

To what extent does the National Science Curriculum in Trinidad and Tobago as presented by teachers engage students as critical thinkers?

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I, Perle Brewster confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

ABSTRACT

This thesis aims to elucidate the influences that determine the extent to which the National Science Curriculum of Trinidad and Tobago, as presented by teachers, engages students as critical thinkers. The interpretation of critical thinking is seen in terms of an emancipatory paradigm which leads to social justice.

The work takes the form of a case study completed at a mixed gender government secondary school. The context is set within an education system that has come out of a colonial history and where critical thinking is seen as important for the economic advancement of the nation. However, the level of success necessary for achieving this advancement is not seen as being actualised within the present educational regime.

A qualitative approach was taken in which critical theory and postcolonial theory were employed in establishing the nature of the power relations at play within this setting.

The methods included content analysis of curriculum documents, exercise books and textbooks, lesson observations, focus group interviews with students from Forms 1 to 5 based on a video clip stimulus and structured interviews with teachers. The interviews were all subjected to NVivo coding to determine the themes related to the research questions.

The main findings were that students' skills in terms of the cognitive and affective domains and their critical thinking skills did not appear to develop significantly as they progressed through school nor were the students any more confident to engage in social activism. The pedagogical methods used were more based in direct instruction and did not fulfil the expectations of a critical pedagogy as advocated in the National Certificate of Secondary Education (NCSE) and Caribbean Secondary Examination Certificate (CSEC) syllabuses.

A neoliberal agenda is seen as influencing the maintenance of an elitist education system and suggestions are provided for changes within the administration of the system, teacher training and pedagogical methods which would result in a more appealing, relevant and motivating school science.

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CHAPTER 1 Postcolonial context

1.1 Empirical setting

On arriving from England and taking up the post of Principal at Bishop Anstey High School East, Trinidad in 2008, with its 875 girls, I noted that students in the lower school, between the ages of twelve and fourteen, only had access to practical science on six days in an academic year. With so few practical classes it occurred to me that students were not involved in much science investigation and this would have an impact on their acquisition of the inquiry skills that science should provide. The walls of the four laboratories were bare, providing little visual stimulus for engaging students' interest in science. My attention was also drawn to the fact that the science curriculum did not include subjects such as astronomy and evolution which were areas I considered important for students, so as to help them address the fundamental questions of '*Who am I?*' and '*From where do I come?*'. In addition, I was struck by the authoritative manner in which teachers maintained order and discipline. Considering that this school is one of the best resourced schools in the twin island state of Trinidad and Tobago, I wondered about the science experience of students across the country. What was the nature of the curriculum? What did it demand in terms of pedagogy and how did teachers go about fulfilling these demands?

Following on from my Institution Focus Study which identified challenges facing a school Principal attempting to develop a critical thinking ethos, I intend to explore the effect of the science curriculum on the development of students' critical thinking. It is possible to see science education contributing to the aspirations outlined in the description of the 'The Ideal Caribbean Person' (Appendix 8). However, the focus on "critical thinking, questions the beliefs and practices of past and present and brings this to bear on the innovative application of science and technology to problems solving" (Caribbean Community and Common Market (CARICOM)¹, 1997, para. 3) speaks directly to science education.

¹ Abbreviations are defined in Appendix 7.

As a prerequisite to interrogating students' 'criticality' in science in a school in Trinidad and Tobago, it has been necessary to discern the effect of Trinidad and Tobago's socio-economic development on the creation and implementation of educational policies. The creation and fidelity to the implementation of such policies is a reflection of the situation of those involved. Their situation is located in a history and the conditions of the present environment which is influenced by politics, culture and other social pressures. This chapter will describe how Trinidad and Tobago's colonial experience has influenced the nature of its education system. It will take the form of: a description of the historical perspectives; Trinidad and Tobago's economic global relationships and the politics involved in the implementation of education policy.

1.2 Historical perspectives

Colonialism is believed to have imposed and inspired specific modes of transnational engagement on the part of colonized nations like Trinidad and Tobago that determined, not only how they related to the 'mother country', but also their decisions about whether and how to conceptualize, position, and articulate their identities in relation to the world (Nwankwo, 2011). Postcolonial theory involves a number of different practices, ones that take place in a wide range of disciplinary fields, such as anthropology, political economy, philosophy and historiography. It has been used to analyse and bring to the forefront issues of race, nation, empire, migration and ethnicity with cultural production (Moore-Gilbert, 1997). Postcolonialism in this thesis is regarded as the phase after independence in which political and cultural demands are made to confront the received histories and ideologies of the former colonisers, making room for the resisters' knowledge to emerge (Kanu, 2007). Considering that power, resistance and identities are unstable and contingent, postcolonial theory permits investigations into the nature and level of agency exercised by those who influence the development of critical thinking within science education in Trinidad and Tobago (Lunga, 2008). It allows me to be reflexive about its education system. Having trained as a teacher and a postgraduate student in the United Kingdom I have to be mindful of "othering one's own world" (Fuchs 1993, p. 108) and ensure that analysis is viewed concurrently as an insider and outsider (Kincheloe & McLaren, 2005).

Trinidad and Tobago's colonial and postcolonial history has been characterized by the maintenance of elitist systems and resistance to such systems (Dudley, 2007). This has led to periods of significant changes such as the abolition of the slave trade, the cessation of indentured labour and the coming of independence in 1962. At these times, the people's dreams of emancipation and the creation of a just society seemed at hand. However, to this day, Trinidad and Tobago's economic arrangements support a capitalist system where there continues to be issues of an elitist education system, gender and race inequality, a questionable respect for all things 'Euro-' or 'United States of America (USA)-' centric and a reluctance to challenge the status quo in order to create a truly democratic society. According to Paulo Freire "It would be naive to expect the dominant classes to develop a type of education which would enable subordinate classes to perceive social injustices critically" (Freire, 1985, p. 102). Walter Rodney (1973) points out that colonial school systems were designed to support administrative structures and private firms owned by Europeans, not to give students confidence and pride. The agenda was to instill a sense of deference towards all that was European and capitalist.

After the emancipation of the slaves in 1838, a black middle class emerged in Trinidad mainly through education and ability. Schooling was seen by the black working and middle classes as the main opportunity for mobility. This did not come easily as it was necessary to overcome the hostility to mass education. This hostility was based on the fear that the educated or semi-educated would decline to perform at their assigned class roles (Brereton, 1972). There was, however, some support for free education: "in lieu of the unintelligent and unskillful hands we are constrained to employ at present ... we shall then have to deal with intelligent and skillful agents" (De Verteuil, 1884, p. 386). The Roman Catholic and Anglican churches through their missionary activities and major involvement in education maintained the social relations of colonialism and by extension those of capitalism. Meekness, compliance and acceptance were encouraged and their influence resulted in alienating the people from their past and their acculturation into Euro-centric cultures (Mugambi, 1996). These churches gave relatively little support to the indentured, non-English speaking Hindu and Muslim East Indian population which arrived after emancipation as

they saw them as requiring special provision. The Canadian Presbyterian Mission, between 1868 and 1902, focused on Indian rural communities providing social services, the Christian doctrine and education. The Mission had a monopoly on Indian Education (Roopnarine, 2011).

