same class over the whole university term. During both practicals the demonstrators related particular incidences that they had observed and interesting comments that students had made.

In terms of Kolb's learning cycle, the methodology of observation was focusing on two aspects of the cycle for the students. In the first practical we were watching their first "concrete experience" of the chemistry, and their comments, questions, planning and reflection as well as their practical reports, gave us insight into what they were feeling and thinking (Kolb 1984).

The type of observation discussed above, is described by Gilham (2000) as participant observation. It is characterised by description and interpretation. The emphasis is on the meaning behind the observed behaviour, it is largely informal, and the analysis is primarily interpretive.

In order to answer the first part of Research Question 1: "How does service-learning change the way chemistry is learned and perceived by the student?" a comparison must be made with a 'normal' chemistry practical. As discussed at length in Chapter 2, the usual problem with practical chemistry as it is normally taught, is that it becomes a process of following a recipe. Critical thinking is rarely employed, and a deeper conceptual understanding of the processes being 'practised' and their connection to the real world is rarely felt. When these students entered the laboratory for the initial dye practical, most of them had researched and written the first draft of their essay on dyes

and dyeing. Those that had done so realised then, that the discovery of dye synthesis was the start of the modern chemical industry; an immediate connection had already been made to the importance of the practical synthesis.

The first 45 minutes to an hour of the practical was characterized by much confusion. Each laboratory bench had the structures of both of the two starting materials pasted onto the bench with the labels A-D and 1-5, but the structures were not named. Students struggled to connect the structures pasted to their desks with the names on the reagent bottles (which were not all IUPAC names). Lecturers and demonstrators directed students to the various reference books kept in the labs to look up the names of the reagents of which they were unsure. Being a combinatorial synthesis practical, every pair had a different combination of reagents and so each pair had to find the correct starting materials on their own and they could not ask another student which one to use. (See Figure 4.2.2.1.1)

This situation of enforced independence caused some of the students to feel very uncomfortable, as they were so used to following a recipe and were not used to having to think hard and use references just to be able to begin. They thus struggled to get going with the practical. However, once the initial confusion had passed, students began to enjoy what they were doing and an element of competition developed between pairs as they competed to synthesise the best colour dye.

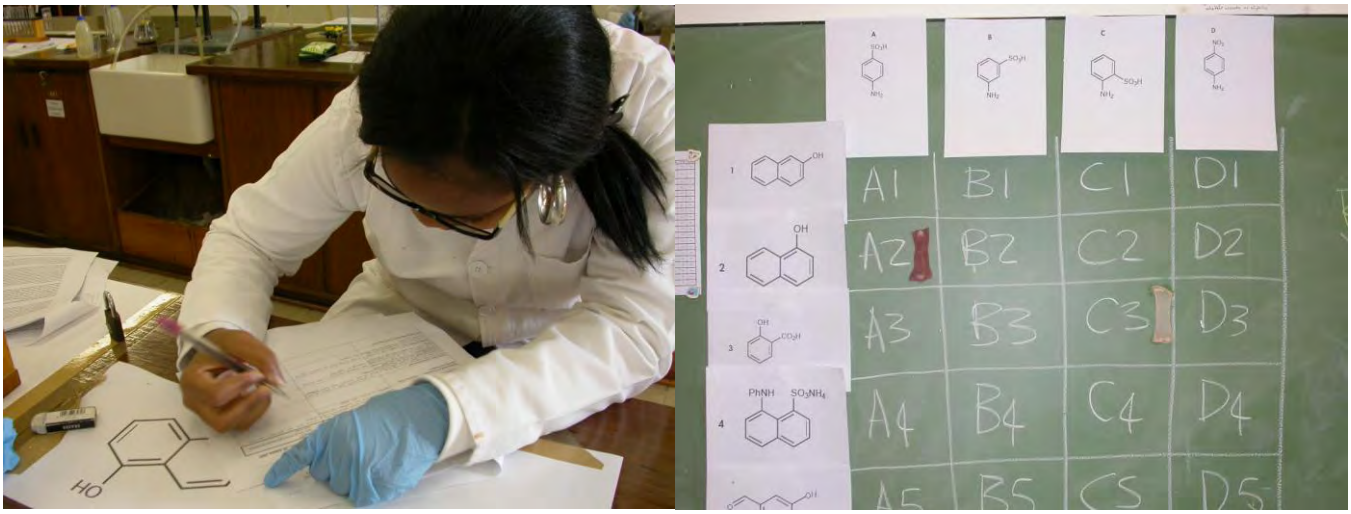


Figure 4.2.2.1.1 *The structures pasted to the benches corresponded to the structures pasted on the board. Here a student completes in her reflection and the structure of 1-naphthol, starting material 2, on her desk is clearly visible. She would also have had either A, B, C or D pasted to her bench***.**

All observers noted that there was a change in the engagement of the class, they were asking many more chemistry related questions than usual, and asking fewer questions specifically related to the write-up. This was explained by the demonstrators to be a result of the planning and reflection grid that the students were filling in, as well as a result of the fact that they ―needed to know" the chemistry, as Demonstrator 2 put it, in order to teach the Grade 12 learners the following week. Demonstrator 4 commented that the questions she had been asked were ―more detailed." She felt that usually the students ―did not care" about the answers to questions they asked apart from their immediate use in doing the write-up and getting the marks, but that in contrast, these students ―really want(ed) to know because they need to teach!"

Demonstrator 2 observed that the students were ―more inquisitive" and confirmed that the questions students were asking were more detailed and conceptual in nature, asking more about why processes in the practical were done in a certain way, and what was happening chemically at each step. He said that he was challenged as a demonstrator because in general, the students accept ―quick answers" to their questions, but this time they asked further questions to his answers and probed deeper for better understanding. He also observed that although it was late in the afternoon, every student appeared to be happy and not ―blak (concerned) that they are still here at 5 o'clock."

Demonstrator 1 kept reiterating that the students were ―more in tune" with the practical and much more involved, because ―in all the other pracs they just follow the recipe." In his opinion, as a PhD student who has been demonstrating for many years, since this practical was more application based and they could see what they were making, they were more interested and excited about the practical. He also mentioned how the planning and reflection grid really helped them while they were doing things because they were ―actually asking the right questions."

Demonstrator 1 was very vocal about the different atmosphere in the laboratory in comparison to other weeks; he felt it was a more positive and ―chilled" (laid back) atmosphere where students were enjoying themselves and were understanding the

chemistry much better. ―The students could see," he said, ―they drew out the structures and you could see they were thinking about where everything was going." He also felt the practical was more interactive with students asking questions, and that because of this discussion, both amongst themselves as well as with the demonstrators, the discussion section of the write-up flowed naturally as a result of the questions they were asking. There were not many questions about how to do the discussion part of the write-up which Demonstrator 1 felt was because the students had asked all the in-depth questions during the practical and understood the work. He mentioned that normally that is what the students ask about the most.

In terms of preparation for the practical the following week, he spoke about how students rarely think further than the goggles and laboratory coat that they need, especially in terms of safety in the lab, but now they were really thinking about what they were doing and what chemicals they were using. They were also starting to think about what to say and how to say it to the learners, as well as critically examining the practical and their own performance to look at the challenges they faced and how they could ensure that those things were not problems the following week. He mentioned the students' excitement level and opined that they were enjoying chemistry more because it was not ―just book chemistry, you know?"

In their interaction with the students, all the demonstrators and the lecturer were aware that many students were anxious, and even afraid of the learners coming the following week. Many students took the responsibility very seriously and worried that their own understanding of the material was not good enough to be able to teach it properly. This prompted all the questions and critical thinking even with regard to the answers the demonstrators gave them.

The atmosphere in the laboratory was industrious and busy, with students working well in their pairs or, in two cases, in groups of three. The students were very aware that they were getting a mark for the cleanliness of their bench at the end of the afternoon, and so most students were working carefully and methodically and their benches were orderly.

The dye practical provides an excellent vehicle to measure a student‘s ability to work in a clean and ordered manner as the intense colour of azo dyes makes them easy to notice on glassware, clothing and hands if they are not carefully handled.

Figure 4.2.2.1.2 *These pictures show student-lecturer and student-demonstrator interaction. The demonstrators wear orange and the lecturers wear blue. As can be seen the demonstrator and lecturer are engaged in deep discussion with the students, and using both written and verbal forms of communication.*

Student interaction with the demonstrators was frequent and often took some time. It was clear that the questions students were asking were not answered quickly and most of the demonstrators spent time showing the students, with pen and paper, and in terms of structure, what was happening chemically. (See Figure 4.2.2.1.2)

The demonstrators and lecturer agreed that the completion of the reflection and planning task, during the course of the practical, was a valuable learning tool that prompted the students‘ critical engagement with the chemistry involved. It also prompted the students to think ahead to the practical the following week where the Grade 12 learners would be involved (See Appendix E for the planning task worksheet). Many students asked me and the other demonstrators about how they could best involve the learners and many wanted to know how complex they needed to be in their explanations to them. This interaction and questioning shows that while the students were seeking to understand the chemistry, they were also focussing on the learning outcomes for the learners and that this preparation guided their own learning, and helped them to focus on each process.

Taking complex concepts which build on a large base of theoretical knowledge and simplifying them to a level that is easy to understand, requires a good understanding of the material and a cognisance of what is really important. This can only happen when the students see connections between the chemistry they have learned and the chemistry they are busy learning, rather than seeing each piece of knowledge separately (Schunk 2008). These connections are unfortunately not characteristically made in a practical setting, as was discussed in Chapter 2. However, in this setting, because students were asking the right questions, many students were beginning to make the necessary connections. This can be attributed to the planning and reflection task which demanded consideration of the learner at every step of the practical, and consideration of why the step was an important one. The planning and reflection task itself will be discussed in more detail in section 4.2.1.3.

From the behaviour of the students during the practical period, it would appear that they were more engaged, more interested and enjoying themselves more than usual in a chemistry practical situation. The kinds of questions they were asking and their deeper engagement with the demonstrators and the chemistry revealed that critical thinking that usually does not take place was employed by most of the students in their quest to understand the material and prepare for the service practical.

4.2.2.2 The Planning and Reflection Task (See Appendix E)

From the observations above, it is clear that the planning and reflection task played an integral role in the process of the practical. The task itself influenced the kinds of questions students were asking, it influenced their mode of thinking about the practical, and it helped them to prepare for the arrival of the learners the following week. For each of the demonstrators this task played a central role in their own interaction with the students as it provided a foundation on which knowledge could be conveyed and concepts learned due to the communication that it prompted.

The students themselves also commented on the value of the reflection task, saying that it made them think about the practical more and guided them to ask the right questions so that they could understand each section better. Many of the conversations that I had with the students during the practical were initiated by the student and not by me. As with the demonstrators, many students came up to me to tell me how enthusiastic they were about the service-learning and how they were enjoying the essay. Personally, as a demonstrator, I have never been asked questions concerning the method of the practical. However, during the afternoon, every aspect of the practical was interrogated and students asked both ―why" and ―how" questions, seeking to understand why the one reaction was done in ice for example, and how the reagents formed the product, even though the mechanism was not part of the practical write-up.

Despite the positive comments and general understanding of the value and purpose of the planning and reflection task, there were a few students who did not engage with the planning and reflection task on a deeper level other than simply filling in the blocks, and who did not appear to show any more interest in the practical than usual. There were some students who were very confused about what to do with the grid and how to fill it in. It took some adjustment for them to realise that there was no correct answer and they kept asking questions which indicated that they viewed this as another task with simple outcomes which they wanted to fulfil so they could get the marks. Most of these students, once they had engaged in conversation with me or the demonstrators, and had begun to understand what the purpose of the task was, were relieved that there was no ‗right' or ‗wrong' answer and proceeded to discuss amongst themselves and fill in their grids.

There were however, still a few who did not see the point of the exercise. They were simply there to do the chemistry and get it done, and appeared not to be worried about the following week. In every case, these were the same students who had not followed instructions carefully in their draft essays, and whose marks over the whole component for both the chemistry and the service aspects showed their lack of interest beyond doing the bare minimum. It is unfortunate that this experience did not seem to change their attitude to the subject in any apparent way. What was strange to me was that these

students had such positive views of chemistry in the pre-questionnaire but their attitude to all aspects of the subject was very negative in practice. This simply confirms that many data sources were necessary to gather meaningful information about the practical, as just the use of questionnaires would never have picked this up. Perhaps these students felt as though they should be positive about chemistry in the questionnaire, and were not entirely honest. As is mentioned by Gibbs (2007), there is the possibility that these students were looking to provide the answer they thought I was looking for. It was also apparent that the students, who did not put much effort into the reflection, were the same students whose language and grammar skills were lacking in the essays. This will be discussed further in the discussion section of this chapter. In many cases as mentioned earlier, the students who struggled to interact with the learners had not completed the planning and reflection task in a meaningful way.

4.2.2.3 The Practical Report

The practical manual that the students received as well as the report section which they had to complete after the first practical can be found in Appendix E. This report was completed by the majority of the class. Four students did not submit their report for various reasons, but the average mark of the submitted reports was 69%. This is a high average for a report which tested conceptual understanding of the material and required discussion of concepts that came straight out of the practical experience. What was also very interesting was that every single submitted report had the correct chemical reaction drawn, the correct product from the correct reagents, and many of them included the mechanism even though this was not specifically required. Since every pair of students had a different reaction using a different combination of reagents and creating a unique product, this must have resulted from understanding rather than copying the work of their peers. This result strongly supports the methodology used and seems to suggest that by giving students structures and not the names of compounds, a deeper level of understanding of the chemical process was gained. From the start of the practical students were engaged with reagents that had a structure and form, rather than named chemicals

whose structure had to be deciphered quickly at the end of the practical in order to complete the report.

Incidentally, students struggled most with the section in which equivalences had to be calculated. Many students made calculation errors or left out parts of the table. This would normally be considered the simple part of the practical where very little understanding is required and simple formulaic calculations are needed, using masses and amounts given in the manual. This was, in many cases, where students lost the most of their marks. Students also did not ask questions about this during the practical, but were rather focused on the chemical processes and the method of the practical and trying to understand these. The discussion section was, in contrast, done relatively well, with most students making very clear attempts at describing the phenomena they had seen, and succeeding in making the connection between colour, structure and the UV spectra even though they had not previously learned about UV spectra. This section of the write-up was also not specifically asked about during the practical, but the kinds of questions students were asking covered the concepts being assessed in this section. See Appendix H for representative extracts from the Practical Reports.

4.2.3 The Second Practical

4.2.3.1 Observations (See Appendix F)

Similar to the first practical, for the second practical required the demonstrators and lecturer to look at interaction between the learner and the students as well as comment on their knowledge of the chemistry, safety aspects and ability to involve the learner in the practical experience. This was a rich source of data, specific to each person, which enabled me to look at the cases which deviated from the norm. In this practical again, there was a large amount of interaction and discussion between the observers which added complexity and richness to the data collected.

In the second practical, we were observing the students ~~–a~~ctively experiment" after planning the interaction the week before (Kolb 1984). The students as a whole, participated wholeheartedly in the exercise with clear enjoyment and enthusiasm. The laboratory was buzzing with energy from start to finish and the students really had ownership of how the process worked as they interacted with the learners. We did not dictate to the students in anyway how they should go about involving the learners in the practical and so each group approached it differently.

The first 45 minutes of the afternoon was very chaotic, students and learners milled around the lab trying to figure out how the practical was going to work and there was much confusion in the beginning while trying to divide up the fourteen learners between the five groups of students. Once this had successfully happened, however, each group of students dealt with their learners differently. One group divided up the parts of the practical amongst the group, and all the learners assigned to that group spent time with each division, doing a different section of the practical. Two of the groups divided up the learners amongst them and so one learner had two students working with them at all times. Two of the groups had a group discussion at the beginning, where they gathered as a group with the learners and explained the whole practical and discussed it with the learners before pairing off and assigning the learners to pairs within the group.

Demonstrator 4 mentioned that the students and learners were very excited and seemed to be enjoying themselves. She noticed how the learners were getting individual attention from the students in her group, who were speaking to the learners in Xhosa. The teacher from one of the schools involved also mentioned her delight at the individual attention her learners were getting. She pointed out that it was an ideal situation – one child with two experts – and spoke about how the students were really explaining well and involving the learners. Figure 4.2.3.1.1 shows the interaction between students and learners.

Figure 4.2.3.1.1 *Students interact with learners, involving them and showing them how to ‚do chemistry."*

The teacher from the second school involved in the project thanked us many times. She spoke of how her learners were enjoying the experience so much and she mentioned that the students were explaining everything. She pointed out that everything was new for her learners, and articulated that in her classroom she could say things like ~~"Y~~ou are supposed to wear a labcoat and goggles," but that her learners had never seen them in reality and the school did not have them. She said, excitedly, ~~"t~~hey get to see what will actually happen if they study science."

Demonstrator 3 spoke about the students who were doing well at explaining and working with the learners. She mentioned how she had observed in her own group and across the laboratory that the students doubted themselves and were quite nervous to begin with, but that they were showing the learner structures, showing them the material safety data sheets and showing them how to calculate from moles to grams for example. She mentioned that the learners in her group were asking lots of questions and looked as though they were enjoying themselves although they were initially nervous. She also mentioned how some of the students were speaking in Xhosa with the learners and that this was getting a wonderful response from the learners. She was also aware that the learners responded very well to the students, but were in contrast quite wary of her.

From the demonstrator‘s individual student comments, it was very apparent that many of the students were nervous, doubtful and slightly uncomfortable at first and were unsure how to engage with and involve the learners. There were many students who initially

seemed afraid of engaging with the learners, especially when explaining the difficult concepts. However, once the practical got underway, the students began to appear to be more comfortable and the learners began to settle down and relax as well.

Some of the students who did not engage in the planning and reflection task in the previous practical, really struggled with the learner interaction; in the words of Demonstrator 1, they "seemed almost afraid" of the learner. It is also not surprising to see that the comment written next to one of these students, S_{30}, in the demonstrator observation rubric, is that "he does not fully understand the chemistry."

"Full understanding" of the chemistry does not appear to be the only indicator for engagement with the learner, however. Some students were observed to be clearly excited and enthusiastic with the teaching of the learners, even though they did not fully understand the chemistry. There were also some students who were not fully engaged with the learners, but who nonetheless knew the chemistry well. In this context, the type of interaction with the learner seemed to be very reliant on the personality of the student and that of the learner. It also took a while for the relationship to develop to the point where they felt comfortable with each other and the real teaching and learning took place. Some students found it easy to interact with and involve the learner in an active way, asking questions and providing opportunities for conversation. Others only spoke to the learner in response to questions the learner had asked, but it can be deduced that the learners felt comfortable enough with those students to ask the questions in the first place.

The lecturer's response to the practical was that it was very positive, with the students and learners learning in groups and appearing to be so enthusiastic. He mentioned a particular student in his observed group who was "terrified" of the responsibility of teaching someone else, but who nonetheless was doing a fantastic job of it. He spoke about how it would be wonderful to do this sort of thing for all practicals, and that although this was logistically impossible, it would be possible to do something similar at each year level. He was impressed that the students actually knew the safety information, and were so clearly "on top of things" in the laboratory. He could see how efficiently and

effectively the students were working, which in his long experience of undergraduate practicals he knows is a sure indicator that they understand the work that they are doing. He was also struck by the caring and careful way in which some of the students approached the learners and their teaching. He was genuinely impressed with the activity and the successful implementation of the service-learning.

From my own observation, the whole exercise was far less chaotic and much more meaningful than I imagined it could be while the learners and students were both in the laboratory. I had feared that lack of space would be a real issue and that confusion and fear on the part of both the learners and students would limit the success of the learning taking place. These fears were, however, unfounded. There seemed to be the right level of control, and the students picked up the reins and took the initiative to lead. Only one student out of the whole class commented that the process was not organized enough, and in fact just fewer than 60% of the class commented in their reflections that the whole experience was excellent the way it was. These students recommended no changes apart from more time to spend with the learners, because they enjoyed it so much and would have liked to develop more of a relationship with them, got to know them better and thus been able to share more relevant knowledge with them.

Space wise, the laboratory was very full, even though there were only fourteen extra learners. Many lecturers and other observers came to see what was happening. This was however dealt with excellently by the students, who maneuvered their way around the laboratory safely and confidently, and directed the learners, having already successfully completed the practical the week before and therefore knowing where all the reagents and equipment were situated.

Despite the initial confusion and slight wariness of both the learners and students, a rapport developed between the students and learners far more quickly than I had anticipated, and smiles and laughter were seen and heard all around the laboratory. Learners seemed to feel very comfortable with the students, regardless of their race, sex or language. In fact, the observations of my _critical friend' who was focusing on the

learner response confirm that this was a mutually beneficial exercise and corroborate the demonstrator, lecturer and teacher perspective that both students and learners were engaged and enjoying themselves, and that even during the course of the practical their perspectives of themselves and chemistry were changing.

When she spoke to the learners asking them what they had learned or when she asked them to explain what they were doing at the time, what really impressed my ‗critical friend' was how they would answer her in the ―language of chemistry." Even though the conversation was in isiXhosa it was ―heavily peppered with Chemistry lingo." She was impressed by the explanations the learners were giving and it was clear to her that they knew what they were doing and most importantly they could explain why they were doing things in a certain way. Some examples she mentioned were that they knew why they were using ice to cool down the reaction, could explain the precautionary measures of wearing protective gear as well as why they had to add certain chemicals at a slow rate rather than all at once.

What came across very clearly for her from, as she put it, ―every single one of the learners" was how much they valued being participant observers. They spoke excitedly about how they were given opportunities to actually do the measurements, add chemicals and fetch needed equipment amongst other things. This was an unprecedented opportunity for them to closely interact with science, especially science at university, something that may have been completely foreign and inaccessible before. They also spoke about how experiencing the practical in this way increased their interest in chemistry as a subject.