The rural-urban movement of these Indians was relatively small when compared to those who remained on the estates and village settlements. The Indians who remained stationary felt uncomfortable leaving their rural base to deal with the challenges of urban life. It has been postulated that this was because they could not see ‘integrating connections’ with established urban communities and so imagined that it would be difficult to develop relationships (Taylor, 2012). They feared living in anonymity, economic marginality and political exclusion in urban areas. Some Indians were simply reluctant to live and socialize with urban Creoles. This behaviour is believed to have been due to Indians bringing with them a firm, uncompromising social structure, which did not allow interracial mixing and supported the colonial policy of divide and rule (Roopnarine, 2011). The Canadian Presbyterian Mission is credited with Indian integration, in so much as they provided the means for upward social mobility for many Indians. Other Indians made it from indentureship to the middle class over via business success (Ramsaran, 1993).

The upward mobility of thousands of blacks, coloured and Indians through education after emancipation resulted in a Trinidad and Tobago society that did not stagnate. It was increasingly more stratified in terms of economic class, and the racial and cultural divide between the Indians and the rest of the non-white community persisted. The leadership and challenge of the black premier Dr Eric Williams in the 1950s was significant in that, for the first time in Trinidad and Tobago, the black middle class gained control of the legislature. Education had modified the plural society making it less unequal, but still racist (Brathwaite, 1953).

Critical race theory (CRT) explains how racism permeates social systems. CRT sees the more understated and hidden processes of power as having adverse effects on black people (Gillborn, 2006). Goswami (2012) comments on the scarcity of critical race analysis in postcolonial

frameworks, which is surprising as modern systems of colonialism highlight race as a social reality. Critical race theorists have tended to focus on race in the United States rather than the broader postcolonial world and postcolonial theorists have, in the main, marginalized race and focused on overseas European empires. A basic insight of CRT is that racism is normal, not peculiar and because it is an integral characteristic of societies, it looks ordinary and natural to persons in the culture (Delgado & Stefancic, 2000). The term 'racism' is used not only to describe crude, obvious acts of racial discrimination but also in connection with the more subtle and hidden operations of power that have the effect of disadvantaging one or more minority ethnic groups (Gillborn, 2006). It is believed that CRT, like other critical theories, can help to explain how schools assist in maintaining the race relationships that exist in society as it is used to explore varying components of the education system, including policy and practice, educational leadership, curriculum and instruction and student perspectives. As explained by McLaren (2007), critical theory frameworks provide an alternative approach to understanding race, class and gender by allowing the challenge of heavily positivist, atheoretical, apolitical, and purportedly value-neutral research and theory.

Khan (2004) is of the opinion that race is marginalized in popular discourse in Trinidad and Tobago with racism being seen as an issue raised only within politics and having no basis in reality. The widespread perception is that all citizens live happily together. Rampersad (2012), referencing Bonilla-Silva and Dietrich (2008) and Coppin (1997) discusses the lack of literature based on race and skin colour originating from Trinidad and how this supports an outlook in which those who raise race issues are seen as racist. Coppin and Olsen (1998) have shown that formal education has provided other ethnic groups, such as white, Syrian/Lebanese, Chinese, mixed and other non-blacks, with the greatest payback in terms of progress within the labour market. At the bottom remained the bulk of the black and Indian population. Rampersad (2012) explains how the head-in-the-sand attitude to race in Trinidad has resulted in official statistics that do not provide detailed measures of racialised patterns. He points to the work of Coppin (1997, 2000), Coppin and Olsen (1998) and Jules (1994) who expose multiple layers of discrimination and inequality in

the workforce and education in Trinidad, involving discrimination based on both race and skin colour.

The value of a secondary school education was obvious in Trinidad and Tobago even before independence. Secondary education was seen to be different from technical or craft training as it put in place the means for the intellectual elite to have an education that would eventually lead to University and entrance to one of the learned professions (GORTT, 1947). Places were restricted to a privileged few before the 1960s but secondary schooling continued to be in great demand across the wider population (Campbell, 1996, 1997). The high demand and restricted number of places meant that a method of selection was needed (De Lisle, 2012). In the post-independence period, the demand for secondary education increased, probably driven by the arguments by then premier, Eric Williams, whose party won the 1961 election on a platform of secondary education for all – “to educate is to emancipate” (Joseph, 2008, p. 295). There was the yearning to follow other prominent persons; and the acceptance that schooling was the way to social mobility (Alleyne, 1996; Brereton, 2007). As part of the colonial legacy, secondary school entrance examination and placement systems still function as gatekeepers because they determine access to what was once considered a cherished pathway. The examinations resulted in a high stakes selection process early on in a child’s schooling career. Just after independence secondary school entrance examinations served to decide selection into secondary school but with eventual universal access, the role shifted towards placement into different types of secondary schools (De Lisle, 2012).

By the 1970s, despite the People’s National Movement (PNM) providing increased access to education, institutionalized racism remained. The Black Power movement headed by the organization National Joint Action Committee (NJAC) was formed in 1969. In addition to NJAC’s demands for the end of racial discrimination, the group also raised its voice against the exploitation by foreign capital and the local mostly white business class and the dominant cultural ideology, supported by government, the churches, the media and the education system which respected elements of European culture whilst denigrating those of Indian and African origin

(Pasley, 2013). What is interesting here is that, encouraged by NJAC, secondary school students expressed their feelings and took action to bring about change. They participated in mass demonstrations and challenged the education system to which they were subjected. They brought out their own journal, 'The Voice of Revolutionary Students', highlighting matters in schools, scrutinizing the education system and political concerns of the society at large (Kambon, 1988). One of the issues stressed by students and youth was the insufficiencies of curricula in schools. It was felt that the existing curriculum destroyed the souls of black people. Demands were made for teaching more Caribbean literature and history and more Afro-Indian studies. Student unrest led to a four-day conference chaired by the Prime Minister, Dr Eric Williams himself. Student delegates were admitted and allowed to give their opinions on the education system. When requested changes were made, complications arose with deficiencies in textbooks to meet the needs of the new alignment of the curriculum. It was also recognized that a new approach to examinations was necessary. The Caribbean Examination Council (CXC) in 1979 prepared the first examinations to replace the external examination conducted by the Cambridge Syndicate and the University of London through the General Certificate in Education (GCE) programmes (Campbell, 1997). Lewis (2007) remarked that CXC embodied real evidence that Trinidad and Tobago was prepared to withdraw from the received colonial model. However, he emphasized that breaking away from inherited epistemologies and hardened habits was not a simple exercise.

The education system inherited from British colonial rule was prominently elitist and examination-oriented, intended to screen, segregate and retain students based on perceived meritocracy, as demarcated only by performance in public examinations. The major characteristics of this system consist of segregated schools and entrenched and embedded institutional practices and philosophies which support academic tracking, streaming and setting. Despite the government's stated commitment to a seamless system, the legitimacy of a discriminating system stayed high among the public, with persistent concern for the fate of 'the top 20% of the ability group' (De Lisle et al., 2010).

1.3 Politics and education (agenda setting)

In the elections of 1956 the PNM's electoral catchwords were 'nationalism and democracy'. It has been recorded that following their victory at the polls, their leader, Dr Eric Williams, said that the PNM was not socialist nor did it believe in nationalization (MacDonald, 1986). Green-Pedersen and Wilkerson (2006) point out that in agenda setting some issues may be politically attractive with regard to vote seeking. Even as Williams clashed with the United States (U.S.) government over the leasing of Chaguaramas in 1959 as a U.S. base (a new foreign military presence on the island), which he envisioned as the seat of the West Indies Federation, he was mindful that U.S. capital and goodwill underpinned the islands' economy. The United Kingdom's ability to maintain satisfactory rates of investment in its overseas dependencies was seen as waning (Williams, 1969). The old-style imperial policy of shielding the empire for metropolitan investment had disintegrated as U.S. capital, alongside superior political and military strength, penetrated the region. Once it became clear that the U.S. had recognized Port-of-Spain's right to negotiate the base issue, the PNM began to move to the right. The anti-imperialist rhetoric that had characterized PNM speeches and publications disappeared (MacDonald, 1986). Being the party leading a new democracy it may have been important to be seen as an international team player committed to political and economic liberalization in order to gain international support (Mansfield & Pevehouse, 2006).

The PNM inherited an economy based mainly on oil and sugar under the control of foreigners. The new, growing sector, regarded as the key to economic development, was manufacturing, based on a policy of 'industrialization by invitation' under the Aid to Pioneer Industries Ordinance of 1950. The PNM completely accepted this structure of economy, and the philosophy of development on which it was based. Its thinking equated industrialization with economic development. It was believed that industrialization could be achieved rapidly by relying on foreign capital, foreign technology and foreign entrepreneurship. All the government needed to do was to seduce North American and European capitalists with generous incentives, especially tax holidays, and to provide adequate infrastructure for their industries (Kambon, 1988).

This situation influenced the formal education planning introduced in the 1950s. Education was seen as a panacea for development. Development of human resources became central to the rhetoric of educational reform and expansion (London, 1997). Jules (2010) claims that in order to allow access to higher levels of education there was an expansion of the education system. At all stages of national development, education provided the human resource scaffolding which enabled the modernization drive. Universal primary education contributed to moving Trinidad and Tobago towards independence and away from a Plantation Economy to more inclusive modes of production. Jules (2010) explains that in his view universal secondary education eased the country towards a service economy and universal tertiary education would allow full participation in the information economy.

Payne (2004) suggests that all countries pursue developmental strategies that have an external dimension in that they have to reach outward in order to seek advantage and secure their interests and position. As a result, they interact with other countries that are working to the same dynamic. The outcome is a complex global politics of development which takes into account the competing strategies of the different states. Carnoy (1999) argues that globalization has an indirect influence on education. The process is a complex one in which interactions between global and local agents lead to global forces being translated into indigenous realities. Supranational organizations such as the World Bank, the Organisation for Economic Cooperation and Development (OECD) and the World Trade Organisation (WTO), transnational corporations, nation states and local political, economic and educational elites have been recognized as intermediaries in the globalization process. Through various instruments such as borrowing, disseminating, standardizing and interdependence there is the swift dispersal of models and practices across the globe. Golding and Harris (1997) believe that in this process the nation state's political power is increased because greater interdependence and interconnections allows for shared appreciation and this increases the state's ability to manage internal and external difficulties. Others recognize that globalization has weakened the nation state in that its cultural and economic separation is no longer maintained, leading one to believe that the national market will end as the main stage for economic activities since the national state has little, if any, control over capital markets (Marginson, 1999).

Niyakan-Safy (2004), on the other hand, highlights the economic growth in Trinidad and Tobago, which she attributes to globalization. From 1999 to 2004 the growth rates averaged between 3% and 4% (Niyakan-Safy, 2004), and exports doubled to 6.4 billion United States Dollars (USD) (National Training Agency, 2006). She is convinced that globalization is not simply a resurgence of neoclassical economics and expresses the view that the policy responses of some countries have been inadequate to deal with the challenges of the process; she underlines Lloyd Best's statement: "We rationalize in terms of islands small and open. However, many small countries show that what is decisive are not God-given size and resources but human agency and business management" (Best, 1998, in Niyakan-Safy, 2004, p. 117).

Dr Bhoendradatt Tewarie, as pro-vice-chancellor of the St Augustine campus of the University of the West Indies, in 2002 pointed out that educational and political leaders in the Caribbean were just coming to the realization of the importance of developing human resources so that they could take advantage of the globalization process. According to him education is vital and higher education had to concentrate on this aspect if Caribbean countries were to match the rate of development necessary for reaping the benefits of globalization (Maharaj, 2002). Crossley et al. (2009) noted that small island states see tertiary education as imperative as they broaden the nature of their economies to cope with the growth of the knowledge economy and service-based market. They assert that knowledge economies depend on highly educated people to innovate, collaborate, research and adapt within a multifaceted and complicated world. Science and technology, with investment in higher education and building research capabilities, therefore now feature in most educational strategy papers of Commonwealth small states. The nature of the human capital required in this process has demanded a great deal from economic and educational structures (Cogburn & Adeya, 2001). Changes in the economy and in the nature of work have made educational reform mandatory (Miller, 1996; OECD, 2007).

The United Nations (UN) Millennium Declaration was adopted by all of the 189 UN Member States in 2000. Out of this declaration came the Millennium Development Goals. The then PNM

government policy agenda to transform Trinidad and Tobago into developed country status by the year 2020, as outlined in the Social and Economic Policy Framework 2003-2005, was in keeping with these goals (GoRTT, 2002). The government of the day's vision of developed country status was described as:

Economic growth will be inclusive and socially responsive to the needs of all segments of the society. It will be based on full participation of the population and promote wealth creation among all income groups.

Trinidad and Tobago will be a society of creative thinkers, innovators and entrepreneurs engaged in a process of lifelong learning. All citizens, particularly, women, youth, the poor, the elderly and persons with disabilities will be given equal opportunities for personal growth, self-expression and active participation in their own development. ...

... a high quality of life based on the highest standards of modern human development ... The society will be cohesive and caring, with strong spiritual and ethical values and a deep sense of nationalism. It will celebrate the diversity of its people and function on the principles of democracy, human rights and social justice ... (GoRTT, 2002, p. 3)

The Vision 2020 plan outlined the following goals for creating an innovative people in its thrust toward development:

1. Become well known for excellence in innovation
2. To create a seamless self-renewing, high quality education system
3. To produce a highly skilled work force to drive innovation and production
4. To harness cultural elements to inspire innovation and creativity. (GoRTT, 2006, p. 1)

The People's Partnership came to power in 2010 and as described earlier in this chapter expressed similar aspirations for the people of Trinidad and Tobago. The 2012-13 data on global competitiveness ranked the quality of education in Trinidad and Tobago 40th out of 144 countries. However, secondary enrolment was ranked at 66th and tertiary enrolment 106th. The quality of mathematics and science education was ranked at 35th (World Economic Forum, 2012). From October 2011 Trinidad and Tobago was removed from the Development Assistance Committee list

of the OECD as it had exceeded the high-income threshold for three consecutive years at the time of the review (OECD, 2013). The media informed the citizens that Trinidad and Tobago was now a developed country according to the OECD with the headline “Trinidad and Tobago now considered a developed country” (Guardian Media, 2011). Nevertheless, according to the International Monetary Fund (IMF) and World Bank data, Trinidad and Tobago remains a developing country (IMF, 2013).