What she mentioned as interesting to note, was that it did not matter whether the students could speak isiXhosa or not, as it did not impede the learning experience for the learner and in her opinion the learners' confidence levels were the same whether the learner had an isiXhosa speaking student teaching them or not.

My ‗critical friend' observer mentioned a particular example of one female learner who had three male students teaching her. She asked the learner how it felt to have all males who did not speak a word of isiXhosa teaching her, and the learner answered confidently that did not bother her, that she could learn from anyone, and that the guys (male students) were explaining the practical to her very well. When asked why she was doing chemistry, her answer was that she really liked chemistry, and that there was ―just so much you can do with it – all these careers that are out there." Her other reason was that she saw the lack of black women in the chemistry field, and commented that it was ―almost as though black people were afraid of it." She expressed her wish to change that by joining in and making her own contribution to chemistry.

From my own observation, the poster created from the results of the previous week's practical became a focal point in the laboratory, and was used as a teaching aid by the demonstrators and students. The students had a sense of ownership of the poster, and they seemed proud to show the learners what they had achieved the previous week. This was a valuable tool to teach and learn chemistry, but also for the students to feel they had something to contribute and offer – I overheard many students telling the learners about their experience the week before and showing the learners which dye colour they had made.

The outside observer, who was focussing more on the learners, also noticed the role of the poster in the learning experience. She noticed that the azo dyes chart was used by the students to explain concepts to the learners and that it became a useful teaching aid. Although she was not focusing on the student experience she did chat with some of them and they clearly had a positive experience. A few of the students spoke to her about how they actually were enjoying interacting and explaining concepts to the learners and one student mentioned that she thought perhaps this group of learners was chosen for the practical because they were the ―clever ones" since they really seemed to know their chemistry.

This observer along with all the demonstrators picked up on a number of the students using everyday examples to bring home some of the chemistry concepts to the learners, which was significant. This also indicates the high level of understanding of the students, if they were able to explain and bring concepts across to the learners in a simple way. The students did not just know the right vocabulary, they really understood, and could explain both at a scientific level, as they demonstrated in their practical reports, and at a novice level, as they demonstrated in their interaction with the learners.

A number of students that I spoke to during the practical, especially the women, gushed about how much they had enjoyed it. The men were less effusive, but nevertheless said how much they had benefited from the experience. One student commented that she had realised that you have to put in more effort, in order to develop a better understanding of the subject matter, and that she was aware of how she had personally developed over the course of the service-learning component, both in her approach to learning chemistry and in her interaction with others. Another student observed that the learners had the opportunity during the practical to feel the students' positive energy about chemistry and would hopefully be inspired to do science. He was very aware of his own responsibility in making that happen.

Another student confided that she never asked questions in lectures and seldom in practicals, but that she had been so surprised by how much she had understood just by engaging with the demonstrators and her fellow students, and so inspired by the learners' quest for knowledge that she had resolved to ask more questions in lectures so that she could "get more out of this." Suddenly she realised what an opportunity she had to understand, and that it was well within her grasp to have more than what she had previously been taking for granted.

The last student that I spoke to during the practical summed up his experience,

> "This was a great way of revision. We obviously had to really know what was going on. The essay, practical and second practical all combined gave us what we needed to know, and we had to know it all, to interact with the learners. I will never forget it" (Researcher observation notes).

4.2.3.2 The Post-Reflection (See Appendix F and H)

The post-service group reflection task was completed by the students and learners who had worked together on the practical in their groups. Thus there were five group reflections, very similar in layout to the pre-service planning and reflection task. The students and learners all gave very positive feedback and some ideas for improvement of the module.

The groups responded to each section on the reflection in a very similar manner. Responses ranged from the superficial and obvious, especially with regard to the –So What?" column, to the more in-depth. Students were aware of how much they had learned from explaining to the learners, and saw how each part of the practical corresponded to specific areas of learning, both within chemistry and seeing chemistry as a part of the world.

Responses were coded (based on Eyler and Giles, 1999) according to the type of learning the students identified was taking place (So What? column) and according to the kinds of changes that the students and learners felt would improve the module for the future (Now What? column). Most groups saw the value of explaining to the learners and identified this as an area of learning and one of the main reasons for doing each section of the practical with the learners. Many groups also highlighted the role of the practical in making the theory real and putting it into practice as an area of learning for both students and learners. The groups also highlighted learning a skill as a reason for doing the practical and an area of learning, as well as putting chemistry and chemical methods into context. See Appendix H for some examples of coding.

In terms of the suggestions for improvement, all groups suggested ideas that built on the practical as it already stood. No group suggested that the practical be changed completely or that the exercise was a waste of time. Many suggestions called for more guidelines as to what exactly to teach the learners, and how to teach and for more time to spend with them, which points towards the students feeling responsible for the experience of the learners and wanting to improve it. Students became engaged and interested in the

learners themselves and wanted to give them the best possible experience. This falls under Eyler and Giles' (1999) learning area of Engagement, Curiosity and Reflective Practice. Some suggestions also included an expansion of the practical in terms of what was done – all asking for more time to explain and show learners the equipment. One group even suggested doing the practical over the weekend! The coding of the responses to both the "So What?" and "Now What?" sections of the reflection suggests that all six areas of learning that Eyler and Giles (1999) discuss (see Chapter 2), covered to a greater or lesser extent, and students are able to articulate what learning they saw as taking place, see Appendix H for more details.

4.2.3.3 The Post-Questionnaire (See Appendix G)

The results of this questionnaire will be presented in comparison and with reference to the pre-questionnaire results. These are raw data comparisons which have not been tested as the main focus of the research was not on quantitative data but on the qualitative responses of the students. This information is thus presented for illustrative purposes only and cannot be used to make statistical inferences beyond the face value of the results given here. Students in general showed a greater appreciation for chemistry and their view of service-learning in the post-questionnaire was very similar to their expectations of service-learning in the pre-questionnaire. Their civic awareness and desire to contribute to society was also positively affected by the service-learning practical. The results are discussed, in detail, below.

The statements the students gave concerning their understanding of service-learning could again be broadly divided into two categories. Either the students saw service-learning in its broad definition or defined it as only applicable to chemistry. There were now only five students who defined service-learning in terms specific to chemistry, and to a greater extent, student responses encompassed the spirit of service-learning. An example of this kind of response came from student S_{13},

> "Service-learning is an enriching experience as it shows the students a practical application of chemistry. At the same time it helps gather skills of communication and teaching from both the Grade 12s and the 2nd years."

On the other hand, with the majority of the class seeing service-learning in a broader sense, there were a three subcategories of response.

1) The students saw their own learning as the most important and sidelined the community (student-focussed), or
2) they saw the process as joint (mutual), or
3) they emphasised the charitable aspect and saw the community as gaining the most from the experience (charity).

However, in comparison to the pre-questionnaire, there were many more responses that emphasised the joint nature of the community and student involvement. This shows that through being involved in the service-learning, students' perceptions of what the community had to offer them changed. This change is also seen in response to the Likert scale questions in the questionnaire. In the student responses, many students used the word 'joint,' and also spoke of working "with the community," rather than "for" the community. Some examples of responses emphasising the joint nature are mentioned here, but further coding and examples can be found in Appendix H.

Service-learning is…

"…helping the community by teaching them skills while having fun and both parties benefitting" (S_{32}).

"…a joint learning experience for both the aspiring scientists and the community…(S_{13})"

"…applying the knowledge you have of chemistry by working with the community…" (S_{11})

"…teaching someone less fortunate while learning from them in the process…" (S_8)

"…engaging in an exercise that is simultaneously beneficial to the community in which you live, and yourself…" (S_{20})

The student view of service-learning was a section of Likert-scale response questions which corresponded with the student expectation of service-learning questions in the pre-questionnaire. There were a few more questions asked in this section than in the pre-questionnaire section, and the graph showing the responses can be found in Figure 4.2.3.3.1.

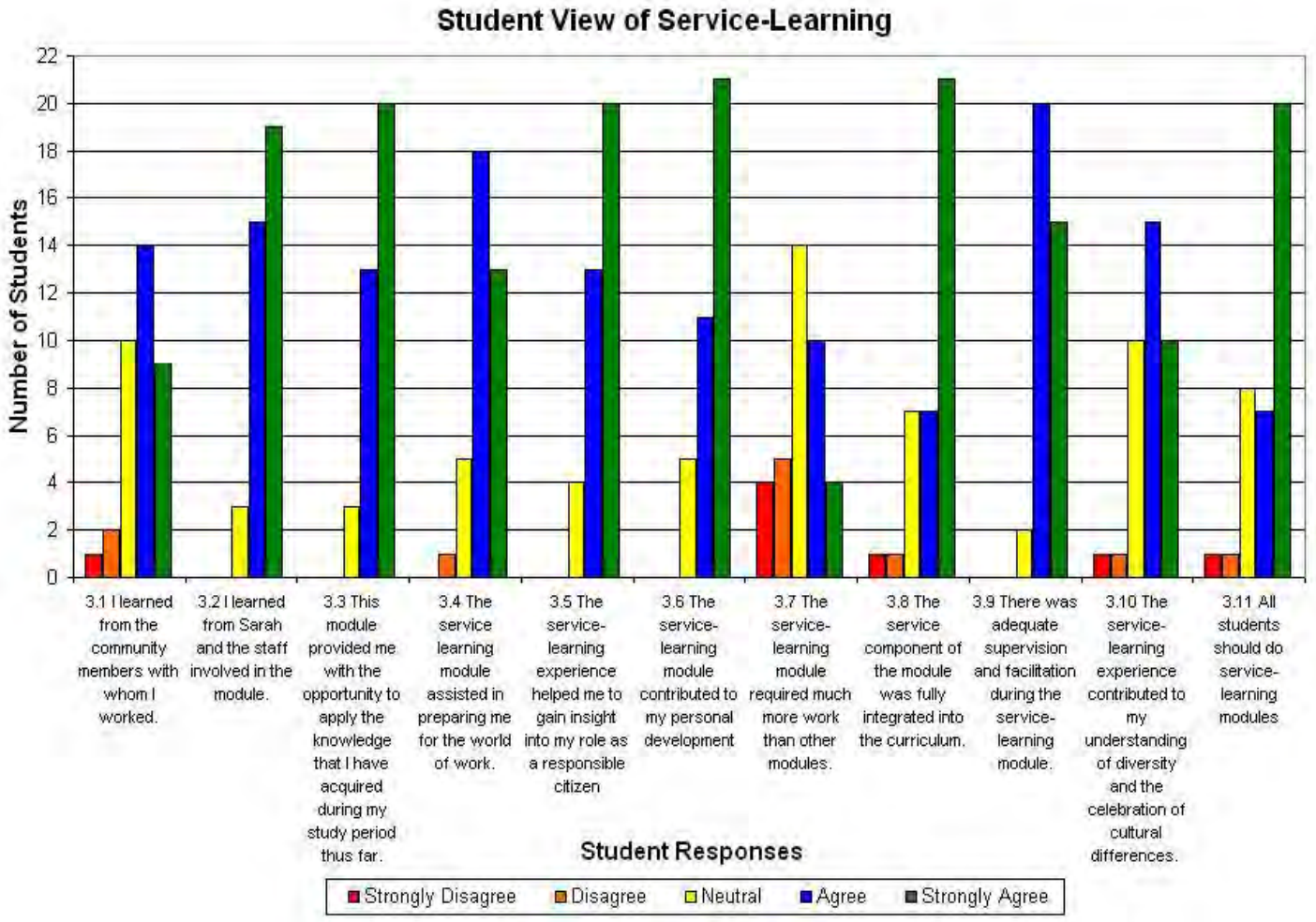


Figure 4.2.3.3.1 *Bar graph showing distribution of student responses in the "View of Service-learning" section of the questionnaire.*

Students were more enthusiastic in their expectation of how much they would learn from community members than they were in their perceptions of the actual experience. This was interesting, because in many cases, a student would say in their questionnaire that they had not learned from the community members with whom they worked, but later on

in the questionnaire would be writing about how they did not realise how much knowledge they had, that they had learned how to teach and impart information and other areas of learning which they would not have learned if the community members were not present. The response to this question when compared to the responses to other questions in the questionnaire seems to indicate that students still see ―learning" as being academic learning, and that the other areas of learning are not acknowledged or given the same status as chemistry learning.

Students' responses to the second question remained similar to the response in the pre-questionnaire, showing that student expectations of the staff were met. There was a big increase in ―strongly agree" and ―agree" responses to the third question which asked about application of knowledge learned thus far. No one answered disagree, and particularly the number of ―strongly agree" responses increased. The student response to this questions shows that the service-learning module gave the students an opportunity to apply and use the skills and knowledge that they had learned in a practical way.

Student perception of how the module prepared them for the world of work changed from being mostly ―strongly agree" to being more ―agree," but the total number of positive responses remained similar, showing that expectations in this regard were met.

The next question which tackled whether students felt that the service-learning experience had provided insight into their role as responsible citizens had, in comparison to the pre-questionnaire, a much more positive response. Student response in the pre-questionnaire was positive, but most students answered ―agree" rather than ―strongly agree" and there were also a number of neutral responses. In the post-questionnaire, however, student response was mainly ―strongly agree," with more ―agree" and fewer ―neutral" responses. The change in perception of the students of their role as responsible citizens shows that the service-learning experience did provide citizenship learning outcomes, even though these were not incorporated into the reflections, or discussed over the course of the module.

A similar situation can be seen with students‘ opinions of their growth and personal development. While students in the pre-questionnaire were not negative in response to this question, the post-questionnaire responses have many more ―strongly agree" responses but fewer ―agree" responses and more ―neutral" answers. The increase in neutral responses could again be because of different value systems attaching meaning to learning and development. Some students might not see overcoming obstacles and learning to work better independently or in a group situation as areas of personal development. Perhaps this question could have been worded more specifically to avoid this problem.

In terms of work load, students in the pre-questionnaire were non-committal, answering mainly neutral. In the post-questionnaire, however there was a distribution of answers showing that here personal opinion and the level of effort each student is normally prepared to put in were being interrogated. Some students strongly disagreed that more work was required. Others ―strongly agreed." However, again, most students answered neutral, showing that the amount of work required of the students was not more than they could handle and not more than what is very often required in other courses.

The other questions dealt with in this section of the post-questionnaire were new compared to the pre-questionnaire and question 3.8 and 3.9 dealt with logistical and practical aspects of the module. The student response indicates that the module was well integrated into the curriculum, and that the supervision and facilitation that the students received was adequate. The question concerning understanding of diversity and celebration of cultural differences had a mixed response, although it was weighted more heavily on the positive side. Those who disagreed were, in general, students who did not interact well with the learners. However, there was one student who responded ―disagree," who did interact well with the learners and had an extensive background in community engagement. In this case, her answer was motivated by the fact that her understanding of cultural differences was already highly developed, and this one interaction did not change her already developed sense of diversity.

The last question asked students whether they felt that all students should do service-learning modules, and the majority of students answered –agree" or –strongly agree," showing that for the majority of the class this was a valuable experience. Those that answered –disagree" and –strongly disagree" were the same students who felt that the work had been too much and who did not make an effort in the practical. Their reflections were not deep and they did not engage with the demonstrators or the learners in the same way that the other students in the class did. It is understandable that for various reasons there will be students who do not make the extra effort because they do not see the point of the exercise. Strangely enough, many of these students wrote in their general comments that they really enjoyed the experience, again possibly seeking to provide the answer which they thought was required.

The next section of the questionnaire consisted of open ended questions looking at the learning taking place during the module. Student understanding of the learning outcomes was questioned. They were asked whether, in their opinion, the community's learning outcomes had been achieved. Questions were asked about what students learned from the community members, their fellow students and themselves. In addition what they had learned about the lecturer and me was questioned along with their understanding of the value of reflection. They were subsequently asked specifically about how they had grown personally, how their social skills had developed and how service-learning contributed to their overall sense of social responsibility. They were finally asked for their recommendations for possible modifications for future classes.

This section had mixed levels of response from the students. The questionnaire was administered after the learners had left at the end of the practical afternoon. Many of the students were tired, and it was a long questionnaire. Some students did not make considered responses to the question even though they knew that the long questions were being assessed as a reflection. Thus the insight from the questionnaire could have provided a more complete picture. However, with the many data sources this does not present a problem. Also as is not surprising, the students who both academically and

practically gave of their best during the module, completed the questionnaire in the same manner. Those students who did not, and whose marks reflect this, completed the questionnaire in a sloppy way.

In terms of the research methodology, if lecture time had permitted, the questionnaire should have been administered the next day. In terms of service-learning reflection practice, this would also have improved the student learning from the process of doing the reflection, as the students would have had more time to think about their experience.

The summary of results is presented here; see Appendix H for examples of the coding.

In Figure 4.2.3.3.2 the student responses to the two questions asking whether their own learning outcomes had been achieved and whether the community learning outcomes were achieved are illustrated. As the figure shows, no students answered ~~"n~~o" to either of these questions.

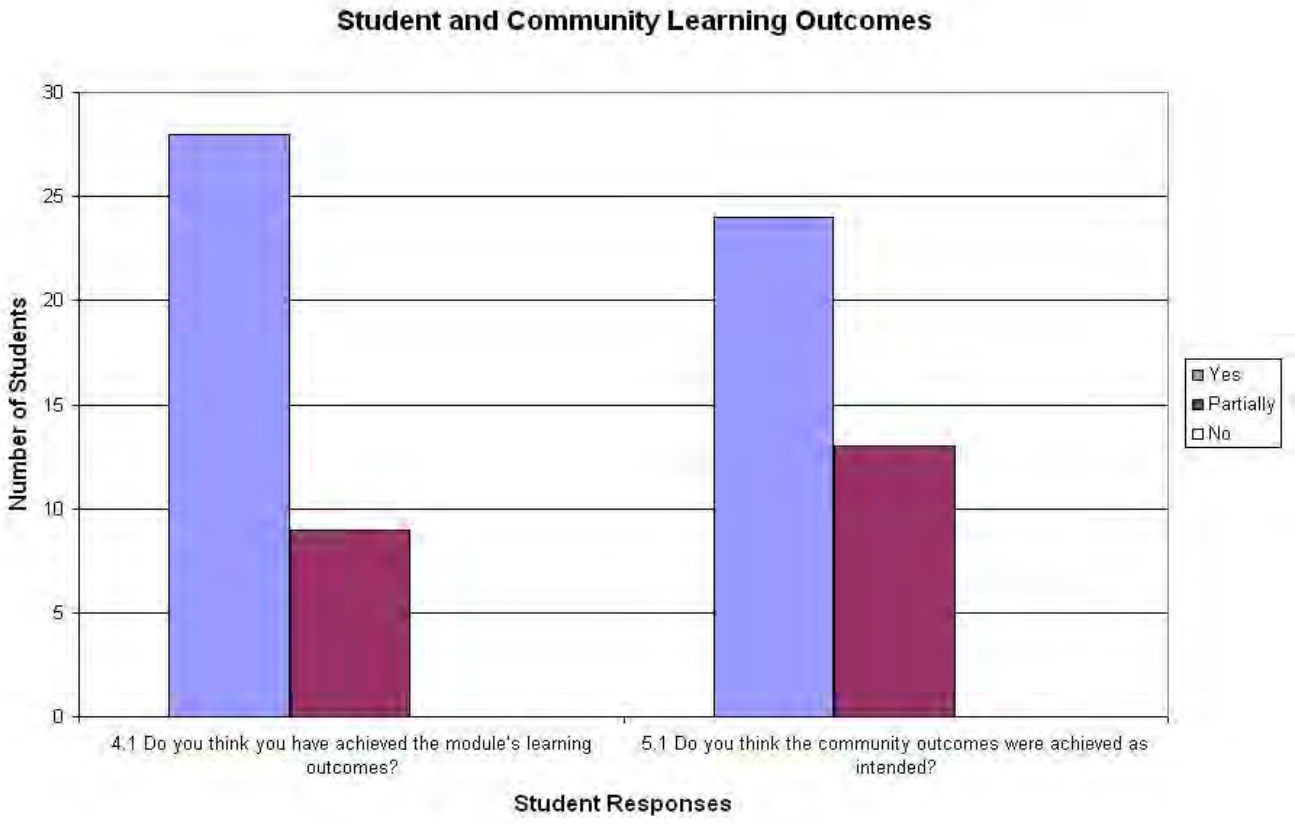


Figure 4.2.3.3.2 *Bar graph showing student responses to questions 4.1 and 4.2 in the post-questionnaire, note, there were no negative responses.*

The majority of the class felt that their own learning outcomes had been achieved, and that the learners had had a good experience, but that ―had more time been dedicated to the exercise, far better outcomes could have been achieved" (S_{20}). This student was not alone in his observation, many students who answered ―partially" felt that time was a major factor in both their and the learners access to the learning the service-learning module could have offered them. Another student (S_{10}) said that in her opinion the learners had only partially achieved the learning outcomes of the module ―because a day is not enough."

The students who answered ―yes" to question 4.1 mentioned their knowledge of dyes and dyeing, understanding of the practical, working in groups and with different people and giving back to the community/social responsibility as reasons why they had fulfilled the learning outcomes. One student (S_{18}) felt that her own learning outcomes had only partially been achieved because ―we as students didn't gain much from the grade 12 learners." However, later on in her reflection she stated that the experience further developed her communication skills with people of all walks of life. Since she learned this through interacting with the learners this gives credence to the idea that many students saw ―learning" only in terms of academic learning, and could not see what they had learned from the learners as ―learning."

However, most students in answering question 6.1 ―What did you learn from community members?" offered many different views on what they had gained from working with the learners. The responses were categorized with the corresponding Eyler and Giles (1999) category in brackets:

- Civic awareness (Citizenship): for example a student (S_{32}) mentioned that she had learned about the learners' lives and that interacting with them had created ―a lot of awareness within me," other students, in the same vein wrote that they had learned what a privilege it was to be at university.
- Enjoyment and seeing chemistry through new eyes (Perspective Transformation): Many students mentioned how the enthusiasm of the learners had caused them to

like and enjoy the module more and ―had enhanced (their) love for chemistry" (S_{27}).