Even with the aforementioned statistics, the Trinidad and Tobago education system has, since Independence, been seen as producing:

- a high emphasis on examinations which has resulted in competitiveness and academic success being prioritized, although the expansion of the system was supposed to provide more technically skilled graduates
- students with little academic success who behave poorly
- student disenchantment coupled with high failure rates at CXC examinations
- secondary and tertiary level graduates who are subject to low absorption rates in the labour force when seeking employment
- graduates unwilling to create their own jobs (De Lisle et al., 2010).

In elitist systems, quality is measured by the ability of the system to yield a few high quality scholars. The aim is not to educate everyone in basic skills and critical thinking but substantial assets are provided, with the best teachers, best schools and the best resources, to a minority. In elitist systems, the quality of schools may vary sharply, depending upon the clients (Wälde, 2000). Practices within the Trinidad and Tobago schooling system have shown an orientation which likens education to mainly academic achievements, tracked by the number and level of certificates that an individual has achieved. This approach is further reinforced by decision makers who:

- have consistently rewarded these students publicly

- position parents and teachers to encourage young people to focus on academic attainment even if they prefer non-academic subjects
- cause large numbers of students to feel marginalized and so increase the incidents of behavioural problems within schools
- evaluate the system's performance in terms of size of investments, numbers of schools built and places provided, but at the same time pay little attention to return on investment.

Few equity policies have been developed in Trinidad and Tobago's schools; of those initiated, many have been implemented with little conformity with the spirit of the original plans. There has been poor implementation in inclusive education, where current structures lag behind those proposed in the 1993-2003 White Paper (Ministry of Education, Republic of Trinidad and Tobago, 1993; Conrad et al., 2010). There are no policies for compensatory education and accountability systems are still in their infancy. This has resulted in high variability in school performance. The segregation architecture is supported by a system of beliefs and expectations among all clients, which further limits performance in 'low ability' schools (De Lisle et al., 2010). The challenge to the development of equity policy can be appreciated by noting Dr Selwyn Cudjoe describe a United National Congress (UNC) member's response to hearing that one of the learning institutions had intentions to 'establish a targeted recruitment programme for male Trinidad age 17-24, especially Afro-Trinidadian males'. The member objected as he felt that this policy could result in racism to others and he threatened to take the matter to international organisations (Cudjoe, 2003).

In this twin island state education is compulsory for children up to age 12 (The Government of the Republic of Trinidad and Tobago (GoRTT), 2010); however, since 16 is the minimum age for employment, there is an expectation that most of the nation's youth will be enrolled in the school system up to the age of 15 (Statistical Digest of the Education System, 2003). In September 2013, 18,039 pupils entered 196 secondary schools (134 public and 62 private) (Doughty, 2013). Relatively high school participation rates have been observed across the age ranges with 87% in

the 5-11 age group, 82% for ages 12-14 and 68% for 15-16 year olds (GoRTT, 2003). School participation in terms of the net attendance ratio ²has also been quite high when one considers the law does not compel students to attend school after the age of 12. Between 2007 and 2011 this ratio was 84% for males and 90% for females for children aged between 12 and 16 (United Nations Children's Fund (UNICEF), 2012).

Despite the excellent performance seen in a relatively small cluster of students, as measured in the 2013 examinations by the 419 scholarship winners coming from 31 schools, with 406 of these awards coming from 17 of the most prestigious schools, this outcome concerns administrators of education. Other groups of students are seen to demonstrate low levels of literacy. According to Programme for International Student Assessment (PISA) 2009, of the high-income economies with per capita Gross Domestic Product (GDP) more than 20,000 (USD), converted using purchasing power parity), Trinidad and Tobago had the lowest reading performance, even lower than some low-income economies such as Chile, Poland and Shanghai, China (OECD, 2012). 416 on the overall reading score was statistically below the OECD average of 493. The score for mathematics was 414 compared with an OECD average of 496 and 410 for science as opposed to the OECD average of 501 (OECD, 2010).

Between 2002 and 2012, the CXC reported a decline in the pass rates in English from 64.4% (United Nations Educational, Scientific and Cultural Organisation (UNESCO), 2010) to 42% (CXC, 2012) and a drop from 51.1% (UNESCO, 2010) to 31% (CXC, 2012) at the Caribbean Secondary Examination Certificate (CSEC) examinations. In more recent times, the June 2013 CSEC results show a 57% pass rate in English and 35% in Mathematics (Newsday, 2013). The Minister of Education explained that:

we are experiencing a tremendous amount of dysfunctionality, particularly in the secondary schools ... Last year there were approximately 2,200 students who were suspended from schools for a seven-day period [maximum that can be authorized by a school principal]. Subsequently to

² The Net Attendance Ratio is the number of pupils in the official age group for a given level of education who attend school in that level, expressed as a percentage of the total population in that age group.

that approximately 700 of these had to have extended suspensions ... There are students who have participated in major criminal activities and who are before the courts of law, and therefore they cannot continue in the school. (Goopeesingh, 2013a, lines 10-16)

Several studies have described relative educational underachievement of males in Trinidad and Tobago and socio-economic and ethnic imbalances with respect to attainment (Worrell & Noguera, 2011). Of the 300 inmates at the three juvenile offenders facilities where the age group spans under 14 to 19 years, 63% of the population were between 14 and 17 with 83% males and 16.3% female. 61% were of African descent as compared to 12% of East Indian descent (Rampersad et al., 2013). Using World Health Organisation (WHO) population data from the Pan American Health Organisation (PAHO) 2012 Report on Health in the Americas, male Afro-Trinidadian youth are seen to be at greatest risk when the above mentioned figures on imprisoned youth are viewed against a background of an ethnically diverse population, with 40% East Indians descent, 37% of African descent, 21% of mixed race, and 2% of other racial groups descending from China, European and the Middle Eastern and a one-to-one male-to-female ratio.

Aspirations for a seamless education system, as outlined in Vision 2020, indicate that the system would be one that is integrated and efficient and able to reduce barriers to learning while producing large numbers of well-trained graduates (McCabe, 2001). This view of education requires the emergence of a set of values where everyone is seen as educable and where employers and educators work to reduce the negative impact of elitism on the levels of motivation in many of Trinidad and Tobago's schools, particularly those which are not seen as 'academic' (Olson, 1997).

A change in the orientation of education and school science which allows students and teachers to contribute to a more sustainable and just society is advocated by Bencze and Carter (2011). They propose that students be encouraged to take sociopolitical action to tackle potential personal, social and environmental challenges that are linked to socio-scientific issues.

CHAPTER 2: Literature review – critical thinking skills for social transformation

2.1 Critical thinking in secondary science in Trinidad and Tobago

I will be considering critical thinking not only as higher order thinking but also as thinking that leads to social transformation, emancipation and social justice, in keeping with the approach of writers such as Peter McLaren (2007). As critical thinkers individuals will be sensitive to their political settings and have the ability to recognise, analyse and act on issues raised in science lessons which affect their ability to live in a just and fair society. This slant on the definition of the term critical thinking will be highlighted as it speaks to an approach to pedagogy which may address societal change, resulting in the progress of all people as opposed to that of the relatively few at the expense of the majority. This can be achieved through the deliberate inclusion of social and political contexts in educational activities involving logic, analysis, synthesis and evaluation. I believe that this approach to critical thinking has the potential to assist in addressing the ambivalence to scholastic effort, lack of motivation and ambition, disruptive behaviour, increasing elitism, widening of gaps in earning potential and possible links with deviant or criminal activity which have all been raised as issues plaguing the progress of young people in Trinidad and Tobago (GoRTT, 2003).

My impression of science education at Bishop Anstey fitted that of King and Ahlquist (1990, p. 3), in that I felt that “the teaching of science remains largely uninspired and conservative”. The description of science teaching outlined by Knapp et al. (1987) resonated with what I faced, that is:

a heavy emphasis on encyclopaedic coverage of descriptive and factual information, too little attention to problem-solving and critical thinking skills, little connection of abstract concepts with everyday experience, and inadequate opportunities for active experiential learning ... Abstract concepts are taught in a vacuum with little connection to the student’s personal interests or larger societal issues. Courses are centred on the textbook and classroom recitations ... and little advantage is being taken of the new technologies. (Knapp et al., 1987, p. 7)

Form 3 students in Trinidad and Tobago make subject choices for the CSEC examinations. At this point a considerable number of them express the desire to be doctors and engineers as these are seen as highly prestigious careers. For the majority of students, however, science is viewed as irrelevant and so few are motivated to develop as scientists. My concern is that this lack of investment may lead to a population of ill-equipped citizens who are unable to make intelligent choices about science and technology. If Trinidad and Tobago is to realize an education system that contributes to:

... the growth and development of civic society ... poverty eradication, equity, food production, wellness, the management of the environment, science and technology and the building of learning culture (Bernard, 2011, para. 2)

consideration has to be given to reconstructing the curriculum and pedagogic styles to which our students are exposed.

King and Ahlquist (1990) believe that science education can be transformed from objective, neutral, inaccessible experience with abstract 'truths' to an experience that is more relevant, contextual and participatory through a critical pedagogy that:

... opposes education as domination, views knowledge and learning as constructed by student and teacher together, and whose goal is personal and social emancipation and empowerment. (King & Ahlquist, 1990, p. 4)

Griffith and Nguyen (2006) stress that even with our focus on the acquisition of academic skills students need to cultivate a sense of value if they are to make the best use of what they have learned. The highest standards in the cognitive domain have to be complemented by the development of skills in the affective domain. This is essential in the development of critical thinking. Emotions and relationships inside and outside the classroom can greatly affect the learning process. Before starting this study, my observations led me to believe that the delivery of the curriculum in schools in Trinidad and Tobago was not organized in order to accomplish this

all-encompassing learning. Democratic and critical pedagogies in science can as they support classroom practices with the end goals being both social justice and a more democratic society (Edwards, 2010).

2.2 Critical theories

Bencze (2010) argues that following the social spending that followed the Great Depression and World War II, economic liberalism, a crucial form of capitalism, re-emerged as neoliberalism. In the neoliberal project the global elite are seen to take steps to maintain their power status through the preservation of traditional social interactions and stratification. This ideology has led profit-orientated governments to implement policies with less emphasis on the public good and more on individual responsibility.

Wrigley (2007) asserts that neoliberalisation in a global capitalist economy continues to require workers who possess intelligence and skills necessary to accrue profit for their employers but at the same time must remain naïve to the point where they do not have a true appreciation of the factors which influence their place in the world. Liberal theorists claim that public education allows for individual progress in terms of development and social mobility. They believe that such education gives political and economic power to the disadvantaged and the disposed. On the other hand, radical educators and a number of sociologists argue that the central purpose of public schooling is to reproduce the dominant ideology and its forms of knowledge, and to ensure the skills necessary to reproduce the social division of labour are shared amongst the population through 'educating' the youth (Apple, 2006). Young people are enculturated to see social interactions in terms of economic logic and nonmaterial basics, like education, as commodities (Bencze, 2010). Curricula and school culture are linked to the power of the ruling class who determine that its values are universal and beyond censure with the result that there is little opportunity for critical learning and social transformation (Aronowitz & Giroux, 1993).

In the knowledge economy the focus is on the philosophy and education that support development and marketing for recurring consumption (Lash, 2002). Science education sorts students into labourers and ‘thinkers and knowledge creators’, with the latter being required in smaller numbers. It is believed that the neoliberal agenda allows for a process whereby success in school science is more easily accomplished by students from middle and upper middle social classes as the pedagogical methods, and required linguistic skills and academic abilities, such as being able to understand large volumes of abstract, decontextualized information, too often exclude other students. Learner-centred techniques used in science classroom activities where students are expected to make individual discoveries are also seen as being disadvantageous to those students who do not possess the necessary social capital, pre-requisite concepts and knowledge to manage these exercises well. School science may be seen as a tool for selecting those students seen as ‘fit’ to benefit from the traditional social order (Bencze, 2010).

Critical theory assists in understanding how social, political and economic factors largely outside of schools’ control influence many of the challenges that they face. Classrooms are viewed through the broader lens of social and political environments of structured inequalities where teachers may promote or challenge the nature of race, class and gender inequalities. Critical theorists have offered critical pedagogies of hope which consider the needs of disempowered students and encourage teachers to empower both themselves and their students (Giroux, 1981, 1988; McLaren, 1995). Critical pedagogy is designed to introduce schools to resisting practices that may influence interpretations so as to contest social norms and make problematic traditional views which determine acceptable behaviours (Lynn et al., 2006).

Wrigley (2007) acknowledges that there have always been agents, with a more democratic vision, who felt that schools should not simply be preparing young people for their subordinate role in a social hierarchy. There are educational organizations that have come to realize the importance of scientific literacy in developing a citizenry not only with the ability to analyze, synthesize and evaluate but also able to handle moral and ethical issues with an appreciation of their links to socio-scientific issues. The implementation of research findings that support this learning has

shown the development of socio-scientific reasoning skills among the learning that is normally expected from students in the science classroom (Bencze et al., 2012). However, Aronowitz and Giroux (1993) expressed the view that the survival of democracy is being threatened as students' ability to cross examine and communicate concepts is declining. They are of the opinion that for schools to fulfil their public and civic role they have to offer a democratic vision and share power with their communities.