- Social and teaching skills (Personal and Interpersonal skills): For example working together, working with different people, communication and qualities such as patience, being responsible.
- Perspective change (Perspective Transformation): for example, ―I can share ideas with them and surprisingly even them, they have the same ideas as me" (S_{14}).
- ―Nothing"
- No response: this category includes those who did not write an answer to this question.

By far the category which came up the most often and also in conjunction with responses that fitted into the other categories was the ―social and teaching skills." This fits into the personal and interpersonal development learning category as defined by Eyler and Giles (1999).

Question 6.2 asked students to state what they had learned from their fellow students during the experience. Here again, the responses were categorized to facilitate answering the research questions. The categories and some examples are quoted below with the Eyler and Giles (1999) categories in brackets. Further examples and coding can be found in Appendix H.

- Chemistry concepts/ Academic skills (Understanding and Application of Knowledge): ―I learnt how to conceptually understand the chemistry" (S_{28}), ―more insight and explanation of the theory of dyes – from what each of us knew – ideas and thoughts were merged" (S_{18}).
- Personal and social skills (Personal and Interpersonal Development: for example communication, working as a team, simplifying knowledge, teaching skills. ―I learnt about group work and dividing the work load so as to get work done much faster and more efficiently" (S_{29}).

- Perspective Transformation: both of chemistry and the way they viewed each other. —..passion from the students" (S_{25}), and —how to make chemistry fun again" (S_{36}), —Gained new respect for my fellow students watching them teach" (S_2).
- Nothing: Only one student responded that he had learned nothing from his classmates.

The next question, question 6.3, asked students what they had learned about themselves during the service-learning experience. The responses were also categorized and further examples can be found in Appendix H. As above, the Eyler and Giles (1999) categories are in brackets.

- Knowledge of inherent skills never needed/noticed/used before (Perspective Transformation): for example, —I'm actually not a bad teacher, I can explain concepts" (S_{18}).
- Awareness of knowledge gained at university (Perspective Transformation): for example, —I know most of the things that I have learnt since first year" (S_{10}).
- Realisation of ability to contribute to society (Perspective Transformation and Citizenship): —..you can actually apply your skills in developing something that can be used to help the community" (S_{12}).
- Self knowledge (Engagement, Curiosity and Reflective Practice): —I interact easily with others" (S_{22}), —That I am able to do things on my own rather than need much help from them (other students or demonstrators)" (S_{14}), —That I need to be more open minded" (S_8).
- Knowledge of how to develop academic skills (Understanding and Application of Knowledge): —..and having critical thinking (skills) especially from the learners' questions" (S_{25}).
- Uncategorized: These were blank answers and those that were not filled in seriously, and other answers which do not fit into a specific category for example —I am very good at these things" (S_3).

The fourth question in section 6 asked students to comment on what they had learned from and about me and the lecturer during the experience that they would not otherwise have known. These were also categorized according to themes.

- Critical thinking skills (Critical Thinking): ―I learnt how to think critically about what I'm doing and to always question why we do things the way we do" (S_{28}), ―They made me ask myself questions about my life, as in what am I doing? Is it really what I want" (S_{27})?
- Admirable character traits, caring for the community (Perspective Transformation and Citizenship): ―They took academics (academic studies) to another, and a better level where many people can benefit" (S_{30}), ―they…involve themselves in the prac activities, not just facilitate" (S_{31}).
- Chemistry Skills/Knowledge (Understanding and Application of Knowledge): ―Learnt lots of details about organic chemistry and pracs that aren't in the syllabus" (S_{35}).

The next question asked students to reflect briefly on their personal experience of the service-learning module. Again responses were categorized according to the learning themes that emerged from the data and these were placed within Eyler and Giles' (1999) categories (in brackets) See Appendix H for more details.

Students described how they felt about the experience and only one student out of the class gave a negative comment, saying that there was too much to do (S_3). Students felt that the experience was a good one with many different areas of learning.

The following categories emerged for student responses and Appendix H gives details of coding:

- Worthwhile/fulfilling experience for students
- Worthwhile experience for learners
- Enjoyable/fun/loved it/great/inspiring
- Felt more involved in the community

Students also mentioned specifically what they had learned to validate their opinions of the module. These are also expanded in Appendix H.

- Applied theory to practical work
- Better understanding of chemistry/academic knowledge (learnt new things)
- Importance of group interaction/communication
- Importance of (interaction with) the community
- Learned responsibility
- More respect for lecturers/teachers
- No response

The next three questions of the questionnaire were in general answered very poorly by the students. This may be because some of them seemed to overlap with previous questions and so some students just left them blank. The question asking students about the value of reflection was misunderstood by most students if they answered it at all. Thus I will not analyse the responses, as they do not shed light on what students learned from reflection. This would probably have been avoided if it had been possible to pilot the questionnaire in the conventional way. The next two questions 6.7 and 6.8 ask about students‘ personal growth and development of their social skills during the experience. The responses here are also not very considered, with many students just saying ―They have grown" or ―a lot" in answer to the questions, rather than actually answering *how* they had developed and how their skills had been influenced by the experience. Those that did answer these questions adequately gave the same kind of responses that came

from the previous questions about learning, from each other and from the learners. Students mentioned social skills like confidence, communication skills and ability to teach and explain as having developed as well as being able to simplify complicated concepts in order to explain them. One student (S_{17}) said how he wished that ~~–e~~very prac that we (do) would do it in the same procedure, that way it would be stamped into my mind as an experience I'll never forget."

Some students mentioned that they felt they had become better people as they realised the value in passing on the knowledge that they had, and that their responsibilities to society had become more apparent to them. In terms of the learning taking place due to the service-learning, these questions merely confirmed the themes already emerging from all the other data.

Question 6.9 asked about students' sense of social responsibility and how it had been developed by being involved in the practical. This was also answered badly, and it was very clear that students were experiencing questionnaire fatigue at this point. However, again the students that did respond confirmed what was emerging from their responses to the previous questions, their sense of social responsibility was developing and had changed over the course of the practical as they now saw the value in the knowledge they had gained at university so far and the importance of passing it on. Many stated that the module had taught them to give back to the community whenever they could.

The last open response question allowed students to offer their opinions and suggestions for change of the module in the future. These responses were also categorized:

- No change/Perfect/great
- Everyone should experience it
- More time
- More background information for the learners
- More colours when we dye with the learners

The rest of the questionnaire consisted of Likert scale questions which will be presented here again in comparison to the pre-questionnaire. The section following the open response questions attempted to illustrate the student view and experience of chemistry after the service-learning module had taken place. Figure 4.2.3.3.3 shows the student responses to the statements given in the questionnaire.

The bar graph clearly shows that students have a very positive view of chemistry and see it, as they have learned it, as being useful to society. Figure 4.2.3.3.4 shows the comparison of results for each question from the pre- to the post-questionnaire.

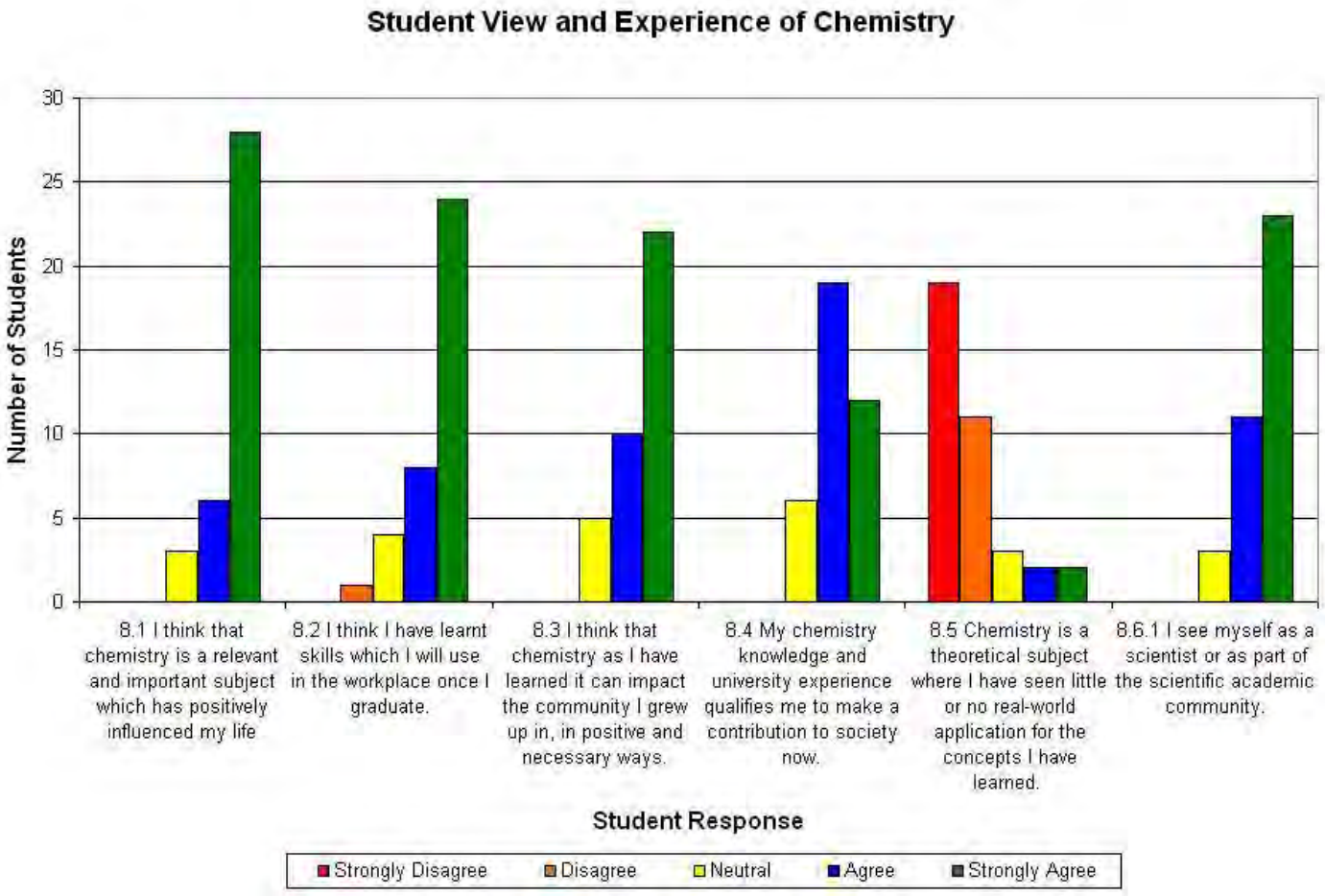


Figure 4.2.3.3.3 *Graph showing the student response to statements concerning their view and experience of chemistry*

What is very encouraging to see is that the number of ~~–s~~trongly agree" answers increased for every question apart from question 8.5 which is reverse scored. However, in question

8.2 the number of neutral responses increases, and one student even disagreed post-service-learning. This question asks about skills in the workplace, so this could be because the student did not see the connection with the social skills learned and the world of work, or it could be that the student does not intend to work in the chemical field. What is probably most encouraging to see is the change in the way students see themselves as positioned within their discipline. Pre-service answers to the last question in section 8.6 indicate that some students are unsure of where they fit in, in terms of the chemistry academic community. Post-service, however, the number of positive responses has increased, there is no longer any student who disagrees that they are part of the community and the neutral responses have also decreased. This shows that the service-learning succeeded in changing students‘ view of themselves as valuable within their discipline and showed them how much knowledge they actually had to offer. Figure 4.2.3.3.4 presents bar graph showing a comparison of students pre- and post- responses to question 8 of the questionnaire.

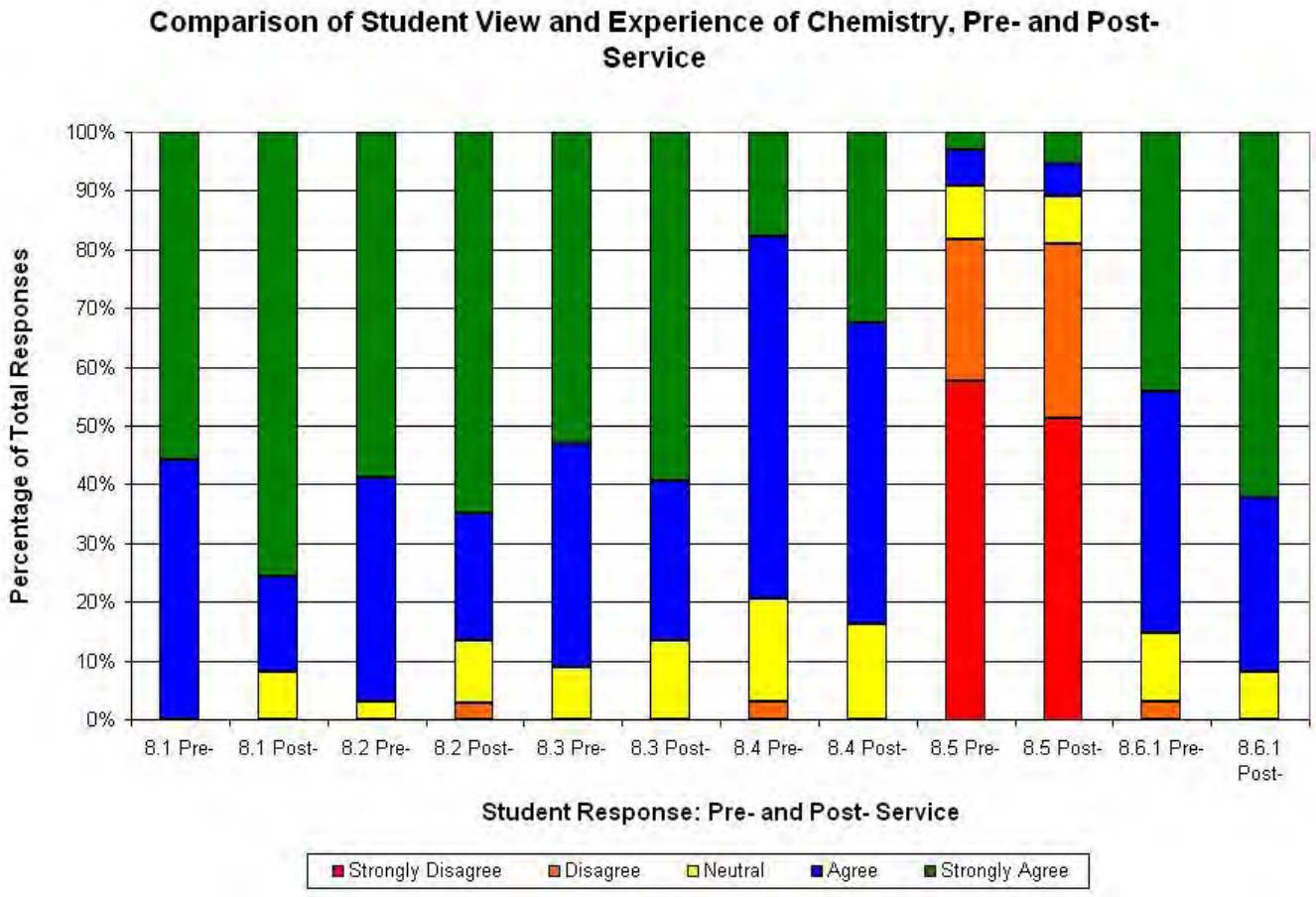


Figure 4.2.3.3.4 *Comparative bar graph comparing pre- and post-questionnaire responses to the same questions.*

In terms of citizenship and responsibility, again the same questions were asked as in the pre-questionnaire, but with an extra question at the end asking if students would become involved in other community engagement as a result of their experience in the course. Figure 4.2.3.3.5 shows the students responses.

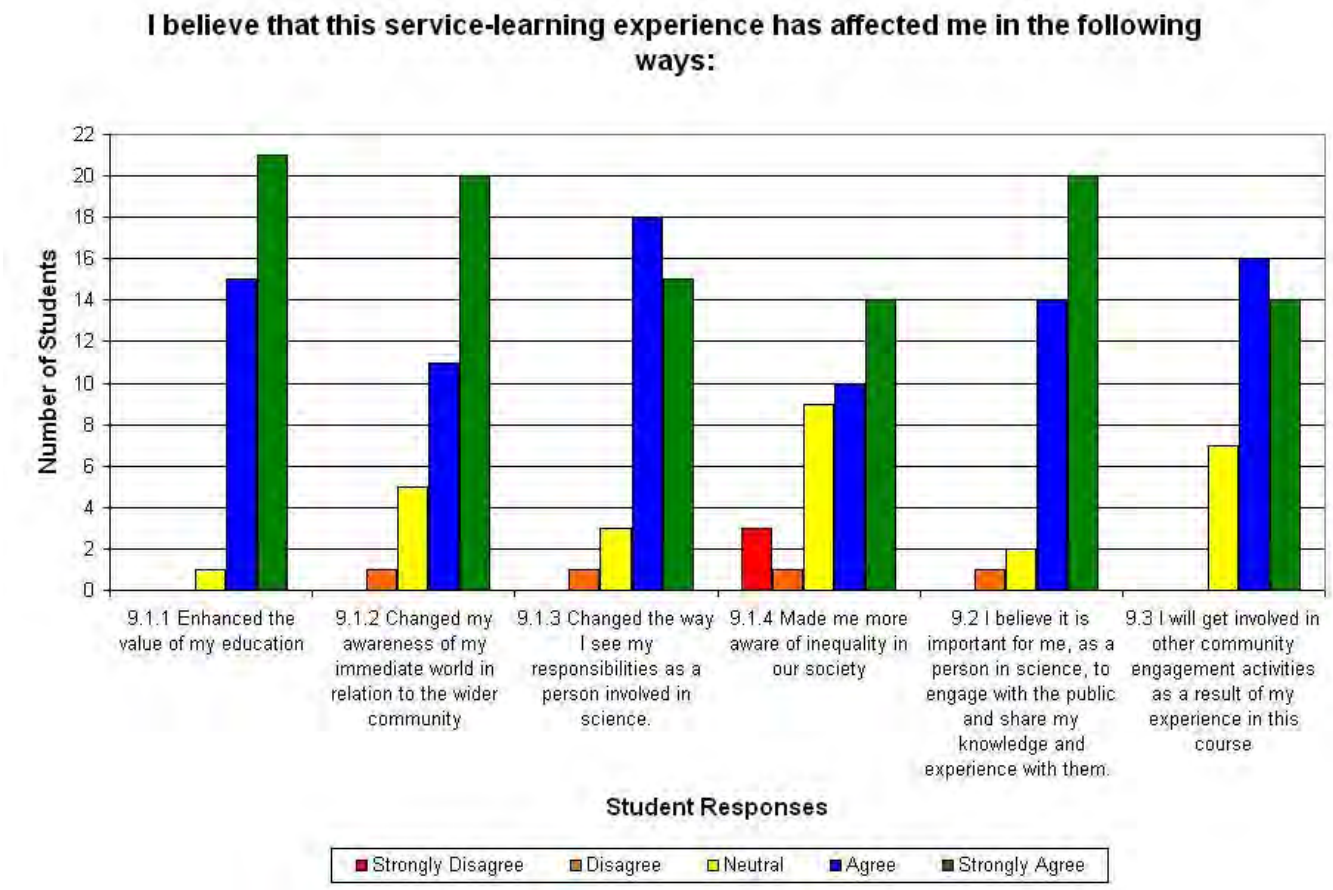


Figure 4.2.3.3.5 *Graph showing student responses to statements regarding their experience of service-learning n terms of citizenship and responsibility.*

The last question, added since the pre-questionnaire, gave a very encouraging response. No student disagreed, and the majority of the class agreed that the course had influenced them to take part in other forms of community service. The responses to question 9.2, asking if students believed they needed to engage with the public about their work in science, remained very similar to the results from the pre-questionnaire. There was one student who answered ~~"d~~isagree" in the post-questionnaire, whereas there were no negative answers in the pre-questionnaire. Question 9.1.4, asking if students had become

more aware of inequality due to their experience of service-learning, had quite a large increase in –strongly agree" responses, but the total number of positive and neutral responses remained very much the same. Similarly students' responses remained similar for question 9.1.3, 9.1.2 and 9.1.1, showing that student expectations of the value of community engagement and what they would get out of it determined how they experienced it.

4.2.3.4 The Essay and Essay Reflections

The students' essays were the ongoing foundation on which the whole service-learning component was built. The essay introduced the topic and provided theoretical and societal understanding of the place of chemistry in the world for the students. It was, for many of them, their first academic essay in the sciences and came with many challenges which the class managed to overcome and many skills were learned through writing the essay.

While these skills are not specific to service-learning as such, the skills that these students learned by writing the essay serve as evidence for the usefulness of using an essay to introduce a service-learning component as was done by the researcher and provide continuity with the subject matter learnt in lectures.

Students performed very well on their essays, and when comparing the standard of writing and layout from the draft essays to the final copies, it is obvious that the formative assessment involved in the marking of the draft essays, provided the students with much needed guidance and help in improving and refining their writing. Many students, in their reflections commented on how the draft essay really helped them to manage their time effectively, and write the best essay possible, as they could see where they had gone wrong, and learn through making mistakes and being shown how to correct them. There were also many students who did not finish their essays in time to hand in a complete essay as a draft. All of these students mentioned in their essay reflections that this had been a mistake, as they would have liked to see how to develop their essays.

The high standard of writing that resulted from these essays is testament to the value of forcing students to submit a draft, as they work over a longer period of time, rather than starting their work at the last minute, and they learn through the mistakes they make in their first attempt. The average final essay mark for the class was 71%. This is a good average especially in light of the fact that many of these students had never submitted an academic essay before, and that the topic of dyes was completely new to the students who had never been lectured on them before.