Advanced skills and specialized knowledge in the Science, Technology, Engineering and Mathematics (STEM) fields are considered to be necessary for the 'knowledge society' created by the global economy. As governments compete for foreign capital, education for developing human capital is being stressed on a global scale (Clothey et al., 2010). The 'Science for All' project was started in the 1980s by UNESCO in an effort to realize a scientifically literate citizenry and workforce. This initiative has been recorded as the first drive to globalize science education. The following challenges have been recognized and persisted from the start:

- Science education is influenced by its social and political setting
- The science content on offer is not attractive to many students
- Teachers are challenged by the different attitudes and cultural expectations of learning of their students who come from multicultural and socioeconomically diverse populations
- Scientific terminology and the alternative use of everyday words pose barriers (Gough, 2011).

In Trinidad and Tobago the National Institute of Higher Education Research, Science and Technology (NIHERST)'s survey on public perceptions of science education reported that 55% of their 1595 respondents indicated little or no interest in science although 91% of them believed that scientific knowledge could improve one's ability to make decisions. 42% of the sample with little education attainment felt that the benefits of scientific development would accrue to only a few individuals. 73% of the respondents agreed that society should use expenditure for science on

more urgent activities. Only 3% indicated that they had participated in protest action or had complained about problems of a scientific nature although 87% said that it was important to take part in these issues (NIHERST, 2005).

In addressing these issues a learner-centred pedagogy has been endorsed as ‘quality education’ in several initiatives of major international bodies funded principally by western capitalist democracies (Gough, 2011). An example of this is seen in the *Education for All: The Quality Imperative* document produced by UNESCO (2004) which advocates a learner-centred approach. Tabulawa (2003) outlines the view that all pedagogies have a political base and so a learner-centred pedagogy is not apolitical. He makes the point that learner-centred pedagogies can allow for the inculcation of predispositions, social attitudes and habits of mind conducive to participation in a neoliberal market economy. Carter and Dediwalage (2010) believe that a learner-centred pedagogy reflects the Western liberal democratic establishments from which they are derived, alongside their neoliberal market values. They say that these values contribute to two roles; firstly, as an individual private economic consumer who needs to act autonomously, take personal responsibility and take on the management of his own affairs; the second role is that of a global worker for the knowledge economy. This second function requires that one has the ability to team work, communicate well, interrogate and innovate, be flexible and easily adapt as one competes for economic advantage. The United States Agency for International Development (USAID) recognizes that the implementation of a particular pedagogy, such as a student-centred approach, may not be successful if the cultural context in which the teachers’ and students’ work is not considered (USAID, 2006). The cultural aspects of science education are rarely ever considered. According to Harding (1993, p. 1) the best science education does little to allow students to understand that ‘nature-as-an-object-of knowledge’ is cultural. She feels that elitist science education is not inclined to allow students to systematically examine the social origins, traditions, meanings, practices, institutions, technologies, uses and consequences of the sciences so that they have an understanding and appreciation of how they have influenced scientific research. She goes on to explain that in this process the knowledge claims of non-Western cultures have been denigrated and silenced while those of the West are portrayed as progressive, rational and

civilized. She suggests that it is important to analyse the Western agendas if a more democratic science is to be achieved. In order to engage all students, science education will need to take on board a critique of traditional science from a range of perspectives (Harding, 1993). McLaren claims that school science reform is allied to the priorities of the marketplace and not to the aims of his preference of a socialist democratic society. He feels that science education is focused on providing students with the science that they need to fit into society and is not about educating them on how they might create, practise and critique science to work with and transform society. He asserts that as long as the present relationship between capital and science education is uncritically accepted science educators will be linked to discourses and social habits that lead to needless human suffering. McLaren insists that critical pedagogy is necessary so that educators and students can “speak truth to power” for social justice (Calabrese Barton, 2001, p. 229).

The concept of critical pedagogy is based in the neo-Marxian literature on Critical Theory which arose as a specific approach to the study of society emanating from the ‘Frankfurt School’. Critical Theory is defined as a form of sociological theory that recognizes society as evolving historically and undertakes a deliberate engagement with the problems of society and processes of social transformation (Morrow, 1994). According to McLaren (2007), critical educators subscribe to theories that are dialectical in that these theories acknowledge that problems in society are as a result of the interactive milieu between the individual and society as opposed to isolated events of individuals or deficiencies of the social structure alone.

Critical theorists view knowledge as historical and socially constructed. Critical pedagogy questions how and why knowledge gets constructed in the manner that it is and how and why some constructions of reality are seen as valid and celebrated by the dominant culture while others are not. It examines the social function of knowledge and whose interests it serves, resulting in an understanding of the relationship between power and knowledge (McLaren, 2007). Emancipatory knowledge is of interest to critical educators as it assists in understanding how social relationships are biased and controlled by relations of power and privilege. Emancipatory knowing is thought to make social and structural change a reality because people can recognize social and political

problems of injustice or inequity, realize that situations can be improved and bring together complex constituents of experience and context in order to change a situation that improve lives. It allows for the realization of ways in which problematic conditions come together, reproduce and stay in place to maintain a status quo that is unjust for some groups within society. This realization leads to imagining a fairer and more equitable condition, to action to change the situation, and continuous cognizance of injustices that endure even as change is taking place (Chinn & Kramer, 2008). This relentless reflection and action to transform the world is praxis and, according to Freire (1993, p. 51), is necessary if one is to remove the force of oppression. He explains that “one must emerge from it [oppression] and turn upon it”.

Burbules and Berk (1999) compare critical thinking and critical pedagogy. They explain that in the critical thinking tradition being critical requires one to be more astute in seeing faulty arguments, rushed generalizations, declarations with insufficient evidence, truth claims based on unreliable data and vague concepts. The basic problem that critical thinkers observe is irrational, illogical and unexamined living. The main instruments of critical thinking are the skills of formal and informal logic, theoretical examination and epistemology. On the other hand, the critical pedagogy tradition investigates particular beliefs as part of a structure of belief and action and having cumulative effects within the society’s power systems, as opposed to evaluating these beliefs for levels of truth. It first questions who benefits from the systems of belief and action, with its chief priority being one of social justice and the transformation of inequitable, undemocratic or oppressive establishment and social relations. The examination of truth may be used to illustrate how power effects happen, but not to determine Truth in a detached manner. McLaren (2007) expresses the view that the term ‘critical’ has been made apolitical via neoconservative and liberal discourse so that ‘critical thinking’ has been reduced to less potent, ‘thinking skills’. With these higher levels of cognitive abilities students are encouraged to thrive in the tough cut-throat world of existing social relations.