The essay reflections were coded in order to categorise the different types of learning that occurred as a result of the essay and the service-learning practical, as well as identify the skills that that the students were aware of gaining through the experience. (See Appendix I)

From the essay specifically, students were very vocal about the challenges posed by the many different skills that they had to learn in order to fulfil the essay requirements: "I found it difficult to do this essay writing task" (S_2), "I felt overwhelmed at times with some of the chemical structures that were thrown at me (S_8)," "I found it vey hard to do things like referencing" (S_{10}). While they mentioned these challenges and gave their ideas for improvement of the essay task, there was an overall sense of gratefulness for and understanding of the value of the essay task. Students proudly stated how they had overcome many of the challenges they had faced. "I had never read a chemistry journal before. However, writing this academic essay was of great benefit to me and I totally enjoyed it" (S_{10}).

Many students mentioned the interplay between the practical and the essay, with some stating that they could not understand the information they had researched until they had done the practical. As S_{15} said,

> "At the beginning I found it difficult to do the essay writing task because of the fact that I had no background of dyes and I couldn't understand what I had to do, the practical experiments contributed a lot into making me understand what I had to do."

Others said that they would have struggled with the practical if they had not had the opportunity to do the research on dyes that they did for the essay.

> "This essay was also beneficial to me in a sense that it prepared me to be able to explain concepts and mechanism(s) that I did not understand during the parallel combinatorial synthesis of azo dyes practical with the learner from high school" (S_{16}).

The background information that the essay gave to them was identified by most students as very valuable in their interaction with the learners. They could position the practical in the real world and this was valuable, both for their own learning and for the experience of the learners.

> "This essay has demonstrated the importance of chemistry as a practical and extremely important subject...(and) had a significant effect in placing the service-learning dye practical into perspective as it provided the necessary background to the topic" (S_{35}).

Thus the combination of the essay and the theoretical background that it provided, along with the practical opportunities that the dye practical afforded gave all students, no matter their preferred learning style, the opportunity to assimilate information and use it practically.

The essay reflections provide insight into each individual student's experience of the service-learning module. It is in these reflections that the evidence of all of Eyler and Giles (1999) is starkly apparent, much more so than in comparing the pre- and post-questionnaires. In these reflections, students are engaging with their own assumptions about themselves, others and chemistry, and it is here that the evidence of change for every student is apparent. Not all students appear to have learned in every area, but every possible area of learning can be found across the responses of the class, and this is despite the learning outcomes being kept vague.

The evidence that there was enhanced understanding of the discipline of chemistry and of its application to industry and everyday life ranges from the marks of the students to the kinds of questions they were asking in the practicals as well as the responses of the students in their reflections and questionnaires. There was also a clear shift to seeing

chemistry as applicable to all spheres of life, not just a privileged, academic or business world. Critical thinking skills were developed, not so much in terms of societal thinking and social justice aims, but in how students engaged with their subject matter, and were able to solve problems in the laboratory and in their essays. Personal and interpersonal skills were developed and consciously so, as students learned to work together with others, gain respect for their fellow students and the learners, and as their teaching skills, communication skills and leadership skills were developed. The ability to work both individually and as a team was developed over the course of the module, with students aware of how they had grown and matured in this area.

Many students wrote of how their ideas about themselves had changed. They realised that they had enough knowledge to impart to someone else, and enough knowledge to understand new concepts without being taught them. Perspective transformation occurred in how they saw themselves able to contribute to society. Perspectives about how learning should take place also began to change; with students making comments like, „I wish most tasks would be like doing this essay" (S_{19}), and S_7's realisation that it had been through the teaching that his content knowledge had developed to be more in-depth. The planning and reflection task was also identified by the students and demonstrators as being one of the causes of improved learning. In fact, the idea of completing this kind of task in group discussion has been brought forward as a possible addition to all practicals by the lecturer.

Engagement, Curiosity and Reflective practice (Eyler & Giles 1999) was clearly learned and developed over the course of the module. Students' essay reflections are far more in-depth and meaningful than their planning and reflection tasks. Students were engaged and interested in the learners as their desire to spend more time with them and suggestions for longer contact time in the future point out.

Citizenship outcomes are far more difficult to measure, as we can only look at intention to do service as the questionnaire did. This outcome was not emphasised in this module and is probably the least obvious one in terms of what naturally comes out of service-

learning. While the evidence for this kind of learning outcome is minimal, it is not entirely lacking as the results from the post-questionnaire and some of the essay reflections show. This kind of learning, does, it seems, need to be emphasised, and reflection tasks designed specifically to stimulate thought and discussion around these issues in order for this learning outcome to be achieved. However, in order to measure it, longer term studies beyond the scope of this project would need to be undertaken.

Nevertheless, this occurrence of evidence for so many different kinds of learning seems to suggest that there is something inherent in the nature of service-learning which makes these kinds of learning possible. Certain outcomes can be emphasised and stressed, but inherent in the nature of service-learning it appears that there is the opportunity for those who want to take it, to learn far more than in conventional pedagogical methods.

What is also apparent, as with the post-questionnaires, is that in many of the reflections the students address me personally, thanking me and also the lecturer for the opportunity to take part in the service-learning component and even, in some cases, wishing me luck for my thesis.

> —I am very grateful to have had the opportunity to be a part of this service-learning process. It has shown me that with the academic knowledge I gain through university comes real-life responsibility. Many thanks to you, Sarah, and the best of luck with your thesis" (S_2).

This firstly confirms that the decisions to name myself in the questionnaires and involve myself with the class as a facilitator as well as a researcher were good decisions, because they brought about a relationship where power on my part did not hinder the learning process or invalidate the research process.

> —Initiatives like the service-learning run by Sarah Abel are effective bridges in making chemistry come alive. I have enjoyed learning about dyes and the chemistry involved. It is initiatives like these which can make us able to empower communities, and in doing so, allow the community to empower itself" (S_{28}).

Secondly, the good relationship that I developed with the class and the success of the service-learning module, both in student perception and in results, also suggests another important point. Whether the service-learning course is being researched or not, and regardless of the paradigm in which this is done, service-learning requires a facilitator who can passionately drive the process. Without this belief in the importance of the service coming from the facilitator, the students are unlikely to be inspired to become passionate themselves.

> „Finally I would like to say thank you to (the lecturer) and the demonstrators who helped out at the practical afternoons. And thank you to Sarah Abel for giving me the opportunity to be the first to participate in the concept of service-learning. I thoroughly enjoyed it" (S_8).

4.3 Discussion

4.3.1 Research Question 1

> How does service-learning change the way chemistry is learned and perceived by the student and what other (non-discipline-specific) learning takes place due to the service-learning component?

4.3.1.1 Characterizing the learning in service-learning

As the results presented in the preceding section indicate, service-learning provides the opportunity for students to experience chemistry in a contextualized, meaningful and enjoyable way. Service-learning, as a pedagogical approach, opens up new areas of learning and appears to improve assimilation and understanding in traditional subject learning.

As the literature discussed in Chapter 2 indicates, simply doing practical work is no guarantee that students will learn theory better. Millar (2004) indicates the necessity to scaffold students' attempts to make a link between the theoretical domain of ideas and the practical domain of objects and observables. Bradley *et al.* (1998) also talk about the necessity to design and manage practical experience in such a way that students see the

value of the experience so that enthusiasm and enjoyment is maintained. As the experience of the Department of Chemistry indicates, these issues are the reason why practicals often become a boring exercise for students where the purpose is doubly hidden. In other words, students firstly do not understand what they are doing in terms of the chemistry, and secondly they also do not understand the value of the experience in a wider context.

Service-learning however, provides a scaffolding tool with which to design and manage practical experience where the purpose is very clear – to serve someone – and from this clear purpose, interest, enthusiasm and further learning result.

In terms of Kolb's (1984) learning theory, learning is defined as ~~"th~~e process whereby knowledge is created through the transformation of experience" (p38). An ordinary practical, while providing experience, does not provide the opportunity for the experience to be transformed, and thus the learning process stagnates and does not move through the complete cycle, allowing progress and new levels of discovery (See Figure 2.2.2.1 in Chapter 2).

As is clear from the responses of the students and the observations made of the practical, service-learning, through reflection and interaction, provides many opportunities for knowledge to be created and transformed through experience. As the observations highlight, it is the planning and reflection aspect of service-learning which prompts students to ask questions and pushes them to think critically. Thus they become active rather than passive learners. The questionnaire responses indicate that with service-learning, previous service and experience are less of an indicator in how successful service-learning is than one might think. In fact, it is the depth at which students engage with the reflection and planning opportunities and the effort that they put into their interaction with the community which determine the learning that they extract from the process.

Students were aware of how service-learning had stretched them and provided opportunities for development in both chemistry and their understanding of wider social issues. Students learned in all six areas articulated by Eyler and Giles (1999), developing personal and interpersonal skills, through working in groups with other students and through their interaction with the learners. Planning and reflection and the increased interaction with demonstrators and the lecturer that this activity produced, developed critical thinking skills and a better understanding of the chemistry and its application to everyday life. The essay, and the reflection included in its conclusion, provided the thread which connected and contextualized the practical, service and lecture material. The essay gave students a wider background not only in dyes and dyeing but also in the relevance of the chemical industry to everyday life. The students were able to learn and master scientific writing skills, research skills, referencing skills and skills in using chemical structure drawing software, as well as learning to work independently and teaching themselves. Learning to work on their own in this way, brought many students to the realization that the knowledge and skills that they already had, were valuable and extensive enough to be of use to them and to others.

Interacting with the learners and the course material caused many students‘ perceptions about themselves, chemistry, their contribution to society and the scientific field to change dramatically. The students realized what they had to offer.

The students‘ general consensus that they wanted to spend more time with the learners and the many suggestions for longer contact time with the community as well as more lectures and information to help them teach better serve as an indication that the students were engaged with the learners and began to care about them. The students were generally eager to give the learners a valuable experience and became interested in and curious about them. Students‘ capacity for self-reflection developed throughout the module, with their essay reflections looking more profoundly and deeply into their experience, in comparison to the first pre-reflection and planning task.

For most students, the service-learning experience did have the effect of showing them how learning could take place, and that the way that they were accustomed to learning was not the only way. Without the reflection, the interaction with the learners would not have been as valuable to the students‘ academic or personal learning, and critical thinking skills would certainly not have been learned or developed. Likewise with only a planning and reflection task the students‘ learning in the areas of personal and interpersonal skills, engagement and self-reflection would not have developed.

Service-learning, through its incorporation of all four stages of Kolb‘s (1984) cycle of experiential learning, creates new knowledge through the transformation of experience, and expands the notion of learning in one context, chemistry in this case, to include learning and development in personal and interpersonal skills, critical thinking, understanding and application of knowledge, and engagement and reflection. In addition students‘ perspectives are changed with regard to themselves and their capabilities, their place in society, their responsibility to society and society itself. Learning and discovery of innate ideas and prejudices and the realization that many of their beliefs about themselves are not necessarily true, begin to educate students for socially responsible living and citizenship.

The areas of learning discussed above could be emphasized and expanded by focusing on particular outcomes and tailoring reflection and class discussion to bring these particular issues to light. However, in this case, even though learning outcomes were kept vague, and student academic learning was the focus, all the other areas of learning still emerged from the data, depending on the individual‘s engagement with the materials and opportunities provided to them.

4.3.2 Research Question 2

> How does service-learning change students‘ awareness of social issues and citizens‘ responsibilities?

4.3.2.1 Factors influencing change in student awareness of social issues

From the data, it would appear that the answer to this question lies in the _other learning' that takes place in service-learning, in other words all the learning that is not specifically related to chemistry. Changing students' awareness of social issues and citizens' responsibilities would not happen if students feel that the issues are not their problem (yet) or that they are powerless to solve them due to their lack of knowledge. From student responses, it seems that rather than being unaware of problems in society or of citizens' responsibilities, students distance themselves from the domain where the solutions are, because they feel that they are not part of the scientific community as the pre-questionnaire results show. Alternately it may be because they do not know how much knowledge they have. They may also not be able to see how their knowledge could be of use to someone because they have yet to understand the value of the knowledge that they have.

By engaging in service-learning, these false perspectives begin to change because students use knowledge and resources to which they have access to provide a service. Prejudiced and incongruent ideas about society also begin to change as students interact one on one with members of their community and realize that things are not the way that they originally thought they may have been.

In terms of the way that this module was designed, service-learning, rather than taking students out of their comfort zone and into the community, brought community members into a situation that they might otherwise never have thought they could experience. Students could see their privilege through new eyes and develop a new appreciation for the responsibilities that they had to society.

Service-learning also seems to be as successful as the facilitators desire it to be. Students easily notice where passion and enthusiasm are and they respect it, often desiring to emulate it. Without passionate facilitation and encouragement along the way, students will generally not succeed in making the connections between the academy, the work environment and society and the citizenship outcomes of service-learning will be lost.

CHAPTER 5

CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

"This is a great module! Keep it in [the] Second Year Syllabus!" – (S_{35}, Post-questionnaire, p 4)

5.1 Introduction

This section attempts to summarize the major findings of the study as outlined in Section 5.2. Section 5.3 outlines the limitations of the study while Section 5.4 offers some recommendations for future service-learning courses. Section 5.5 provides an overview of some of the implications and recommendations for future research; and Section 5.6 concludes the present study.

5.2 Summary of the Major Findings

- Student learning in service-learning is mainly facilitated by the interplay between the service with the interaction with the community that this requires, and the planning and reflection that precedes and concludes the activity (Kolb's complete learning cycle, Kolb 1984).

- The understanding of chemistry concepts and application of knowledge was enhanced compared to other practicals.

- Student learning across all facets of this service-learning module can be classified according to the six areas of learning (see Chapter 2 and Appendices H and I) articulated by Eyler and Giles (1999), with academic learning and interpersonal skills being the main areas of learning experienced by all students.

- Evidence of other learning, not discipline-specific, was evident despite these learning outcomes being undefined for the students, and seems to be dependent on

the amount of effort an individual student is prepared to put into the reflection and interaction parts of the module.

- Passionate facilitation is an indicator for student enthusiasm and success, as students noted the ideology and beliefs of the staff through their actions, and were inspired by it.

- The majority of the class reported a change in their perceptions of themselves in relation to society as well as a sense that they could contribute in some way to bridge the divide between themselves (as comparatively privileged) and those who do not have access to the information and education that they do.

- Citizenship outcomes, while present, were the least emphasised area of learning. More specific targeting of this outcome in discussion and reflection is necessary for it to become a major learning outcome of the course.

- The major areas of learning seemed to be in Personal and Interpersonal Development, Critical Thinking, and Engagement, Curiosity and Reflection (Eyler & Giles 1999). This is consistent with the findings of other practitioners (Sedlak *et al.* 2003 and Simons & Cleary 2006).

5.3 Limitations

The limitations of the study are outlined as follows:

5.3.1 Specificity vs. Generalisability

Since the present study involved only one class and only one experience of service-learning, the results cannot be broadly generalized for service-learning practice. However the results of this study will be of invaluable use to the Department of Chemistry in understanding how service-learning benefits their students, how to maximise these

benefits and in justifying why service-learning is a valuable exercise. The results of this study may also be of use to other practitioners in the South African HEI context or in the science HEI context in providing practical ideas of how to implement an introductory service-learning course.

5.3.2 Time Constraints

There were time constraints due to the length of the university term and the number of lectures and practicals set aside for the service-learning experience. Perhaps if more time had been available for interaction with the community and for deeper structured reflection, the study would have revealed deeper insights into how service-learning can change ideas and perceptions. A longer period of observation would also have yielded richer data.

5.3.3 Piloting

Due to the limited sample size, the pre and post-questionnaires for the students were not piloted to the research sample community (See Section 3.6.2).

5.3.4 Explicit Learning Outcomes and conflict with research agenda

In terms of good service-learning practice, learning outcomes should have been explicitly expressed in writing so that better connections could have been made by the students between the service and their academic learning (Bender *et al.* 2006 and Rubin 2001). Doing so would have caused the students to place similar value on all types of learning taking place, and not mainly on academic learning (Bender *et al.* 2006). However, this also would have skewed the results of my study to some extent because I was trying to discover whether the service-learning experience did engender other types of learning and what those were. These emerged out of the data and the students‘ reflections on their own without prompting from me as the researcher or the explicitly stated outcomes which would perhaps have caused the students to say they had learnt these things in the hope of getting better marks. Thus there was tension between the desired research outcomes and

service-learning good practice which may have decreased the effectiveness of the service-learning experience.

5.3.5 Short-term Service-learning

The HEQC guide to Service-Learning in the curriculum states that a service-learning course should include between 20 and 40 hours of community service over a period of time, for instance over a semester (Bender *et al.* 2006). This practical only consisted of 5 hours of service (See Limitation 5.3.2). There are also service-learning advocates who downplay the efficacy of short-term or once-off service-learning projects especially in terms of community benefits (Tryon *et al*. 2008).

McCarthy (1996), however, states that there is great value in these kinds of experiences as introductory service-learning activities which can serve as a foundation for all other experiences. While acknowledging that short term and once-off projects are necessarily limited in depth, purpose and intensity; he provides numerous examples which suggest that, "they can result in perceptual and attitudinal changes among participants and inspire their commitment to further service" (McCarthy 1996, p 133). Since this is what the students gained from the experience, along with enhanced academic understanding, it would appear that for them the experience had value.

Thus it would seem that this understanding depends on the specific needs of the community and the type of service being offered. As discussed in Chapter 2, in South Africa, with such a shortage of scientists and science and mathematics teachers, the public communication and understanding of science is of paramount importance. Those learners who attend schools with few resources and do not have access to the internet, have very little concept of what studying science would be like at a university and may in many instances feel that this is far beyond their reach, as discussions with the learners' science teachers demonstrated. Thus providing this service enables learners to enter a laboratory at the university, not, as in an outreach case to use the facilities to do school work, but to experience a university practical, with university students in a university

laboratory. The realization that they could understand a complicated reaction and perform tasks in the laboratory could be an important catalyst in changing community learner perceptions of what they can accomplish, and change the image of science from ‗scary and inaccessible' to something a little more concrete and obtainable (See Section 5.4 – Implications of Study and Recommendations for future research).

5.4 Implications of Study and Recommendations

5.4.1 Recommendations for this course

Despite the limitations mentioned above, the findings of this study have some implications, and recommendations for future courses can be made as follows:

- From the recommendations made by students, and issues that came up in the group post-reflections that included the learners, it appears that it would be beneficial if the students are given more time to do the service part of the practical. Numerous students commented that they would have liked to meet the learners beforehand and get to know them. They felt that this would have facilitated more meaningful interaction and that they would have had a clearer idea of how to approach the subject matter with them.

- Students felt that they needed some additional materials detailing the Grade 12 chemistry curriculum so that they understood at what level to pitch the theoretical concepts.

- Some students felt that as the laboratory was quite crowded, the practical should be done over two afternoons.

- Pre- and post-visit activities by the teachers which would ensure the greatest benefit to their learners were not formalised. It may be that the lecturer or even the students could consider designing these activities with the teachers for them to use, as clearly teacher's time is limited. Learners would be better prepared to

handle the theory and the practical and student _teaching' could enrich their understanding of the subject matter more effectively.

- The general sense that developed during the course of the research period, through observation, and which is also echoed in the feedback received from the students, demonstrators and lecturer, is that this course and the type of impact it makes on the students is largely personality driven. The component will only have maximum effect and obtain student commitment and support if it is run by someone who is excited and involved. Without this personality aspect, the connections between the activity and students' development will be lost, as it could become just another task to complete.

- Many students were inspired to expand the impact of the course, suggesting that more t-shirts should be dyed so that the learners could distribute them back at their own schools, or wanting to develop more of a relationship with the learners. Ideally students could deliver the shirts to the learners after the practical in their class, so that the project goes full circle, taking the students into the learners' situation. After this a final reflection could happen, having allowed the students more time to reflect, so that a deeper appreciation and understanding for the significance of their service would be more apparent. A whole lecture to discuss and debrief students would also help to cement the concepts learned, and give students a chance to reflect at leisure and not under time pressure.

5.5 Recommendations for future research

In this study, many interesting angles and as yet unexplored avenues presented themselves for exploration, but were simply beyond the scope of a Masters thesis. Thus presented here are some recommendations for further and/or future research:

- In this project, the community plays a minor role in terms of the focus of the research. It would be very interesting to examine the short and long term effects

that such an activity has on the learners and their teachers. Does the excitement generated from the practical afternoon result in better marks or the study of science at university? Is the teacher inspired to inspire his/her learners? Does the experience change a teacher‘s approach to teaching? If not, what are the factors that hinder these things? Some of these questions would provide useful answers to change and adapt the service-learning component to serve community needs better.

- The present study only investigated the immediate impact of the service-learning experience on the students. Similar studies could be done over a longer time scale in order to see the long-term impact of the experience. The questionnaires could only evaluate *intention* to do community service and changes in ideas and perceptions. It would be of great value to see whether these intentions develop into actions.

- Many student and demonstrator comments indicated that the pre-planning and reflection task was largely responsible for an increase in understanding of each part of the practical and an appreciation for the practice of organic synthesis. This task also provided the necessary scaffolding for critical thinking to take place. It would be interesting to research the effect of the reflection and using a pre-planning and reflection task model on the practical report writing skills of the students. Researching using experiential learning principles in ordinary practicals and academic structured reflection might shed new light on pedagogical possibilities for the chemistry laboratory.

- The same service-learning activity with different reflection models may yield different results in terms of the kinds of learning that result. A similar study to the present one, but comparing learning with different reflection models would improve the quality of the component greatly.

- Another avenue of research would be to compare and contrast the service-learning experience on the part of the students according to socio-economic background and/or gender. In this study race, gender and socio-economic background were ignored. One student (S_{34}) commented in his post practical questionnaire reflection that he had ~~l~~earnt that even though they (the Grade 12 learners) are studying in [sic] disadvantaged schools just like I did they know alot [sic] 2 [sic] and can do more if they can be given a chance." This completely surprised me, as I had thought that students from a similar background to the learners would have known this intuitively. This is certainly an area to explore further in terms of understanding how service-learning is experienced by students from different backgrounds.