2.3 Significance of the study

Developing critical thinking skills in students is seen as valuable for a number of reasons. A thread can be seen as one tracks the objectives stated by government, industry, learning institutions, parents and students. The People's Partnership came into power in 2010. Pillar 1 of its manifesto – People-Centred Development – We Need Everyone and All Can Contribute claimed:

We commit to making human development a central thrust through the education system and through the creation of other infrastructure to support life-long learning, skills building ... and the building of a competitive economy. (The People's Partnership, 2010, p. 7)

When addressing their plans for education they described the desire to:

ensure that our young people ... possess critical thinking skills. We will embark on curriculum reform to address the needs of 21st century development and the labour market needs of the society and build ... a more participatory education strategy that is problem-based and dedicated to producing problem solvers and solution providers ... we will reform the curriculum at secondary level to ensure that the school environment is more conducive to learning, intellectual development, creativity and the development of critical thinking skills. (The People's Partnership, 2010, pp. 29-30)

According to Report V on Skills for improved productivity, employment growth and development at the International Labour Conference, 97th Session in 2008:

A low wage, low-skill, low-productivity development strategy is unsustainable in the long term and incompatible with poverty reduction. Investment in education and skills helps to “pivot” an economy towards higher value added activities and dynamic growth sectors. (International Labour Conference, 97th Session, 2008, p. viii)

The report explained that all countries that have succeeded in linking skills with productivity have focused their skills development policy to meet skills demand in terms of relevance and high quality skilled workers. An effort to ensure equality of opportunity in access to education and

work is made in order to meet the demand for training across all sectors. The employability of the citizenry and sustainable enterprise are supported by the ensuring availability and affordable training in key skills.

The aim of skills development policies is to enhance capabilities and knowledge systems within the economy and society which prompt and maintain a sustainable process of economic and social development. These countries are therefore seen to implement objectives based on a labour market perspective and on the strategic role of education and training in bringing about technological change, domestic and foreign investment, diversification and competitiveness (International Labour Conference, 97th Session, 2008).

The reason for the Government's focus on the development of critical thinking skills may be appreciated on examining the results of an enterprise survey of firms operating in Trinidad and Tobago in 2010 undertaken by The World Bank, designed to scrutinise the issues that may influence operational efficiency in Trinidad and Tobago. Most employers found that 'an inadequately educated work force' was the major obstacle they faced in operating in Trinidad and Tobago. Fifty percent of the firms found it difficult to obtain technical skills such as problem solving, while 48% found that potential employees lacked social skills (World Bank, 1995). The World Employment Report 2004-05 'Employment, Productivity and Poverty Reduction' concluded that most working poor wanted more productive work as opposed to more work if they were to escape poverty (International Labour Conference, 97th Session, 2008). Here productive work is taken to include all labour that is required to support the direct producers as defined by Cockshott and Zachariah (2006). Producers require critical thinkers.

Curriculum designers, universities and schools are organized in an effort to ensure that young people will find satisfying employment and employers be furnished with qualified workers. The purpose of the education system in Trinidad and Tobago can be seen as having as its major focus the provision of well qualified workers with the critical thinking skills needed for supporting economic development and competition within a global setting.

In the government's plan of action it highlighted one of its major goals of secondary school education as aiming to “develop skills of problem-solving, critical and creative thinking, decision making, valuing” (Melville-Myers, 2001, p. 11). These ambitions have permeated all levels of the education system so that in the school under investigation, St Francis College, describes its members as “... independent learners, who can think critically ...” in its handbook (St Francis College, n.d., p. 8). The Strategic Plan of the University of the West Indies (UWI) also describes its graduates as critical thinkers who:

... will be sought by national, regional and global employers. These graduates must be able to apply analytic thought and logical reasoning to a body of knowledge and to clarify the assumptions, reasoning and evidence of a specific issue and apply scientific principles. Key functions include generating alternative ideas, practices and solutions that are unique and effective, and exploring ways to confront complex and ambiguous problems and provide solutions. (UWI, 2012, p. 42)

This thesis may also shed light on challenges that present with the implementation of other policies within the education system as their success or failure may be subject to similar dynamics that arise when attempting to develop critical thinking skills in science in Trinidad and Tobago's youth.

2.4 The capacity of the Trinidad and Tobago education service

Before the concerted drive for universal secondary education in the Caribbean at the start of this millenium, teachers were trained to work with students who fell within a relatively narrow ability range. With universal secondary education, Leacock (2009) feels that the teacher education now required brings about a radical change for teachers as they:

- Cope with students with from increasingly more diverse social, economic and academic backgrounds
- Assist their students to develop literacy and numeracy skills alongside teaching the subject content of their area of expertise

- Diagnose students' weaknesses and strengths and plan lessons in which these are considered
- Use appropriate technology in their teaching.

George et al. (2003) observe that the pace of educational reform has increased globally and note that teachers have a major part to play in bringing about changes in the system. They explain that the reforms in Trinidad and Tobago's education system aim to cater for individual differences within a decentralized context as they attempt to equalize educational opportunity and increase equity in the structures, at the same time requiring schools to become more effective via autonomous management systems. According to Carter and Deliwala (2010), the neoliberal agenda has led nation states to use a combination of centralization and decentralization as a means of reducing cost. The state attempts to expand its education system at the same time taking steps to reduce cost, allowing for increased economic potential. They explain that decentralisation has brought about privatization, corporatization, increased accountability, internal competition and delegated responsibility with fewer restrictions on institutional infrastructures. These steps are intended to reduce inefficiencies in the system and offer greater choice, flexibility, competition, democracy, equity for all and high standards. Centralisation is seen in curricular and teacher reform where control may be brought to bear via curriculum prescription, standardized tests and permits the feedback of more information to central government agencies.

Data provided by Schoenfeld (2002) indicated that standards-based reforms work when curriculum, assessment and professional development are synchronized. This supports the neoliberal agenda, which holds schools responsible for improved student achievement (Porter, 1995). In Trinidad and Tobago student achievement is measured in terms of examination success and so teachers focus on those strategies that will bring about high percentages of examination passes and not necessarily more educated students. Teachers through teacher-centred methods focus on content and the dissemination of knowledge with little attention being paid to higher order skills (Melville-Myers, 2001).

As described by Bencze (2000), pedagogical approaches based on constructivist learning theories are encouraged but with teachers anxious to ensure that students have the information necessary for getting through their examinations they manage students' construction of knowledge through their judicious use of language, depreciating students' prior conceptions and curtailing their abilities to develop as independent critical thinkers. These coercive practices may interfere with students' learning about science, learning to work as scientists and learning science (Hodson, 1998). Students may have difficulty developing the skills necessary for selecting suitable problem-solving techniques in contexts that are important to them. Another concern is that students could become intellectually dependent and unable to evaluate knowledge claims autonomously (Munby, 1980). According to Hodson (2003), students may see themselves more as consumers of knowledge and less as producers of it. A steady diet of conclusions provided by teachers is thought to stifle students' desire to ask questions and to come to their own conclusions. It has been suggested that inundating young people with what could be considered 'consumer goods', in terms of what science and technology have achieved and what they can offer, serves to make them passive and less critical (Dobbin, 1998). Students in a democracy should be provided with the opportunity to construct their own knowledge and to grow in a manner that suits their needs, interests, aptitudes and viewpoints (Bencze, 2000).