- Researching service-learning with an explicit social justice and transformation agenda, such as that advocated by Mitchell (2002), Pollack (2009) and Cooks *et al.* (2004), to see if the learning outcome of Citizenship is achieved, and compare the other learning outcomes to the current project where learning outcomes besides the learning of chemistry knowledge were kept vague.

5.6 Conclusion

The involvement of the Department of Chemistry in outreach activities has been ongoing for some years now, but this is the first time that such community engagement has been explicitly harnessed for academic purposes. This action research project was so successful in terms of the perception of the Department, that the model for service-learning in this course has been included in the curriculum for future years, before the results of this study were even available. The Head of Department was so impressed by what he had observed in the practicals that in his mind, the project was a success.

The study shows that implementing Kolb‘s learning cycle and employing experiential education methods is highly effective in cementing academic concepts and improving understanding of academic work, critical thinking and problem solving skills. The service component also adds to the sense of responsibility that each student has to complete task objectives and understand academic content. The enthusiasm and commitment shown by the students during the practical and the level at which they engaged with the material, asked higher order questions and strived to understand more thoroughly, shows that the time taken to complete a service-learning activity is well spent. The sacrifice of other synthesis practicals is not a substantial loss to the quality of education received by the students.

The act of reflection, particularly before the service-learning actually takes place, has a profound effect in promoting critical thinking, problem solving skills and better understanding of academic material. The essay served the triadic purpose of placing the service-learning dye practical in context, providing a background in the chemistry of dyes, and linking the discipline of chemistry both to the industrial and business world, as well as to the social constructs that influence its relevance and usefulness.

The improved attitude to the discipline, the change in perception of themselves as valuable and useful within the scientific community, the improved relational, social and writing skills, and the ability to work better in teams and on their own, could all contribute to the quality of work that these students produce and the standards that they set for themselves in terms of their academic work in the future.

Although not explored directly in this study, the benefits for the community of learners and the enhancement of their view and perception of chemistry and higher education in the sciences in general, emerge as manifold.

In conclusion the quotes below, in the students‘ own words, highlight why the pedagogy of service-learning cannot be underestimated in its effect on the learning of students.

–By teaching, I believe my understanding of the content became more in depth. To teach something, I *needed* to fully understand the chemistry I was teaching" ($S_{7,}$ essay reflection).

–The entire process as a whole has greatly challenged and inspired me as it has forced me to open up my mind; from working with a diverse range of people to the importance of research and the influence of science in the past present and future. I am pleased that I got this opportunity to take part in such a project" (S_{32}, essay reflection).

–I did not realize how much information I could actually share with someone else who is not in [sic] the same level as me. I realize that chemistry does not only end in the lab, one can actually use their knowledge to help a community and make other students understand that they can use their knowledge to make something and make life better for their community. In this whole process I learnt that sharing the information with other [sic] makes you understand more about what you are doing. Working with others enhances your communication skills and you learn things you would not (have) thought of if you were working on your own…I enjoyed this journey and I hope next year it will be repeated." (S_{12}, essay reflection)

–I learnt to rely on myself in a lab situation and that I can think of solutions to problems and apply theoretical knowledge rather than just follow a recipe" (S_{36}, post-questionnaire).

The service-learning practical –contributed (to my sense of social responsibility) in a positive way cause [sic] I know that I have to give back to the community. I loved the practical very much" (S_{34}, post-questionnaire).

–I…learnt to become more tolerant and accepting of someone less fortunate than myself and they are in fact no different from us" (S_8, essay reflection).

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APPENDIX A

1. Letter to Students

Dear 2nd year student,

As part of the Chemistry Department's ongoing commitment to outreach and community engagement, the Second Year Chemistry Organic Module will contain a Service-Learning Component for the first time this year. Your participation in the course is a DP requirement, as is the completion of all assessment and practicals that form part of the course.

The course implementation and evaluation will form the basis of a Master's research project in Chemical Education and your participation and involvement in the process will add greatly to the quality of the research produced. All your **involvement will be strictly confidential** and no one will be able to trace your comments and feedback or your reflections and essays back to you personally from the research produced.

You have the right to withdraw from the research at any point as well as talk to me (Sarah Abel – 0726000388/ sarahruth.abel@gmail.com) about any concerns you may have. If you withdraw however, you will still need to complete the course and the assessment tasks as this is a DP requirement, but your work **will not be used** as data in the research process.

This research proposal has been accepted by the Higher Degrees Committee and permission for the research has been given by the Head of Department and lecturer for this course Prof M. Davies-Coleman.

Many Thanks

Sarah Abel
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Rhodes University
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APPENDIX B

1. Informed Consent Form

MSc Research Project: ***The Implementation and Evaluation of a Service-Learning component in Second Year Organic Chemistry Course.***

CONSENT FORM

I hereby consent to participate in research regarding the implementation and evaluation of Service-Learning in a Second Year Organic Chemistry Course. I understand that I am participating freely and without being forced in any way to do so. I also understand that I can withdraw from this research process at any stage should I not wish to continue and this decision will in no way affect me negatively.

I understand that this is a research project whose purpose is not necessarily to benefit me personally, but that my input and participation will improve and change the way this course is offered in the future, to the benefit of all chemistry students and the Department itself.

I have received the contact details of the research student, Sarah Abel (0726000388 or sarahruth.abel@gmail.com), and will contact her should I need to speak about any issues that may arise from my participation in the research process.

I understand that this consent form will not be linked to my questionnaire response, my essay, my practical report or my reflections or to my feedback in the independent SGID report conducted by the Centre for Higher Education Research, Teaching and Learning.

I understand that my answers and assessment tasks will remain confidential.

I understand that feedback will be given to the Chemistry Department and to Rhodes University and that a Master's thesis will be published on the results of the completed research.

....
Signature of Participant Date

.....
Student Number of Participant

APPENDIX C

1. Letter to Schools

The Science teacher
Name of School Senior Secondary School

Fax no: .....

Attention: *Name of Teacher*

Grade 12 DYE PRACTICAL EXPERIENCE: 27 August 2009

Dear *Name of Teacher*

With regard to our discussion earlier this year, the dye practical experience is going ahead on the afternoon of **THURDSAY 27 AUGUST 2009.**

You and your Grade 12 Physical Science learners are invited to join our 2nd year students in the chemistry lab from **13h00 till 17h00 on the 27th of August**. The students will make Azo Dyes together with your learners which they will then use to dye t-shirts that we will provide. We will also provide transport to Rhodes from your school and back again at the end of the afternoon. The bus will pick the learners up outside the school at **12h30** on the day.

This practical experience fits into the Grade 12 curriculum under the subject of Organic Chemistry and can be slotted into the context of Chemistry in the Home and Chemistry for Industrial Application.

Please will you provide us with the exact numbers of your class and their T-shirt sizes in preparation for the afternoon. (Fax no. .....) or phone no.....

Regards

Mrs Joyce Sewry and Miss Sarah Abel

2. Essay Assignment Sheet

SECOND YEAR ORGANIC CHEMISTRY ESSAY

Topic: **The Chemistry of My Favourite Colour**

Word Limit: **2000-3000 words**

Due Date: **DRAFT – 12h00 Fri 21 August 2009**
FINAL – 12h00 Mon 31 August 2009

A **HARD COPY** MUST BE HANDED IN TO THE CHEMISTRY SECRETARY **BY 12H00** ON BOTH THE DUE DATES **AND AN ELECTRONIC COPY** MUST BE **EMAILED** AS A WORD DOCUMENT ATTACHMENT TO**:**

Sarah Abel: sarahruth.abel@gmail.com

IF YOU DO NOT SUBMIT BOTH COPIES YOUR ESSAY WILL NOT BE MARKED.

Your Essay Must Include:

- A general introduction to dyes, dying and the textile industry with reference to the importance of dyes in everyday life
- At least one industrial process (including the reaction scheme and mechanism) used to manufacture a synthetic dye of your chosen colour.
- A natural source of your colour dye and some background information with reference to when and where it was used and how it was discovered. You must find its chemical structure and try to find the social significance of the colour in the culture(s) which used it.
- General information on mordants/fixatives and how and why they are used.
- Information on how the dye binds to different textiles.
- A **minimum of 6 references** of which at least ***3 references must be from the books placed on short loan*** and at least ***2 journal/periodical articles*** as well as any other sources you might like to use, all referenced correctly in the ACS style.

A NOTE ON STRUCTURES:
Your structures must not be copied and pasted from the literature. All structures must be drawn in Symyx Draw using ACS Settings.

Symyx Draw is available for free download from www.symyx.com/downloads/ where you register for free and download the Symyx No Fee zip file.

Once downloaded, choose –Open a new document using a template" and load the ACS template from the File menu.

SHORT LOAN BOOKS FOR THIS ESSAY:

The following books are on short loan so that you all have equal access to them. They should prove to be useful in writing your essay as they all have some of the information you need. **Remember that your essay must cite *at least three* of these sources. Watch out for plagiarism!!**

1) Lee, David Webster. *Nature's Palette: The Science of Plant Colour.* 580 LEE
2) Robinson, Stuart. *A History of Textiles*. 746.6 ROB
3) Trotman, E.R. *Textile Scouring and Bleaching*. 667.14 TRO
4) Trotman, E.R. *Dyeing and Chemical Technology of Textile Fibres.* 667.3 TRO
5) Greenfield, Amy Butler. *A Perfect Red*. 667.26 GRE
6) *Industrial Dyes: Chemistry, Properties, Applications.* ed. Hunger, Klaus. 667.25 IND
7) Christie, R.M. *Colour Chemistry*. 667.2 CHR
8) Otterstatter, Gisbert. *Coloring of Food, Drugs and Cosmetics.* 664.062 OTT
9) *The Analytical Chemistry of Synthetic Dyes.* 574.86 ANA
10) Rys, P. *Fundamentals of the Chemistry and Application of Dyes.* 660 RYS
11) Gurr, E. *Synthetic Dyes in Biology, Medicine and Chemistry.* 547.86 GUR
12) Fierz-David, H.E. *Fundamental Processes of Dye Chemistry*. 660 FIE
13) Mayer. *The Chemistry of Natural Coloring Matters.* 547.86 MAY

PHARMACY LIBRARY:

1) Adrosko, RJ. *Natural Dyes in the United States*. 667.26 ADR

PERIODICALS:

These periodicals are not on short loan, and can be found online. They may contain information you need.

1) Textile Research Journal
2) Clothing and Textiles Research Journal
3) Dyes and Pigments

FURTHER INFORMATION:

For your convenience and to help you to write your essay well; below is some further information that may prove useful.

What is an Academic Essay?

An essay is short piece of academic writing in which you present an argument or information on a particular subject in a formal way, using various references and sources to substantiate your ideas. These sources **must be referenced** in a specific way.

What do I need to demonstrate in an Academic Essay?
You need to demonstrate that you have a good understanding of the topic and can discuss the information you have gathered in your own words with sources acknowledged and referenced correctly. You need to use an appropriate number of sources and show that you have covered all areas of the topic as given to you on the assignment sheet. You need to write your essay in formal English with correct grammar. Slang, contractions (words like *couldn"t, can"t,* and *isn"t*) and other informal language are not acceptable.

How do I reference and what style should I use?
The Rhodes Chemistry Department uses the American Chemical Society's (ACS) Reference Style and there are many websites such as:
http://library.williams.edu.citing/styles/acs.php which give brief, easy to understand information and examples of how to reference in this style. The in text reference style ensures that every piece of information is tagged to a specific reference, rather than just having a list of sources at the end. The ACS style guide is also available online for further information.

What is plagiarism and how do I avoid it?
Rhodes has a very strict policy on plagiarism and it is in your best interest to avoid plagiarizing, as the consequences are very serious. Plagiarism is knowingly taking someone else's ideas or information and passing them off as your own. This can include direct quotations where all the words are identical or paraphrasing part of a book or article. The easiest way to avoid this is simply to acknowledge your source and reference it correctly.

How do I access short loan books and search for information in the library?
Short loan books are available at the front desk of the library. In order to take them out, they prefer you to have the Title, Author and the Call Number on hand so they can get the book for you. This information is available on OPAC and I have also given it to you.

Further books and periodicals can be found by searching OPAC by keyword, or if you need to find a book, periodical or journal, you can search for the Title to get the call number and thus find it in the library.

How do I access online information?
The library website gives you instant access to online journal repositories and specific search engines. Science Direct and EBSCO Host are two that usually prove to be very useful and these can all be accessed from campus computers. Scifinder is also very useful and this can be accessed from some computers in the library and Chemistry Department. Ask the librarians to help you if you get stuck.

APPENDIX D

1. Draft Essay Marking Rubric

DRAFT ESSAY MARK RUBRIC

RUBRIC OUT OF A TOTAL OF 10, BUT REDUCED TO 5.

DESCRIPTION	MARK (OUT OF 10)
Assignment guidelines have been followed. Essay is complete and well written –a few changes could be made: improve language usage, expand on concepts or small spelling/grammar errors and typos. References are cited correctly and there is evidence of wide reading.	**10**
Essay is complete, assignment guidelines have been followed, there is evidence of wide reading and referencing done correctly. Style of writing and grammar/evidence of understanding not quite at a level to give full marks.	**8-9**
Assignment guidelines have been followed in general and there is the correct number of references. The essay is almost complete with a few grammar, language and/or style issues which can easily be rectified. There may be problems with referencing.	**6-7**
Assignment guidelines not followed (use discretion as to what degree), large chunks of missing information, little to no evidence of reading, badly written, clearly a last minute job. Blatant paraphrasing and copying of text and clear indication of minimal understanding.	**2-5**
Not handed in or not done. No LOA.	**0**

2. Email sent to 2nd year class – Comments, information and instructions for the final essay

General Notes on Your Draft Essays:

Dear Chem 202,

Well done on your essay drafts. Each of you has personalized comments on your essay, but there were a few main problems which I will highlight here:

1. Verbatim Copying or very simple paraphrasing:

Almost all of you were guilty of this to a greater or lesser extent. Make sure that you write things in your own words and that you fully understand what you are writing. In your final draft you will be severely penalized if your essays still contain large sections of hardly altered text. It is easy to see when this happens because you are all using the same references.

2. Referencing

Attached to this email is an example of academic writing with referencing done in the ACS superscript numbered style, and the reference list.

The very first reference that you cite in the text will be number 1. The second 2 etc. If after reference 3 you cite reference 1 again you put a superscript1 in the text.

Your final reference list must have the references numbered and typed in the right style, in the order in which you used them. In other words, the first reference that you use is reference 1.

3. The Conclusion

Most of your essays just ended quite abruptly. Some of you did conclusions but I would like each of you to use the Reflection Model I have given you below to write a conclusion which should be between 200 and 300 words long and end off your essay nicely.

Conclude your essay with a section entitled "Reflection" where you **critically reflect on your essay** and the experience of writing an academic essay for the first time.

Mention how writing the essay affected your understanding and enjoyment of the service-learning dye practical, if it all. Included in this section must be some of your thoughts on the applicability of chemistry and specifically organic chemistry to everyday life.

Completing these sentences may be of help in critically reflecting on your essay:

Writing this academic essay was of benefit to me because...

I found it difficult to do this essay writing task because...

Some of the skills I learnt were...

My essay could have been better/easier if I had...

These sentences are just some ideas to help you get going.

4. Symyx Draw Structures

If you know the IUPAC name of your compound (which you should all know from the literature), go to the top of the Symyx Screen and choose the –Chemistry" drop down menu. Go to —Generate Structure from Text" and type in the IUPAC name, press enter and your structure will appear. If you don't know the IUPAC name then you will have to draw it which you can do using the templates. Then use the –clean" function also in the drop down menu to make it look nice.

In order to show the important hydrogens in your structure automatically, go to the –Options" drop-down menu and choose –Settings." Under –Atoms," click on –show hydrogen labels" and change the setting from —off" to —hetero." To draw a mechanism or reaction scheme, draw your structures and choose the correct arrows from the –Arrows" tool bar. If it doesn't appear automatically go to –Window" and click on –Arrows Palette."

The Computer Lab on the First floor next to the Chem 2 Lab will be open from 2-5 on Tues and Wednesday Afternoon. I will install Symyx Draw on the computers there so you can use it if you cannot download it yourself. There will also be setup files on those computers so you can install Symyx on your computer if you want to.

Referencing Sample

Metal Organic Frameworks (MOFs) are a relatively new and interesting class of compounds which have gained a large amount of recent attention due to their unique properties. They are the subject of a rapidly growing field of research investigating their remarkable characteristics; a large number of new materials have resulted, and various studies have been done in investigation of their application in a number of different areas, more specifically for this project in the area of the guest inclusion of other molecules. [1]

Very simply, metal organic framework compounds are polymeric crystal lattices which contain metal or metal oxide centres linked by organic bridging ligands. The precise coordination geometry between the organic linkers and the metal centre gives the molecules their distinctive scaffolding look and explains why they are porous on a micro and sometimes nanoscale. The materials are highly ordered and periodic crystal structures. [2] This definition of metal organic frameworks covers those which contain guest molecules in their pores, and those which do not.[1]

The need for the development of safe and efficient means of hydrogen storage as a green energy carrier and alternative fuel means for engine driven machinery and motorcars, has led to the focus on these porous materials as potential hydrogen storage materials and due to their low densities and unusually high surface areas they are ideal candidates.[3]

The structural stability of MOFs upon water adsorption is a very important issue for potential applications of MOFs for gas adsorption and storage materials because water is very difficult to remove from industrial gas resources; however this aspect has received little attention in the literature.[3]

The metal organic framework compound studied in this project, $\{Na[Cu_2(H_2C_{10}O_8)(OH)]\cdot 7H_2O\}$, has a copper oxide or hydroxide centre and a benzenetetracarboxylate organic linker molecule. In this type of MOF it has been shown that the metal oxide cluster is primarily responsible for hydrogen adsorption, while the organic linker plays only a secondary role.[3] For this reason, studying of the crystal unit and its pore is very important to try and identify where and how included molecules bind to the crystal framework and how stable their inclusion renders the crystal structure. An important question is: Does the framework decompose on addition or removal of water molecules? With this particular MOF this is a very pertinent question. The crystal occurs with 14 H_2O molecules included in its pore. The number of molecules that are so strongly bound that they can be considered to be part of the framework needs to be discovered.

Computational Methods

Energy values are the basis to which almost all of a material‘s physical properties can be related. As such, the properties that are related to energy can be determined theoretically if energy values can be determined. [4]

References

(1) Lamprecht, E. Thermal, Spectroscopic and X-Ray Diffraction Studies of Copper(II)1,2,4,5-benzenetetracarboxylates and copper(II)oxalate: A study of Metal Organic Frameworks (PhD Thesis), Rhodes University, Grahamstown, **2008**.

(2) Frost, H.; Snurr, R. Q. *J. Phys. Chem* **2007***, 111*, 18794.

(3) Li, Y.; Yang, R. T. *Langmuir* **2007***, 23*, 12937.

(4) Allan, D. C.; Payne, M. C.; Teter, M. P. *J. Chem. Soc. Faraday Trans.* **1990***, 86*, 1221.

How to Format In-Text Citations

(For more detailed information see ACS Style Guide, pp 287-290.)

Superscript numbers

At the end of the cited information:
Fluoridated water as well as various fluoride products such as toothpaste provide fluoride ions necessary for remineralization.[1]

Within the cited information:
Rakita[1] states that fluoridated water as well as various fluoride products such as toothpaste provide fluoride ions necessary for remineralization.

How to Format Reference Lists

Books

(ACS Style Guide, pp 300-305)

Single author	Chang, R. *General Chemistry: The Essential Concepts,* 3rd ed.; McGraw-Hill: Boston, 2003.
Edited Book	Gbalint-Kurti, G. G. Wavepacket Theory of Photodissociation and Reactive Scattering. In *Advances in Chemical Physics;* Rice, S. A., Ed.; Wiley: New York, 2004; Vol. 128; p 257.
Book in Series	*Omega-3 Fatty Acids: Chemistry, Nutrition, and Health Effects;* Shahidi, F., Finley, J. W., Eds.; ACS Symposium Series 788; American Chemical Society: Washington, DC, 2001.
Article from a reference book	Powder Metallurgy. *Kirk-Othmer Encyclopedia of Chemical Technology,* 3rd ed.; Wiley: New York, 1982; Vol. 19, pp 28-62.

Articles

(ACS Style Guide, pp. 291-299 and pp. 317-319 for online articles)

Article in a scientific journal	Evans, D. A.; Fitch, D. M.; Smith, T. E.; Cee, V. J. Application of Complex Aldol Reactions to the Total Synthesis of Phorboxazole B. *J. Am. Chem. Soc.* **2000,** 122, 10033-10046.
Article in a popular/non-scientific magazine	Manning, R. Super Organics. *Wired,* May 2004, pp 176-181.
Article from an online journal	Peacock-Lopez, E. Exact Solutions of the Quantum Double Square-Well Potential. *Chem. Ed.* [Online] **2007,** 11, 383-393 http://chemeducator.org/bibs/0011006/11060380lb.htm (accessed Aug 23, 2007).

Web/Online

(ACS Style Guide, pp 316-325)

Note: Different web browsers break the text in different places of a URL. The URL should begin on the same line as the rest of the citation information, with a break inserted after a slash, if needed.

Web page	National Library of Medicine. Environmental Health and Toxicology: Specialized Information Services. http://sis.nlm.nih.gov/enviro.html (accessed Aug 23, 2004).
Article from an online journal	Peacock-Lopez, E. Exact Solutions of the Quantum Double Square-Well Potential. *Chem. Ed.* [Online] **2007,** 11, 383-393 http://chemeducator.org/bibs/0011006/11060380lb.htm (accessed Aug 23, 2007).
Article from full text database	Begley, S. When Does Your Brain Stop Making New Neurons? *Newsweek* [Online] July 2, 2007, p 62. Expanded Academic Index. http:/galegroup.com (accessed Aug 23, 2007).
Article published online in advance	Chung, J.M. and Peacock-Lopez, E. Cross-diffusion in the Templator model of chemical self-replication. *Phys. Lett. A* [Online early access]. DOI:10.1016/j.physleta.2007.04.114. Published Online: June 12, 2007. http://www.sciencedirect.com (accessed Aug 23, 2007).
Computer Program	*SciFinder Scholar*, version 2007; Chemical Abstracts Service: Columbus, OH, 2007; RN 58-08-2 (accessed Aug 23, 2007).

APPENDIX E

THE FIRST PRACTICAL

1. The Practical Manual

Parallel Combinatorial Synthesis of Azo Dyes

A Combinatorial Experiment Suitable for Undergraduate Laboratories

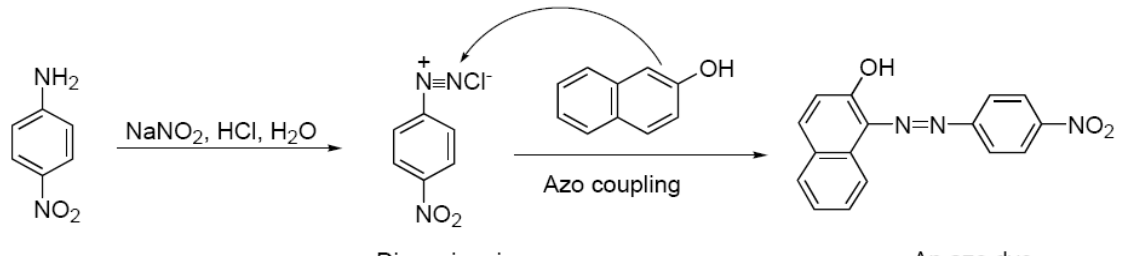
Benjamin W. Gung* and Richard T. Taylor
Department of Chemistry and Biochemistry, Miami University, Oxford, OH 45056,
gungbw@muohio.edu
From: Journal of Chemical Education

Background

Arguably, the most notable development in synthetic organic chemistry in the last decade is probably the so called combinatorial chemistry. The goal of combinatorial chemistry is to prepare a large number of structurally diversified but related compounds efficiently. A new journal has emerged that is devoted entirely to combinatorial chemistry. The pharmaceutical industry has embraced this new development and invested millions of dollars into the area. The products from a combinatorial synthesis are usually called a library, which must be screened for a desired activity. This desired activity could range from anti-tumour or anti-HIV properties to effective catalytic properties.

In this experiment, the principle of combinatorial chemistry is shown through preparing azo dyes using the combinatorial approach. The coupling reactions involve an aromatic diazo compound and an electron-rich, water-soluble aromatic compound as the coupling partners. The so-called "point of diversification" involves the structure variation on each reactant. Each aromatic ring can be diversified by substitution pattern. Each student is assigned a unique coupling reaction on the basis of his/her position in the lab (see Figure on next page) by the diversification of the aromatic coupling partners. The entire class will perform the same reaction while each student will synthesize a distinct product. Assay and the identification of individual compound are a straightforward process for this parallel experiment. A fabric dyeing experiment follows the coupling experiment.

Reaction scheme for the dye preparation



Each student should compare the structure of the coupling reaction product with other students in the lab. At the end of this experiment, the colours of the dyed fabric strips from the entire class should be compared. Any conclusions from the correlation of the product structures to the colour strips and the UV spectra should be discussed in the lab report. This lab report will be due on the first Tuesday of the fourth term.
In the laboratory, the positions of the lab benches are divided into columns headed with letters (**A-D**, see Figure) and rows labeled with numbers (**1-5**, see Figure on the board). Different columns of the lab bench positions will be using different aromatic amines while each row has a unique aromatic compound to couple with the diazonium ion generated from the amine. You need to first find out your bench position in the lab according to the Figure. Based on your bench position, you will be able to decide which two reactants to use for this lab. Your combination of starting materials should be unique and should produce a unique azo dye (**A1-D5**, see Figure). Double check with one of the demonstrators before you start the experimental procedures.

(A) Couplings using the Diazonium Salt from Aminobenzenesulfonic acid

(1) Diazonium Salt Preparation

In a test tube place 0.49 g (2.8 mmol) of an aminobenzenesulfonic acid, 0.13 g of sodium carbonate, and 5 mL of water. A clear solution is obtained by warming the test tube in a water bath. Remove the test tube from the water bath and add a solution of 0.2 g of sodium nitrite in 0.5 mL of water. In a second test tube place 0.53 mL of concentrated HCl and 3 g of ice. The solution from the first test tube is added dropwise with a Pasteur pipet to the second test tube. The resulting mixture is placed in ice-water bath to induce precipitation of the diazonium salts. The suspension is used in the next step.

(2) Coupling reaction

In a 50 mL Erlenmeyer flask place 2.6 mmol of one aromatic coupling reagent (1- or 2-naphthol, salicylic acid, or 8-anilino-1-naphthalenesulfonic acid ammonium salt depending on your bench position in the lab) and add 2 mL of a 2.5 *M* aqueous solution of sodium hydroxide. Place the Erlenmeyer flask in a ice-water bath. The suspension of the diazonium salts prepared in the first step is added portionwise with a Pasteur pipet to the Erlenmeyer flask. The reaction mixture is stirred with a glass rod after each addition. The color of the solution should change during this period of reaction. Let the reaction proceed for about 10 min with occasional stirring. Then heat the suspension on a hot plate till the solid dissolves. Add 1 g of NaCl and continue heating to dissolve the solid. Cool the Erlenmeyer flask at room temperature first. Then cool it in an ice-water bath. Using a Hirsch funnel to vacuum filter the solid. Wash the solid with 2 mL of saturated NaCl solution and let it dry in the air. Weigh the product of azo dye.

(3) Dyeing a fabric strip

Disposable gloves should be worn in this experiment. Dissolve 50 mg of the azo dye prepared in the previous step in 20 mL of water in a 100-mL beaker and add 20 mL of the Ferrrous Sulphate Solution (fixative), stir well and heat on a hotplate. Put a strip of the fabric in the solution of the azo dye and keep it immersed and boil the solution for about

5 minutes. Remove from heat with a tweezers and rinse the fabric with tap water. Pat dry the dyed fabric with a paper towel and compare the color with your lab mates.

(B) Couplings using the Diazonium Salt from 4-Nitroaniline

(1) Diazonium Salt Preparation
In a 0.5 x 4" test tube, place 1.5 mL of concentrated hydrochloric acid and 1.5 mL of water. Place the test tube in an ice-water bath. In another test tube of the same size, place 0.7 g (5 mmol) of 4-nitroaniline, 0.38 g (5.5 mmol) of sodium nitrite, and 1.5 mL of water and mix the content well by using a touch mixer. Add the suspension to the HCl solution at 0 °C using a pipet. Stir the reaction mixture during the addition with a glass rod and occasionally thereafter for about 10 min. Remove any solid particles by gravity filtration using a small glass funnel and a small cotton plug. Collect the filtrate in another test tube.

(2) Coupling reaction
Dissolve 5.1 mmol of one of the four aromatic coupling reagent (1- or 2-naphthol, salicylic acid, or 8-anilino-1-naphthalenesulfonic acid ammonium salt) in 10 mL of a 2.5 *M* aq. sodium hydroxide solution in a 50-mL Erlenmeyer flask and place it in an ice-water bath. Add the diazonium solution from the previous step to the Erlenmeyer flask dropwise with stirring. Leave the flask in ice-water bath for about 10 min and record any color change. Slowly add about 1.5 mL of concentrated hydrochloric acid to the mixture till the pH is between 3 and 4. Add one gram of NaCl and heat the Erlenmeter flask on a hotplate till it is boiling. Cool the mixture to room temperature and then in ice-water bath. Vacuum-filter the solid in a small Buchner funnel (The solution can be used to dye the fabrics directly if no solid is formed). Wash the solid with 2-5 mL of water and leave it dry. Weigh your product.

(3) Dyeing a fabric strip
In a 100-mL beaker, dissolve 50 mg of the azo dye prepared in the previous step in 20 mL of water. Add 20 mL of Ferrous Sulphate Solution (fixative). Add 3 mL of a 2.5 *M* sodium hydroxide solution to the beaker and heat the mixture on a hot plate and stirring it with a glass rod. Put a strip of the fabric in the solution of the azo dye and keep it immersed and boil the solution for about 3 minutes. Remove from heat with a tweezers and rinse the fabric with tap water. Pat dry the dyed fabric with a paper towel and compare the colour with your lab mates.

Warning
• 4-Nitroaniline is a highly toxic compound. Avoid skin contact with arylamines.
• Sodium hydroxide is caustic. Avoid skin contact.
• Hydrochloric acid is highly corrosive. Handle it with care.
• Sodium nitrite is a toxic oxidizer.
• Naphthol derivatives are irritants. 1-Naphthol is toxic.
• Diazonium salts are explosive in the solid state and should be kept in solution and used immediately after preparation.

• Azo dyes are irritants. Wear gloves when dyeing the fabrics.

1. Experimental procedures are based on the lab manual: Daniel R. Palleros, *Experimental Organic Chemistry*, John Wiley & Sons, Inc., New York, 2000, pp. 627-628.

Lab Report **Names:** _____

_____

Title of the Experiment **Parallel Combinatorial Synthesis of Azo Dyes**
Date: _____
:

Introduction

A parallel combinatorial synthesis of azo dyes will be performed by the lab section, which uses distinct colors to illustrate the concept of diversity and structure-function relationships. In the experiment, the positions of the laboratory are divided into a grid. Each bench position produces a unique azo dye, whose structure is coded according to the lab bench position. At the end of the experiment, a fabric strip is dyed using the synthetic dye. A colorful spectrum of azo dyes will be produced collectively by the class. The reaction involved is the diazo coupling between a diazonium ion and an electron rich aromatic compound.
Reaction Equation (make this specific to YOUR substrates):

Reagents	Equivalents	mmol	weight/volume			
amine						
	1					
$NaNO_2$	1.1					
HCl(concentrated)	3.5					
Alcohol (name)	1					
NaOH(2.5 *M*)	4.9					
NaCl	3.4					
Product (draw)						

Synthesis
(1) Diazonium salt preparation

(2) Coupling reaction
In a 50-mL Erlenmeyer flask, _____ (_____ g, _____ mmol) is dissolved in ___ mL of a 2.5 *M* aq. sodium hydroxide solution and the flask is put in an ice-water bath. The diazonium solution from the previous step is added to the Erlenmeyer flask dropwise with stirring. The flask is left in ice-water bath for about 10 min and red colour starts to appear. About 1.5 mL of concentrated hydrochloric acid is slowly added to the mixture till the pH is between 3 and 4. One gram of NaCl is added to the mixture and the Erlenmeyer flask is heated on a hotplate till it is boiling. The mixture is cooled to room temperature and then in ice-water bath. The solid is vacuum-filtered in a small Buchner funnel. The solid is washed with 2-5 mL of water and left to dry. A total of _____ g (____%) of a solid is obtained.

(3) Dyeing a fabric strip
In a 100-mL beaker, 50 mg of the azo dye prepared in the previous step is dissolved in 20 mL of water. Three mL of a 2.5 *M* sodium hydroxide solution and 20 mL of the ferrous sulphate solution is added to the beaker and the mixture is heated on a hot plate and stirred with a glass rod. A fabric strip is put in the solution of the azo dye and it is kept immersed. The solution is boiled for about 3 minutes.
The fabric is removed with a tweezers and rinsed with tap water. The dyed fabric is patted to dry with a paper towel.

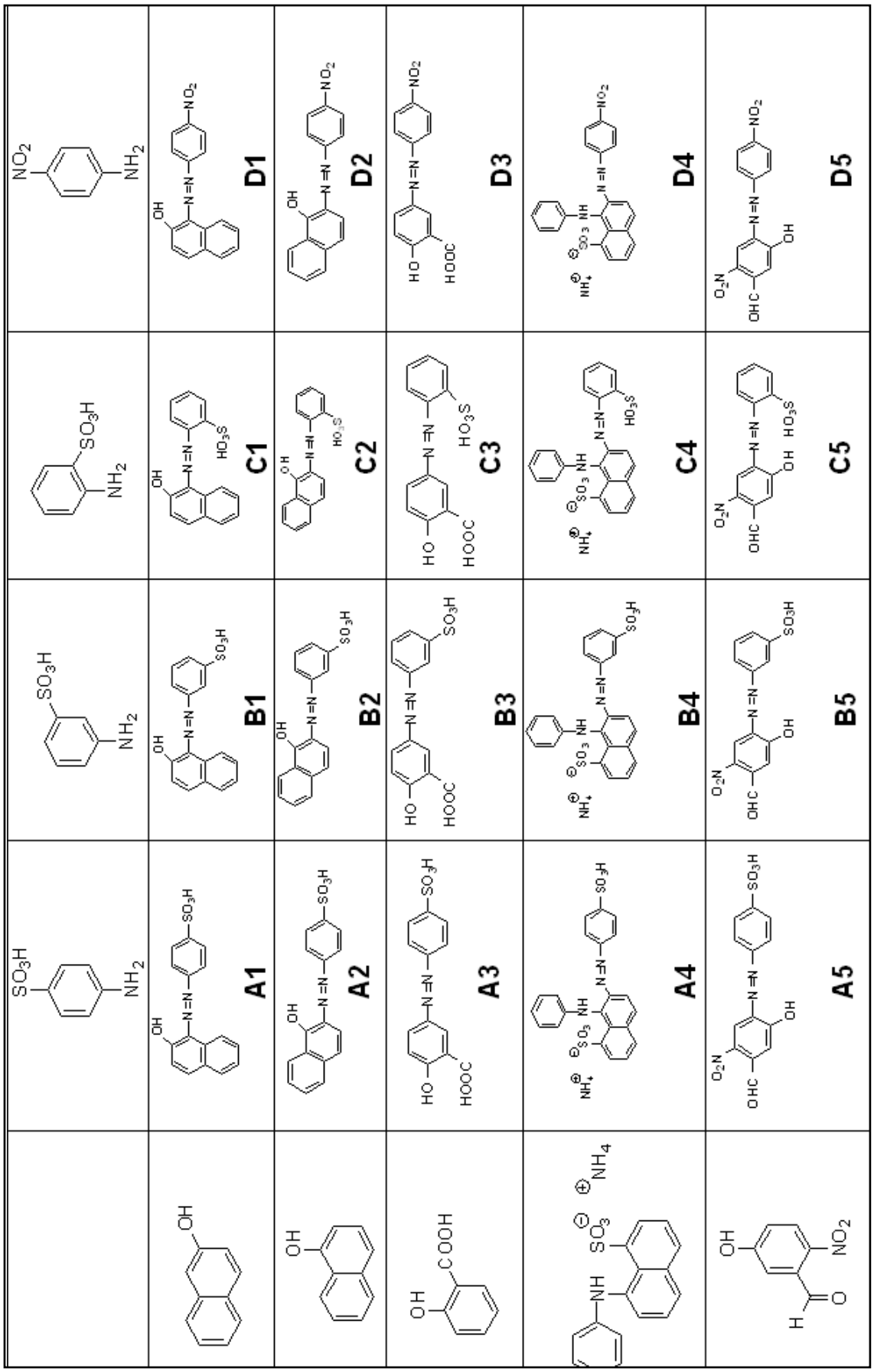
Discussion

Include here a discussion of the combinatorial approach in obtaining a range of different colours observed in the laboratory and the relationship between the UV spectrum and the observed colour for YOUR dye and at least ONE OTHER. Some discussion of the relationship between structure and colour would be an advantage.

References

(1) Palleros, D. R. *Experimental Organic Chemistry*; 1st ed.; John Wiley & Sons: New York,
2000.
(2) Lehman, J. W. *Operational Organic Chemistry*; 4th ed.; Prentice Hall: Upper Saddle River, 2002.

2. Table of Laboratory Bench Positions and Azo Dyes made



PLANNING AND REFLECTION TASK **2nd Year Dye Practical – 20 August 2009**

WHAT? • Information/concept • Synthesis Step	**SO WHAT?** • Reasons for doing this, challenges, difficulties • Importance for me and Grade 12 learner	**NOW WHAT?** • How will we do this and include the learners next week?
Safety: Lab rules, chemicals		
Background to Combinatorial Chemistry, Dyes, Dyeing and Fixatives		
Preparation of Diazonium Salt		
Coupling Reaction		
Dyeing of Fabric		
UV Spectra Discussion and Comparison		

4. Rubrics for Demonstrator Marking

DEMONSTRATOR RUBRICS 20 AUGUST 2009

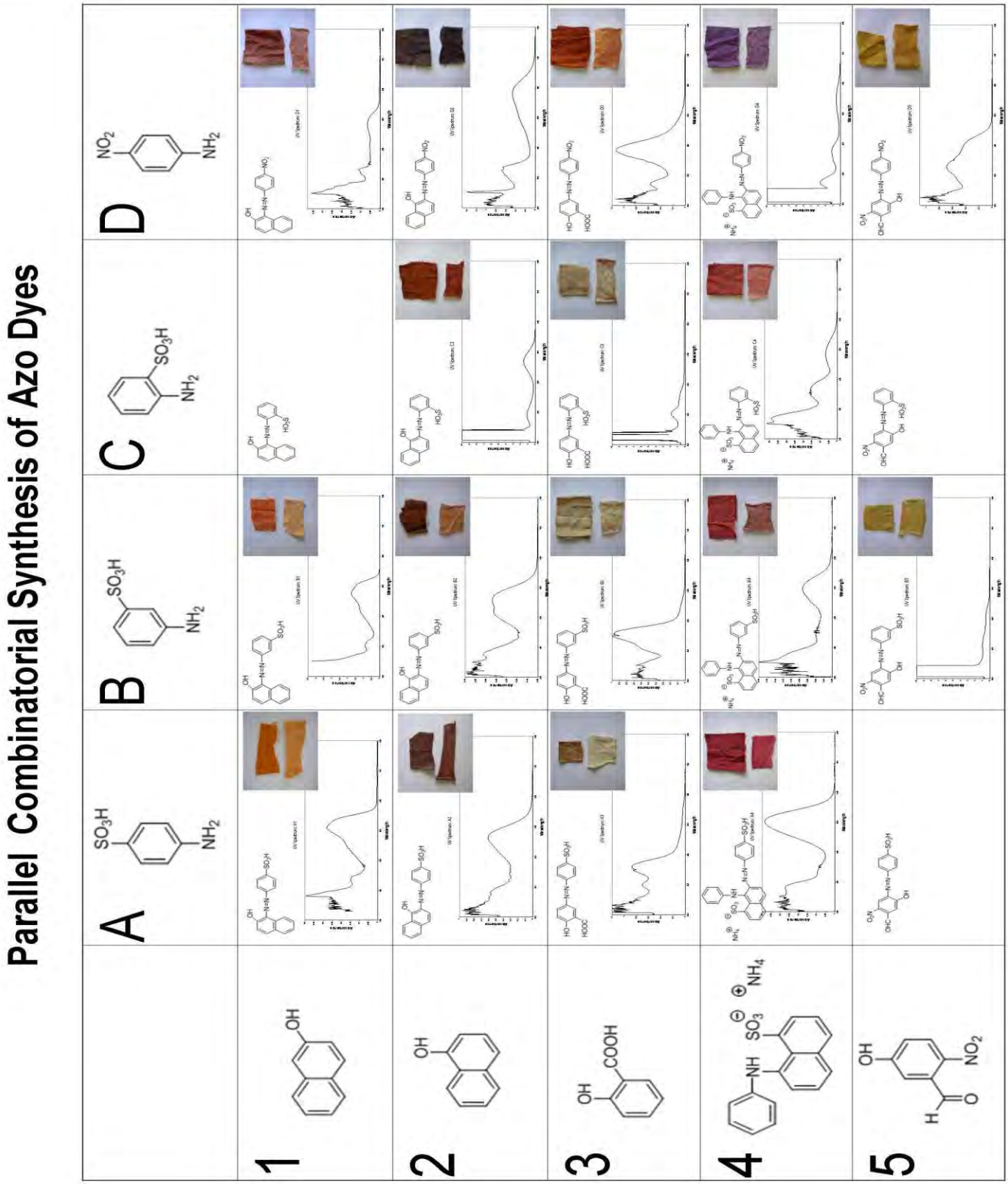
RUBRIC FOR PLANNING AND REFLECTION TASK

DESCRIPTION	MARK (OUT OF 5)
Both partners can answer questions and display knowledge of topic and practical. They both show evidence of deep engagement with the –So What?" and –Now What?" blocks of the grid. The grid is filled in, in detail.	**5**
Both partners can answer questions and display knowledge and evidence of engagement with the –So What?" and –Now What?" question blocks of the grid, but the grid is not filled in, in great detail. **OR** The grid is filled in, in detail but only one partner displays evidence of engagement and knowledge while the other appears less knowledgeable.	**4**
Partners struggle to answer some questions but do well in others and the grid blocks are adequately filled in.	**3**
Partners appear not to know much about the prac and the grid is scantily filled in with very little effort shown.	**1 or 2**

RUBRIC FOR CLEANLINESS

DESCRIPTION	MARK (OUT OF 5)
Bench is clean, neat and tidy with no spills. All glassware is clean and packed away.	**5**
Bench is neat and tidy with some small spills. All glassware is clean and packed away.	**4**
Bench is neat and tidy but with some unwashed glassware and some large spills.	**3**
Bench is messy and untidy, there is unwashed glassware and other clutter on the workspace and many large spills.	**1 or 2**

5. The Poster



APPENDIX F

THE SECOND PRACTICAL

1. The Demonstrator Rubrics

DEMONSTRATOR RUBRICS 27 AUGUST 2009

RUBRIC FOR SAFETY KNOWLEDGE

DESCRIPTION	MARK (OUT OF 2)
Student knows the relevant safety information for both 4-nitroaniline and 8-anilino-1-naphthalene sulfonic acid and the general safety information of the equipment and other reagents used in the synthesis of the purple dye.	**2**
Student knows the general safety guidelines but not for 4-nitroaniline and 8-anilino-1-naphthalene sulfonic acid specifically OR They have looked up the two main reagents but don't know any other safety information regarding the azo dye synthesis.	**1**
They are a danger to themselves and everyone else in the lab because they don't know any safety information.	**0**

RUBRIC FOR STUDENT ENGAGEMENT AND LEARNER INVOLVEMENT

DESCRIPTION	MARK (OUT OF 8)
Student is fully engaged with the Grade 12 (communication, asking questions, helping, prompting, teaching) and has provided the opportunity for the Grade 12s to be fully involved in doing the prac.	**7-8**
Student is engaged with the Grade 12 but learner is not fully involved in the process of doing the prac. (Grade 12 watching and listening rather than doing and questioning)	**5-6**
Student is just doing the prac and answering questions that the Grade 12 has asked, as opposed to involving the	**4**

learner in the process.	
Neither the student nor the learner seem to be communicating very well with each other and the Grade 12 is not learning as much they could and is hardly involved in the process.	**3**
The student is making no effort whatsoever to engage with the Grade 12 and the Grade 12 is not involved in the process at all	**1-2**

2. Demonstrator Observer Sheet

Demonstrator Name.....GROUPNUMBER.....
OBSERVER MARK SHEET

Student Name	Mark		Comments and Observations
	2	8	
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			

WHAT? • Information/concept • Activity	SO WHAT? • Why is this important/necessary • What did we learn (students and learners)?	NOW WHAT? • How can this experience be improved for future classes?
Working in the lab in teams with the Grade 12s. **Observing and teaching safety and lab protocol.**		
Background to Combinatorial Chemistry, Dyes, Dyeing and Fixatives		
Synthesizing the dye with the Grade 12s		
Discussing the UV spectra and colour correlation with the Grade 12s		

Dyeing the T-shirts		
Working with people who are different from me in some way (eg age, background, race, home language, different access to education, nationality, less science knowledge etc)		

APPENDIX G

RESEARCH INSTRUMENTS

1. The Pre-Implementation Questionnaire

RHODES UNIVERSITY
MSc PROJECT – IMPLEMENTATION AND EVALUATION OF A SERVICE-LEARNING COMPONENT

Pre-implementation questionnaire (2009)

Dear Student
You are asked to complete this questionnaire because you are going to be involved in a service learning module. Your honest and considered response will be of great value to my research. I want to know what your understanding and expectations of this component are; as well as your opinions and feelings about chemistry and community engagement. Please note that your responses will be treated confidentially.
Thank you, in advance, for your insights and contribution!

1. Student information

1.5 Gender (Tick the number that applies)

Male	1	Female	2

2. Student Understanding of Service-Learning

2.1 Please state your understanding of service-learning by completing the following: ~~–~~Service-learning is ..."

_____

_____

_____

_____

3. Student Expectations of Service-Learning.
Please indicate your level of agreement with each of the statements below.

1. Strongly Disagree	**2**. Disagree	**3**. Neutral	**4**. Agree	**5**. Strongly Agree

3.1 I think that I shall learn from the community members with whom I am going to work.

1	2	3	4	5

3.2 I think that I shall learn from Sarah and the staff involved in the module.

1	2	3	4	5

3.3 I expect that this module will provide me with the opportunity to apply the knowledge that have acquired during my study period thus far.

1	2	3	4	5

3.4 I expect that the service learning module will assist in preparing me for the world of work.

1	2	3	4	5

3.5 I think that the service learning experience will help me to gain insight into my role as a responsible citizen.

1	2	3	4	5

3.6 I think that the service learning module will contribute to my personal development.

1	2	3	4	5

3.7 I think that the service learning module will require much more work than other modules.

1	2	3	4	5

4. Learning outcomes of the module

4.1 Do you know what the learning outcomes of the module are?

Yes	1
Partially	2
No	3

4.2 If YES or PARTIALLY, please specify what you regard as the most important outcomes.

_____

_____

_____

5. What is your understanding of the intended outcomes of the module for the community?

_____

_____

_____

6. How do you think your learning experience will be changed by having Sarah research this course?

_____

_____

_____

7. Any remarks regarding your feelings, opinions and concerns about this service learning module you are about to participate in.

_____

_____

_____

_____

8. Student View and Experience of Chemistry
Please indicate your level of agreement with each of the following statements:

1. Strongly Disagree	**2**. Disagree	**3**. Neutral	**4**. Agree	**5**. Strongly Agree

8.1 I think that chemistry is a relevant and important subject which has positively influenced my life.

1	2	3	4	5

8.2 I think I have learnt skills which I will use in the workplace once I graduate.

1	2	3	4	5

8.3 I think that chemistry as I have learned it can impact the community I grew up in, in positive and necessary ways.

1	2	3	4	5

8.4 My chemistry knowledge and university experience qualifies me to make a contribution to society now.

1	2	3	4	5

8.5. Chemistry is a theoretical subject where I have seen little or no real-world application for the concepts I have learned.

1	2	3	4	5

8.6.1 I see myself as a scientist or as part of the scientific academic community.

1	2	3	4	5

8.6.2 Please explain your answer, giving reasons why you have strongly agreed, agreed, are neutral, or have disagreed or strongly disagreed with the above statement.

_____

_____

9. Previous Service and Citizenship

9.1 Have you been involved in any community engagement or outreach activities in the past 4 years?

No	1	Yes, while at school.	2
Yes, while at university.	3	Yes, at both school and university	4

9.2 If yes, was any of this service or outreach related to the direction of your academic studies? **Tick all those that apply.**

Yes, it was directly related to the subjects I am studying.	1
Yes, but only generally science related.	2

No, it was totally unrelated to science.	3

9.3 Please give some details on the type of outreach you have been engaged in.

_____

_____

9.4 Please indicate your level of agreement with each of the following statements:

1. Strongly Disagree	**2**. Disagree	**3**. Neutral	**4**. Agree	**5**. Strongly Agree

I believe that community engagement experience will affect me in the following ways:

9.4.1 Enhance the value of my education.

1	2	3	4	5

9.4.2 Change my level of awareness of my immediate world **in relation to** the wider community.

1	2	3	4	5

9.4.3 Change the way I see my responsibilities as a person involved in science.

1	2	3	4	5

9.4.3 Make me **more** aware of inequality in our society.

1	2	3	4	5

9.5 I believe it is important for those in science to engage with the public about their work.

1	2	3	4	5

Thank you very much for you time and insight!

2. The Post-Implementation Questionnaire

RHODES UNIVERSITY
MSc PROJECT – IMPLEMENTATION AND EVALUATION OF A SERVICE-LEARNING COMPONENT

Post-implementation questionnaire (2009)

Dear Student
You are asked to complete this questionnaire because you have been involved in a service learning module**. Your honest and considered response will be of great value to my research and to yourselves as the questionnaire forms part of the reflection component of the course.** I want to know if your expectations of the experience have been met. Your responses will be treated confidentially.
Thank you, in advance, for your insights and contribution!
PLEASE NOTE THAT YOUR RESPONSES TO QUESTIONS 6 AND 7 WILL BE ASSESSED FOR FULLNESS OF ANSWERS AND EVIDENCE OF ENGAGEMENT IN THE ACTIVITY. THIS WILL FORM PART OF YOUR TERM MARK.

1. Student information

1.6 Gender (Tick the number that applies)

Male	1	Female	2

2. Student Understanding of Service-Learning

2.1 Please state your understanding of service-learning by completing the following: ~~–~~Service-learning is ..."

_____

_____

_____

_____

3. Student Expectations of Service-Learning.
Please indicate your level of agreement with each of the statements below.

1. Strongly Disagree	**2**. Disagree	**3**. Neutral	**4**. Agree	**5**. Strongly Agree

3.1 I learned from the community members with whom I worked.

1	2	3	4	5

3.2 I learned from Sarah and the staff involved in the module.

1	2	3	4	5

3.3 This module provided me with the opportunity to apply the knowledge that have acquired during my study period thus far.

1	2	3	4	5

3.4 The service learning module assisted in preparing me for the world of work.

1	2	3	4	5

3.5 The service-learning experience helped me to gain insight into my role as a responsible citizen.

1	2	3	4	5

3.6 The service-learning module contributed to my personal development.

1	2	3	4	5

3.7 The service-learning module will required much more work than other modules.

1	2	3	4	5

3.8 The service component of the module was fully integrated into the curriculum.

1	2	3	4	5

3.9 There was adequate supervision and facilitation during the service-learning module.

1	2	3	4	5

3.10 The service-learning experience contributed to my understanding of diversity and the celebration of cultural differences.

1	2	3	4	5

3.11 All students should do service-learning modules.

1	2	3	4	5

4. Learning outcomes of the module

4.1 Do you think you have achieved the module‘s learning outcomes?

Yes	1
Partially	2
No	3

4.2 Please explain your response (YES / PARTIALLY / NO)

_____

_____

_____

5. Learning outcomes for the community

5.1 Do you think the community outcomes were achieved as intended?

Yes	1
Partially	2
No	3

5.2 Please explain your response (YES / PARTIALLY / NO)

_____

_____

6. Learning from others (reciprocity).

6.1 What did you learn from community members?

_____

_____

_____

_____

6.2 What did you learn from your fellow students?

_____

_____

_____

6.3 What did you learn about yourself during your service learning experience?

_____

_____

_____

6.4 What did you learn from and about Sarah and your lecturer during the service learning experience that you would otherwise not have known?

_____

_____

6.5 Please reflect briefly on your personal experience of the service learning module.

_____

_____

_____

_____

6.6 What did you learn about the value of reflection during the service learning experience?

_____

_____

_____

6.7 How have you grown personally through the experience?

_____

_____

_____

6.8 How have your social skills developed and grown through the experience?

_____

_____

_____

6.9 How did the service learning experience contribute to your sense of social responsibility, if at all?

_____

_____

_____

7. Please share any final remarks regarding your feelings, perspectives, concerns, difficulties and, especially, **recommendations for improvement** of this module.

_____

_____

_____

_____

_____

8. Student View and Experience of Chemistry
Please indicate your level of agreement with each of the following statements:

1. Strongly Disagree	**2**. Disagree	**3**. Neutral	**4**. Agree	**5**. Strongly Agree

8.1 I think that chemistry is a relevant and important subject which has positively influenced my life.

1	2	3	4	5

8.2 I think I have learnt skills which I will use in the workplace once I graduate.

1	2	3	4	5

8.3 I think that chemistry as I have learned it can impact the community I grew up in, in positive and necessary ways.

1	2	3	4	5

8.4 My chemistry knowledge and university experience qualifies me to make a contribution to society now.

1	2	3	4	5

8.5. Chemistry is a theoretical subject where I have seen little or no real-world application for the concepts I have learned.

1	2	3	4	5

8.6.1 I see myself as a scientist or as part of the scientific academic community.

1	2	3	4	5

8.6.2 Please explain your answer, giving reasons why you have strongly agreed, agreed, are neutral, or have disagreed or strongly disagreed with the above statement.

_____

_____

9. Citizenship and Social Responsibility

9.1 Please indicate your level of agreement with each of the following statements:

1. Strongly Disagree	**2**. Disagree	**3**. Neutral	**4**. Agree	**5**. Strongly Agree

I believe that this service-learning experience has affected me in the following ways:

9.1.1 Enhanced the value of my education.

1	2	3	4	5

9.1.2 Changed my level of awareness of my immediate world **in relation to** the wider community.

1	2	3	4	5

9.1.3 Changed the way I see my responsibilities as a person involved in science.

1	2	3	4	5

9.1.4 Made me **more** aware of inequality in our society.

1	2	3	4	5

9.2 I believe it is important for me, as a person in science, to engage with the public and share my knowledge and experience with them.

1	2	3	4	5

9.3 I will get involved in other community engagement activities as a result of my experience in this course.

1	2	3	4	5

Thank you very much for you time and insight!

3. Original CHESP Pre-Questionnaire (from HEQC Guide, Bender *et al.* 2006, p 206 - 208)

*CHESP STUDENT QUESTIONNAIRE (PRETEST)**

Dear Student

You are being asked to complete this questionnaire because you are enrolled in a course that has a service-learning component. We are very interested to find out what your expectations are of this course.

HIGHER EDUCATION INSTITUTION (HEI): .....

TITLE OF COURSE: .....

STUDENT NUMBER: .....

DEMOGRAPHICS

First, we would like to know some information about you.
(Please circle the correct response).

Gender

Female	1
Male	2

Race

Asian	1
Black	2
Coloured	3
White	4

What is your age? ..... (years)

Which year of study are you currently in?

First year	1
Second year	2
Third year	3
Fourth year/ Honours	4
Master's	5

Name of service agency or service provider you will work with during the course (where appropriate): . . . . . .

YOUR UNDERSTANDING OF SERVICE-LEARNING

Please provide your understanding of service-learning by completing the sentence below

I understand 'service-learning' to be

. . . . . .

. . . . . .

YOUR EXPECTATIONS OF THE COURSE

We would like to be informed about your expectations of the course in which you are enrolled. *Please indicate your level of agreement with each of the statements below.*

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Not applicable
I think that I will learn from the community in which I work	1	2	3	4	5	6
I think that the community will benefit from the work I do	1	2	3	4	5	6
I think that the service provider will benefit from the work I do	1	2	3	4	5	6
I think that this service-learning course will take more of my time than other courses	1	2	3	4	5	6
I think that the service-learning course will cost me more money than other courses	1	2	3	4	5	6
I think that the service-learning course will require much more work than other courses	1	2	3	4	5	6

Were you involved/ consulted in the planning of the course in any way?

Yes	1	No	2

If yes, specify in what way . . . . . .

. . . . . .

. . . . . .

Do you have a clear idea of the learning outcomes for the course?

Yes	1	No	2

If yes, specify in what way . . . . . .

. . . . . .

Do you think the service provider and community members involved in this course will benefit from the course as was intended?

Yes	1	No	2

If **yes**, describe why this is so. If **no**, why not? . . . . . .

. . . . . .

Have you been given clear rules and guidelines for working in the community?

Yes	1	No	2

If yes, specify . . . . . .

. . . . . .

What kind of preparation do you think you will need for working with the community?

Specify . . . . . .

. . . . . .

Do you think the assessment of this service-learning course will have to be different from that of other courses?

Yes	1	No	2

If yes, specify how . . . . . .

. . . . . .

Finally, please add any other comments (feelings, concerns, opinions; difficulties you foresee) you have about the course you are about to attend.

. . . . . .

. . . . . .

Thank you for your insights regarding service-learning!

4. Original CHESP Post-Questionnaire (from HEQC Guide, Bender *et al.* 2006, pp 209-212)

*CHESP STUDENT QUESTIONNAIRE (PRETEST)**

Dear Student

You are being asked to complete this questionnaire because you are enrolled in a course that has a service-learning component. We are very interested to find out what your expectations are of this course.

HIGHER EDUCATION INSTITUTION (HEI): .....

TITLE OF COURSE: .....

STUDENT NUMBER: .....

DEMOGRAPHICS

First, we would like to know some information about you.
(Please circle the correct response).

Gender

Female	1
Male	2

Race

Asian	1
Black	2
Coloured	3
White	4

What is your age? ..... (years)

Which year of study are you currently in?

First year	1
Second year	2
Third year	3
Fourth year/ Honours	4
Master's	5

Name of service agency or service provider you worked with this during the course (where appropriate):

YOUR UNDERSTANDING OF SERVICE-LEARNING

Please provide your understanding of service-learning by completing the sentence below
I understand 'service-learning' to be

. . . . . .

. . . . . .

. . . . . .

YOUR EXPERIENCES OF THE COURSE

We would like to hear about your experiences of the course in which you are enrolled. *Please indicate your level of agreement with each of the statements below.*

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Not applicable
I learnt from the community in which I worked	1	2	3	4	5	6
The community benefited from the work I did	1	2	3	4	5	6
The service provider benefited from the work I did	1	2	3	4	5	6
This service-learning course took more of my time than other courses	1	2	3	4	5	6
This service-learning course cost me more money than other courses	1	2	3	4	5	6
This service-learning course required much more work than other courses	1	2	3	4	5	6

Do you think the course was well-planned?

Yes	1	No	2

Explain your answer . . . . . .

. . . . . .

. . . . . .

What new knowledge, skills and/or attitudes did you gain through participating in the course?

Specify what these are . . . . . .

. . . . . .

Do you think the service provider involved in this course benefited from the course as was intended at the beginning of the course?

Yes	1
No	2
Don't know	3
No service provider	4

If **yes**, describe how the service provider benefited. If **no**, why not?

. . . . . .

. . . . . .

. . . . . .

Do you think the community members involved in this course benefited from the course as was intended?

Yes	1
No	2
Don't know	3
No community	4

If **yes**, describe how the community members benefited. If **no**, why not?

. . . . . .

. . . . . .

. . . . . .

Were you given clear rules and guidelines for working in the community?

Yes	1	No	2

If yes, specify what these rules are (at least the three most important rules).

. . . . . .

. . . . . .

What kind of preparation did you receive for working with the community?

Specify:

. . . . . .

. . . . . .

. . . . . .

Do you think the assessment of this service-learning course was different from that of other courses?

Yes	1	No	2

If **yes**, specify how . . . . . .

. . . . . .

. . . . . .

Finally, please add any other comments (feelings, concerns, opinions; difficulties) you have about the course you have just completed.

. . . . . .

. . . . . .

Thank you for your insights regarding service-learning!

5. Pilot Questionnaire

NAME:……..……..
TIME TAKEN TO COMPLETE
SURVEY:……

Pre-implementation questionnaire (PILOT 2009)

Dear Student
You are asked to complete this questionnaire as a pilot study to check the ease of use of the questionnaire. Your honest and considered response will be of great value to my research. I don't expect you to be able to answer all the questions; but please answer those you can and give your opinions and feelings about chemistry and community engagement. Most importantly please mark unclear/confusing/ambiguous questions on the survey and feel free to comment anywhere if a question is confusing or badly set out. Also please indicate how long it takes you to complete the survey. Please note that your responses will be treated confidentially. Your name will not be associated with the findings in any way.
Thank you, in advance, for your insights and contribution!

1. Student information

1.7 Gender

Male	1
Female	2

1.8 Home language

Afrikaans	1
English	2
IsiXhosa	3
Sesotho	4
Setswana	5
IsiZulu	6
Other	7

1.9 Age

<= 18	1
19	2
20	3
21	4
22-24	5
25+	6

2. Student Understanding of Service Learning

2.1 Please state your understanding of service learning by completing the following: "Service learning is ..."

_____

_____

_____

3. Perceptions of and Interest in Chemistry

I would like to know about how you view the discipline of chemistry and your qualifications and experience of chemistry so far.

Please indicate your level of agreement with each of the following statements:

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

3.1 I think that chemistry is a relevant and important subject which has positively influenced my life.

1	2	3	4	5

3.2 I think have learnt skills which I will use in the workplace once I graduate.

1	2	3	4	5

3.3 I think that chemistry as I have learned it can impact the community I grew up in, in positive and necessary ways.

1	2	3	4	5

3.4 My chemistry knowledge and university experience qualifies me to make a contribution to society now.

1	2	3	4	5

3.5. Chemistry is a theoretical subject where I have seen little or no real-world application for the concepts I have learned.

1	2	3	4	5

3.6.1 I see myself as a scientist or as part of the scientific academic community.

1	2	3	4	5

3.6.2 Please explain your answer, giving reasons why you have strongly agreed, agreed, are neutral, or have disagreed or strongly disagreed with the above statement.

_____

_____

4. Previous Service and Citizenship

4.1 Have you been involved in any community engagement or outreach activities in the past 4 years?

No	1
Yes, while at school.	2
Yes, while at university.	3
Yes, at both school and university	4

4.2 If yes, was any of this service or outreach related to the direction of your academic studies?

Yes, it was directly related to the subjects I am studying.	1
Yes, but only generally science related.	2
No, it was totally unrelated to science.	3

4.3 Please give some details on the type of outreach you were engaged in.

_____

_____

4.4 Please indicate your level of agreement with each of the following statements:

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

I believe that community engagement experience will affect me in the following ways:

4.4.1 Enhance the value of my education.

1 2 3 4 5

4.4.2 Change my level of awareness of my **social** context within the greater community.

1 2 3 4 5

4.4.3 Change the way I see my responsibilities as a person involved in science.

1 2 3 4 5

4.4.3 Make me **more** aware of inequality in our society.

1 2 3 4 5

4.5 I believe it is important for those in science to engage with the public about their work.

1 2 3 4 5

5. We would like to know about your expectations of the service learning module for which you have enrolled. Please indicate your level of agreement with each of the statements below.

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

5.1 I think that I shall learn from the community members with whom I am going to work.

1	2	3	4	5

5.2 I think that I shall learn from the researcher and staff involved in the module.

1	2	3	4	5

5.3 I expect that this module will provide me with the opportunity to apply the knowledge that have acquired during my study period thus far.

1	2	3	4	5

5.4 I expect that the service learning module will assist in preparing me for the world of work.

1	2	3	4	5

5.5 I think that the service learning experience will help me to gain insight into my role as a responsible citizen.

1	2	3	4	5

5.6 I think that the service learning module will contribute to my personal development.

1	2	3	4	5

5.7 I think that the service learning module will require much more work than other modules.

1	2	3	4	5

6. Learning outcomes of the module

6.1 Do you know what the learning outcomes of the module are?

Yes	1
Partially	2
No	3

6.2 If YES or PARTIALLY, please specify what you regard as the most important outcomes.

_____

_____

_____

7. What is your understanding of the intended outcomes of the module for the community?

_____

_____

_____

8. What do you regard as the module's intended outcomes for the researcher?

_____

_____

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9. Any remarks regarding your feelings, opinions and concerns about this service learning module you are about to participate in.

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Thank you very much for you time and insight!

6. Demonstrator Focus Group Interview Questions

Demonstrator Focus Group

This focus group discussion is for the purpose of both member checking, in other words checking that the information I have taken from your observations is correct and that you are happy with what you have written, and to informally interview you as a group to hear some of your thoughts on the service-learning practical experience. Please feel free to discuss the questions that I ask you amongst yourselves.

1) Did the practical, in your opinion, enhance the students‟ experience of chemistry?

2) Do you think they learned more chemistry than they normally would have?

3) What other skills do you think they learned?

4) Of what value do you think the experience was for the students?

5) Do you think the students enjoyed themselves and saw the value of what they were doing?

6) What do you think they learned about themselves?

7) Any general comments?

APPENDIX H

1. Extracts from the Practical Report Discussions

—From the spectra, a maximum wavelength absorbance was at 500nm where a green colour was absorbed and (the) transmitted/observed colour was red which correlate(s) with the colour we observed. The chromophore used had a substituent of sulfonic acid which is a deactivating group – leading to disturbance in the conjugate π system. This is why our colour was not blood red, but red having a kind of purple shading." (S_{17} and S_{25}, Practical Report)

–The presence of auxochromes causes a shift to longer wavelengths (lower energy), which is called the bathochromic shift. (red shift) The red shift occurs because auxochromes donate electron density, hence increasing conjugation resulting in red shift. Therefore moving across from A to B to C to D, the λ_{max} is increasing as well as the shade of the dye (changing). (S_{34}, Practical Report)

–The combinatorial approach used in the practical yield(ed) many different colours of different shades. After having taken a look at the poster, a trend could be noticed. The colour changed down the table and the shade changed across the poster. The chromophores were the y-axis (π–rich conjugated systems, 1,2,3,4) and the auxochromes were the x-axis (the substituents provided by A, B, C and D.)" (S_{28} and S_{35}, Practical Report)

–The combinatorial approach gave different colours and different shades of dyes. This is possible because of the shifting of absorption peaks of the different products. This indicated that the diazonium group was the same but the difference of the SO_3H groups and NO_2 groups which can be viewed as auxochromes affected the final product's absorbance properties and the colour." (S_{13}, Practical Report)

2. Coding and Expansion of Post-Reflection Results

The codes below are taken from Eyler and Giles' (1999) book on service-learning, but some are adapted to be slightly more specific to this context.

Learning Codes:

1) Personal and Interpersonal Development
2) Engagement, Curiosity and Reflective Practice *adapted to* Further interest in learners and evidence of engagement
3) Understanding and Applying Knowledge – *of chemistry*
4) Critical Thinking – *in an academic sense*
5) Perspective Transformation – *showing awareness of context and relevance of chemistry and or the change in student opinion of learner*
6) Citizenship - *civic awareness* (Eyler & Giles, 1999)

WHAT? • Information/concept • Activity	**SO WHAT?** • Why is this important/necessary • What did we learn (students and learners)?	**NOW WHAT?** • How can this experience be improved for future classes?
Working in the lab in teams with the Grade 12s. Observing and teaching safety and lab protocol.	*Learnt how to divide tasks...students learned from explaining to learners...safety in the laboratory...how to consult MSDS...learners learnt lab and chemical safety...important that students point out safety measures...communication is vital...how to work in groups*	*Provide safety data and background info to learners beforehand...have an explanatory lecture/workshop with Grade 12s before coming to the lab*
Background to Combinatorial Chemistry, Dyes, Dyeing and Fixatives	*So we understand the theory behind the practical and how it relates to the real world...learners feel like they've learnt how to make a dye and the importance of them...understand why we do something rather than following a recipe...gain insight-can modify experiment to work better if we understand...the dye industry is a developing industry thus it is advantageous for chemists to be informed...practically applied theory*	*Learners should get background information...learners want to learn more of the chemistry beforehand...learners would like to have more hands-on experience...for learners to see the effect of combinatorial chemistry, let us make more than one colour with them*
Synthesizing the dye with the Grade 12s	*The learners gained experience of, and put organic chemistry into action...students learnt a lot while explaining...pass on proper protocol to learners...helps student understand what they are doing*	*Give more background on the learners to students, too short time, maybe do reaction on weekend?..learners want more opportunities to participate...the learners want to prepare other colours for this experiment...learners like the*

	and helps learners understand when they do it with us...learning a skill learners and students know how to experiment with dyes.	*experience of working with students...learners enjoyed using the equipment...students also want a t-shirt*
Discussing the UV spectra and colour correlation with the Grade 12s	*Concludes the prac and makes sure the learners understand...we understood how absorbance works...understand how we get colours...learn roles of auxochromes and chromophores...better understanding of the concept of wavelengths and how colour correlates to the spectra*	*Learners need more background knowledge...provide personal spectra charts...too little equipment for all of us...another poster...ready made examples to help explain...show learners the UV spectrometer...more time...group discussion of UV spectra...students should be pre-lectured on UV spectra*
Dyeing the T-shirts	*Put chemistry into practical use...confirm theory of fixatives...practical experience of theory...possible future careers...applications of chemistry...makes chemistry fun...practical use of chemistry*	*More variety of colours...more patterns of tie-dyeing*
Working with people who are different from me in some way (eg age, background, race, home language, different access to education, nationality, less science knowledge etc)	*Broadens communication skills...creates awareness...learners feel they have gained knowledge and had fun doing it...when conveying knowledge it shows the students just how much we know...to merge ideas...working with (the students) was quicker and easier...learning from each other...revision especially for students..*	*Went well, no complaints...would have preferred more time with the learners...would have liked some tips on teaching...more info on the people we were working with...maybe learners should have more background knowledge so they can ask specific questions...we could have more than one prac session with the learners*

3. Coding of Post-Questionnaire: Student Understanding of Service-learning

There were two broad categories of responses. Either students defined service learning as only chemistry related, or they saw it in its broader applicability.

Then there were three categories of response in terms of the definition of service-learning and its context.

1) The students saw their own learning as the most important and sidelined the community (student-focused), or
2) they saw the process as joint (mutual), or
3) they emphasised the charitable aspect and saw the community as gaining the most from the experience (charity).

Category	Representative Student Responses
student-focused	*It is academic learning that involves community work…a way of using the knowledge gained from lectures to prepare for the working world…*
mutual	*Helping the community by teaching them skills while having fun and both parties benefiting…you learn while you do something useful for you and the community…helping ourselves as well as other people…learning with students from other schools. We show them how to make stuff they do not know and learning from them at the same time…a process that involves teaching less privileged people and helping, encouraging and motivating them. The potential and opportunity to learn is available to both parties involved.*
charity	*A way of enhancing education through filtrating knowledge to the wider community – thus instilling social responsibility in us as learners, by engaging with the community. Moreover, from doing this gaining satisfaction from knowing I have played a role in society…using what you learn in helping someone in great need*

4. Coding of Post- Questionnaire: Learning Outcomes of the module

–What did you learn from community members?" offered many different views on what they had gained from working with the learners. The responses were categorized into (with the corresponding Eyler and Giles (1999) category in brackets):

Code	Representative Student Responses
Civic awareness (Citizenship):	*I learned to communicate science to people who might know less or have less of an understanding than I do. I learned to appreciate the privilege I have being at a tertiary institution and receiving a great academic education with a wide variety of facilities…I learned to be more open to those less fortunate and that they can teach me something as well…there is a great need to involve our fellow community members to ignite interest in science in general…I learnt not to presume a total lack of knowledge on the part of younger learners than*

	myself, as everyone has the capacity to contribute to some extent.
Enjoyment and seeing chemistry through new eyes (Perspective Transformation)	*They are interested and excited about chemistry!...enthusiasm of the learners, made me like and enjoy the module and enhanced my love for chemistry*
Social and teaching skills (Personal and Interpersonal skills)	*How to communicate with other people, how to be responsible. How to help person in the right way. I learned patience from them…communication, patience and teaching skills…learnt how to simplify complicated things into simple, smaller parts that can be explained…I learnt about being a leader and a teacher*
Perspective change (Perspective Transformation):	*I can share ideas with them and surprisingly even them they have the same ideas as me…*
Nothing	*Nothing really except that they needed a lot of help…nothing…not much really…*

Question 6.2 asked students to state what they had learned from their fellow students during the experience. Here again, the responses were categorized to facilitate answering the research questions. The categories and some examples are quoted below with the Eyler and Giles (1999) categories in brackets.

Code	Student Response
Chemistry concepts/ Academic skills (Understanding and Application of Knowledge)	*More on how colour works, particularly absorption by particular molecules…a lot of chemistry and team work…they explained parts of the experiment that I didn't understand…quite a lot and more insight and explanation of the theory of dyes – from what each of us knew – ideas and thoughts were merged…I learnt how to conceptually understand the chemistry…*
Personal and social skills (Personal and Interpersonal Development)	*Working together to accomplish a task…working as a team …learnt the benefits of teamwork in the lab… I learnt about group work and dividing the work load so as to get work done much faster and more efficiently*
(Perspective Transformation)	*They are so cooperative and make working in the lab enjoyable…I learnt that sharing ideas and explaining them to someone else is benefiting...that we can treat each other as equals and work as a team to achieve a common goal...how to make chemistry fun again…passion from the students… Gained new respect for my fellow students watching them teach*
Nothing	*Nothing…*

The next question, question 6.3, asked students what they had learned about themselves during the service-learning experience. As above, the Eyler and Giles (1999) categories are in brackets.

Code	Student Response
Knowledge of inherent skills never needed/noticed/used before (Perspective Transformation)	*I learnt that I'm quite good at explaining concepts…I know more about chemistry than I initially thought I did…I learnt that I am able to pass on my knowledge and apply it…that I am able to do things on my own…that I actually know more than I thought…*
Awareness of knowledge gained at university (Perspective Transformation)	*I now love chemistry…I know most of the things that I have learnt since first year…that you can actually apply your skills in developing something that can be used to help the community…*
Realisation of ability to contribute to society (Perspective Transformation and Citizenship)	*I want to do more of this, I want to teach people the little that I know and just help nurture their passion for science/chemistry*
Self knowledge (Engagement, Curiosity and Reflective Practice)	*I am capable of interacting and engaging with my fellow students to come up with good working relationships…I worry too much about details-scared of imparting the wrong knowledge. I learnt that once I get started, I actually enjoy teaching others…to be more open minded…there is a lot that I don't know about myself…*
Knowledge of how to develop academic skills (Understanding and Application of Knowledge)	*How I can improve my skills…*

The fourth question in section 6 asked students to comment on what they had learned from and about me and the lecturer during the experience that they would not otherwise have known. These were also categorized according to themes.

Code	Student Responses
Critical thinking skills (Critical Thinking):	*I learnt to think critically about what I am doing and to always question why we do things the way we do…*
Admirable character traits, Caring for the community (Perspective Transformation and Citizenship):	*She is an understanding person…they are understanding people who care about the community…they are so nice and passionate, most important they know exactly what they are doing, they made me ask myself questions about my life, as in what I am doing, is it really what I want?...She is involved and loves the subject so much…*
Chemistry Skills/Knowledge (Understanding and Application of Knowledge)	*They have taught me to enjoy chemistry practically…more organic chemistry…I got a clear understanding of absorbance and how dyes work…I learnt how the mechanism works which*

	was the biggest challenge for me…

The next question asked students to reflect briefly on their personal experience of the service-learning module. Again responses were categorized according to the learning themes that emerged from the data.

Code	Student Responses
Worthwhile/fulfilling experience for students	*It is a great module and everyone should experience it…It feels good when you have done something positive which can help others because we also encouraged them to work hard so they can come to university…Feel very happy that I could help or teach the community something!!...Learnt more about being a leader, that learning true communication is an art. True leaders serve…I have become more confident and comfortable in the chemistry lab…*
Worthwhile experience for learners	*I think the learners benefited…I think they learned from us…Even though I was involved in teaching someone I learned a lot myself. I have an enhanced appreciation for my lecturers/tutors/demonstrators and for being at Rhodes University.*
Enjoyable/fun/loved it/great/inspiring	*I loved the practical very much. Good work Sarah!...Thank you a lot, very entertaining…Giving back to the community is always a wonderful experience…I want to congratulate Sarah for the success of the entire project and hope that we can have more of these projects…a lot of fun!...*
Felt more involved in the community	*It made me feel like I have something to give to the community…I felt more involved in the community…*

Students also mentioned specifically what they had learned to validate their opinions of the module. (Eyler and Giles (1999) categories in brackets):

Code	Student Responses
Applied theory to practical work (Understanding and Application of Theory)	*We can use chemistry everyday by making products and saving money…*
Better understanding of chemistry/academic knowledge (learnt new things (Understanding and Application of Theory)	*Communication skills and the knowledge of chemistry improved…*
Importance of group interaction/communication (Personal and Interpersonal Skills)	*I gained a lot due to the communication with the students and learners…I was always explaining to the learner so I was constantly communicating with the learner…*
Importance of (interaction with)the community (Citizenship)	*I have learnt that it is important to pass on knowledge so that others can learn…I have the ability to pass on information and knowledge…I would now engage a community member without hesitation…It made me understand how important it is to give back to the community…*
Learned responsibility (Citizenship)	*It made me feel more responsible…I have a responsibility to myself and to others to pass on what we know…I learnt to be responsible…it taught me to give back to the community whenever I can…*
More respect for lecturers/teachers (Perspective Transformation)	*I grew in respect for my lectures and teachers, it was interesting being on the other side…*
No response	

APPENDIX I

1. Essay Reflection Coding Examples

Below, some extracts from students‘ essay reflections are shown with the coding. The essay reflections were coded twice. Once to provide insight into skills and learning provided by the essay as an activity on its own, (this section) and secondly (section 2) to provide insight into the whole service-learning component: the practicals, and all that they included, in conjunction with the essays.

Essay Thematic Codes:

1) Writing essay provides knowledge of broader application of chemistry/ relevance of chemistry/ chemistry in everyday life/ previously unknown facts about chemistry

2) Writing essay develops general research and academic writing skills

3) Writing essay develops specific skills for example using Symyx Draw and Referencing in the American Chemical Society Style

4) Writing essay develops skill in working alone/ develops independence and opportunity for self-study/ self evaluation

5) Writing essay provides enjoyment/ satisfaction/ improves opinion of own capabilities/ inspiration (after feeling the opposite about it)

6) Writing essay develops reading/ understanding/ critical thinking skills

7) Writing essay provides challenges in research/ time-management/ understanding

8) Draft essay provides opportunity for growth and improvement

These codes can also be grouped under Eyler and Giles‘ (1999) areas of learning:

- Personal and Interpersonal Development (4, 7)
- Understanding and Application of knowledge (1, 2, 3, 8)
- Critical Thinking (6)
- Perspective Transformation (5)

1.1 Essay Reflection S_6

"Writing this academic essay was of benefit to me because it opened up a broader view of the amazing things that chemistry can do. It helped me to understand the chemistry behind many of the beautiful colours and products that our eyes look upon. Writing this essay lead me to understand that almost every aspect of life involves chemical processes and that many of the coloured products sold today are synthetically manufactured with the use of chemistry.

I found it difficult to do this essay writing task because the topic of dyes and the textile industry is so broad with respect to the vast number of coloured dyes and products that exist. I found it hard to find large amounts of information on any one specific colour but rather found extensive research into classes of dyes. I found it hard to find the exact chemical mechanism of my selected colour.

Some of the skills I learnt were the extraction of key information from an extensive amount of information and the ability to isolate and summarize key points and issues out from large amounts of information. I also learnt to reference according to the ACS style and other key issues when writing an essay."

1.2 Essay Reflection S_{32}

"„My favourite Colour" essay was the first academic essay I have written, and at the beginning of the assignment and the service-learning course I was very apprehensive of the outcome and possible success of the essay. It seemed an extremely daunting task to have to complete, however, once I started the essay I found it quite satisfying…Upon completion of this essay, I can happily say that I have learnt numerous valuable skills in terms of not only writing academic papers and essays but also reading, understanding and being able to critically appreciate academic works. Valid, reliable sources are crucial to a successful essay. The entire process as a whole greatly challenged and inspired me…"

1.3 Essay Reflection S_{25}

"Writing this academic essay was of benefit to me because there was lots of information I did not know about researching and techniques on how to assimilate information from source since this was my first essay to do so. I found it difficult and challenging to do this essay writing task because there was limited resource (books at the library) and people who were doing the same essay were many even though it was different colours. Due to lack of experience with researching time became a problem and I had to squeeze time for this essay so that I can look for information. Some of the

skill(s) I learnt was a good way of citing information and how to draw mechanism(s) using Symyx drawing structure which can be so useful when by the time that I will be writing my scientific writing. This task was having lots of learning more especially on self evaluation. Strategy of submitting draft first helps me a lots as I got time to go through what I did wrong and it gave a chance to see my mistake be able to correct some. There is nothing specific that I can point out that should have been done better since all strategy employed was a better one."

1.4 Essay Reflection S_7

While writing this academic essay my ability to research, understand and explain myself improved dramatically. The fact that I was doing practical work which related to the essay not only helped me understand the practical work more, but helped me to appreciate the essay I was writing even more as I could see the chemistry I was researching in action. This essay was challenging as a lot of the source material seemed to be written at a higher level of understanding, but this was a challenge which I overcame by reading multiple sources. By doing this, I was able to eventually fully understand concepts which I would not have grasped had I only used one source. The service-learning module also helped me gain some teaching skills, a skill that will benefit my learning as well. By teaching, I believe my understanding of the content became more in-depth. To teach I needed to fully understand the chemistry I was teaching. I enjoyed writing this essay and learnt things about the organic chemical industry which I otherwise would never have known. I find it amazing that such a seemingly unthought-of product such as dyes contributed so much to the kick-start of the chemical industry. This essay has helped me to appreciate the chemistry in everyday life, and, specifically the importance of synthetic dyes.

2. Essay Reflection (with emphasis on the whole component) coding examples

Here I was looking for student statements that showed how the whole component fitted together and how the essay helped with the practical and vice versa. I was also looking at student statements for evidence that learning had taken place. These could be coded according to Eyler and Giles' (1999) learning areas.

Student statements which highlight how the practical, service and essay linked together are highlighted in grey, while the thematic coding is explained below.

Thematic Codes for kind of learning taking place:

- Personal and Interpersonal Development – development of social skills and independence, learning from others, communication skills, etc
- Understanding and Application of knowledge – learning discipline related knowledge and bringing it into new contexts
- Critical Thinking – using thinking skills to critically examine information, situations, and problems and try to solve them
- Perspective Transformation – a change in beliefs about the world, oneself and the discipline of chemistry
- Engagement, Curiosity and Reflective Practice – engagement with the learners and the subject matter and the ability to think about ones own actions and realise how one has changed
- Citizenship – the learning of a new concept or idea which will positively change the way one interacts with the society in which one lives

These codes do overlap to a certain extent, for example, it is obvious that if the student is aware that their own perceptions and ideas have changed, and is expressing this through the medium of reflection, then perspective transformation has occurred, but so have engagement, curiosity and reflective practice being learned. This coding is thus to illustrate some of the steps taken in the thematic coding process, for reliability and validity's sake, but is not a complete picture of the complexity of the data.

2.1 Essay Reflection S_{12}

"...I had never heard of service-learning so I did not understand what it meant then as time went I understood what it was more when the students from the local school came and we helped them to dye their t-shirts. I did not realize how much information I could actually share with someone else who is not on the same level as me. I realise

that chemistry does not only end in the lab, one can actually use their knowledge to help a community and make other students understand that they can use their knowledge to make something and make life better for the community. In this whole process I learnt that sharing the information with other(s) makes you understand more about what you are doing. Working with others enhances your communication skills and you learn things you would not (have) thought of if you were working on your own…I enjoyed this journey and I hope next year it will be repeated."

2.2 Essay Reflection S_7

While writing this academic essay my ability to research, understand and explain myself improved dramatically. The fact that I was doing practical work which related to the essay not only helped me understand the practical work more, but helped me to appreciate the essay I was writing even more as I could see the chemistry I was researching in action. This essay was challenging as a lot of the source material seemed to be written at a higher level of understanding, but this was a challenge which I overcame by reading multiple sources. By doing this, I was able to eventually fully understand concepts which I would not have grasped had I only used one source. The service-learning module also helped me gain some teaching skills, a skill that will benefit my learning as well. By teaching, I believe my understanding of the content became more in-depth. To teach I needed to fully understand the chemistry I was teaching. I enjoyed writing this essay and learnt things about the organic chemical industry which I otherwise would never have known. I find it amazing that such a seemingly unthought-of product such as dyes contributed so much to the kick-start of the chemical industry. This essay has helped me to appreciate the chemistry in everyday life, and, specifically the importance of synthetic dyes.

2.3 Essay Reflection S_8

When I was first told that I had the task of writing a 3000 word chemistry essay on the colour green I was the least bit enthusiastic. I threw the task to the side and saw it as merely an irritant to get in the way of all the other work and tests I had coming up. But when I started writing it, I really couldn"t put the project down. It really interested me in various aspects. Especially as how something as miniscule as colour

and textile fabrics could have such a major impact on our lives and how involved the chemistry was behind it.

I felt overwhelmed at times with some of the chemical structures that were thrown at me, but found if I just took the time to look at them and understand what was being said about them, the structures became less and less complicated. This I attribute to my chemistry knowledge that I have acquired up until now, which I previously thought was very little.

In doing this essay I learnt how to sift through vast amounts of information and, for the first time, chemical structures, to find the necessary resources. I also learnt how to use Symyx draw as an effective resource in writing chemistry essays.

In terms of the service-learning dye practical, I must say I was also not entirely enthused about having matric students take up my Thursday afternoon. However, through doing the practical I realised how enthusiastic I was in showcasing my knowledge to someone who was eager to learn. I also learnt to become more tolerant and accepting of someone less fortunate than myself and they are in fact no different from us.

Finally I would like to say thank-you to Prof. DC and the demonstrators who helped out at the practical afternoons. And thank-you to Sarah Abel for giving me the opportunity to be the first to participate in the concept of service-learning. I thoroughly enjoyed it.