Wrigley (2007) is of the opinion that the popular versions of 'School Improvement' and 'Leadership' in education reform have not resulted in transformation. These are meant to result in greater school effectiveness which is linked to the neo-liberal agenda, in which, instead of schools focusing on equipping all students to engage in critical analysis of their circumstances, schools continue to use traditional parameters, examination results, to determine whether they are making a difference in young people's lives. For example, MacBeath and Mortimore (2001) advocate the use of performance data to reveal inconsistencies at individual student level to highlight variations in the quality of teachers and departments. Wrigley (2007) feels that teachers and school administrators are expected to believe that this version of 'School Improvement' is a type of universal 'common sense' and that organizations like the World Bank reinforce this perception. The policy document, the 'White Paper' describes teachers as:

professionals who share and are guided in their operations by a set of systematic and incisive understandings, beliefs and values about education in general and its relationship to the development of the national community of Trinidad and Tobago. (Ministry of Education, 1993, p. xviii)

It was anticipated that the teachers in Trinidad and Tobago would “lead the reform process” (World Bank, 1995, p. 8). George et al. (2003) summarise the qualities and competencies required by the teachers involved in these reforms as:

- a willingness to participate fully in their own development and that of their students
- an understanding that the school is focused on inclusion of the community so as to enhance the developmental potential of all participants
- an appreciation of a culture of collaboration with all stakeholders in building the vision and mission of the school.

These same researchers found, through an investigation on teacher identity, that teacher identity was not fully congruent with the philosophy and purposes of the reforms being implemented in the system (George et al., 2003). Nalcaci’s (2012) research has shown that there is a significant relationship between the values of prospective social science teachers and their critical thinking skills. In teaching critical thinking skills the teacher is responsible for creating an environment that allows for the development of these skills. Teachers must not simply be individuals who do what they are told but rather be persons who use their personal values, critical thinking and decision making in supporting their students. In Mayo’s (1995) investigation into the critical approaches to education, where he describes the works of Lorenzo Milani and Paulo Freire, he makes the point they both agreed that an emancipatory and democratic education was more concerned with ‘being’ than with ‘having’. He says that they both agreed that there were no technical methods entailed in critical pedagogy and that they advocated that teachers be more concerned with how one should be in order to teach as opposed to what one has to do.

Aronowitz and Giroux (1993) discuss the position of teachers and administrators in modern schooling. They argue that it is necessary to view teachers as intellectuals and engage their

contribution in finding solutions to the issues facing education. They lament that teachers now take on the role of low-level employees and that their experience, intelligence and judgment are rarely considered as they implement the plans of 'experts' in the upper echelons of the educational bureaucracy. They suggest that teachers are not always seen as creative and imaginative thinkers who can critically evaluate the aims of educational discourse and practice.

This perception of teachers, combined with the an ahistorical and depoliticized view of school governance and policy derived from management and organizational theory, makes for schools to be seen neither as environments where there are tussles over different orders of representation nor as places that exemplify particular configurations of power that determine life in the classroom (Aronowitz & Giroux, 1993). Calabrese Barton (2001) believes that the implementation of standards, assessment of students and cross-national comparison of students does not take into account the way in which schooling and the organization and purpose of school science are set up to back capitalist goals. She notes McLaren's insistence that a country's wealth should be judged, instead, by the extent to which forms of oppression are eradicated. According to Freire (1993) this can be brought about as an act of love through dialogue that is a commitment to others, in a name: critical pedagogy.

Having completed my Institution Focus Study (Brewster, 2011), I am of the opinion that the nature of classroom relationships and the pedagogical methods employed are strongly influenced by Trinidad and Tobago's colonial history and the resulting cultural beliefs. Teachers' experiences and training are significant alongside the curriculum. These are all influenced by the dominant values, which from my preliminary observations include respect for and obedience to those in authority, strict observation of formalities, an aversion to risk taking and adherence to religious dicta. Critical theorists such as Giroux (1997), Lankshear and McLaren (1993) and Macedo (1994) hold the view that dominant values determine school culture in general and what is taught in particular. The curriculum is one means by which the 'superior' culture is preserved, as mainstream school officials place premium values on their understandings while discounting knowledge held by other social groups. Critical theory, informed by discourses such as

postmodernism will facilitate my attempts to examine the assimilated experiences of those involved in science teaching and learning and expose the way in which cultivated philosophies influence the way in which science teaching is organised (Kincheloe & McLaren, 2005). In addition, critical theory advances the notion of an elucidative and normative theory which is dedicated to emancipation from all types of oppression, to facilitate freedom, happiness, and a cogent ordering of society. Critical theory pursues a link between empirical analysis of the modern world and social movements which try to transform society in progressive ways (Kellner, 1990).

This study aims to investigate the extent to which the education system of Trinidad and Tobago supports the development of critical thinking in the area of science. Training in science lends itself to the development of critical thinking as scientific methods address areas of problem solving, logical analysis, synthesis and evaluation, allowing for the development of higher order skills. However, writers such as McLaren and Barton have been concerned that the traditional presentation of science hinders students' abilities to see themselves as agents for social transformation. In a conversation with Calabrese Barton, McLaren argued that the relationship between capitalism and urban education has led to schooling practices that favour economic control by elite classes, that the relationship between capitalism and science has led to science whose purposes and goals are about profitability rather than the betterment of the global condition and that the marriages between capitalism and education and capitalism and science have created a foundation for science education that emphasizes cooperate values at the expense of social justice and human dignity (Calabrese Barton, 2001).

The Secondary Education Modernization Programme (SEMP), Secondary School Curriculum for the lower year groups (Forms 1 – 3), has as one of its 'Essential Learning Outcomes' 'Citizenship' where students "determine the principles and actions that characterize a just, peaceful, pluralistic, and democratic society, and act accordingly" (GoRTT, 2008, p. 9), whereas the more advanced CSEC Biology syllabus requires students to "acknowledge the social and economic implications of Biology" (CXC, 2013, p. 2).

The intention of this study is to elucidate the extent to which the ‘received curriculum’ does allow young people in a school in Trinidad and Tobago to develop criticality which, in addition to considering students’ analytical and logical thinking skills, includes a dispositional component in which transparency, accuracy and fair-mindedness in institutional contexts and social relations are significant (Burbules & Berk, 1999). The lessons learned from this thesis may apply to other schools within these islands and other countries in the region that have a similar postcolonial experience.

In investigating the effects of the ‘received curriculum’ it will be necessary to determine the nature of this curriculum and what regulates how it evolves, that is, what the superstructures are that impact the ‘science diet’ to which students are exposed. To me, these superstructures influence the schooling context and consist of the prevailing philosophy of education held by government and school officials, employers, parents and students, the stated curriculum, teacher capacity and resourcing.

2.5 Vision

The science provision in Trinidad and Tobago must be organised so that it contributes to a socially just and equitable society. Our students and teachers should not be seen as:

objects to be manipulated or to be ‘freed’ to follow the dictates of the ‘invisible hand’ of the market, but as co-responsible subjects involved in the process of democratically deliberating over the end and means of all their institutions. (Apple, 2000, p. 48)

Western science has supported human development as it provides a powerful means for understanding our world. However, this science paradigm is caught up in the progress of global capital and contributes to hegemonic interests in varying forms of imperialism. Any change must build on the strengths of the present system in being intentional and unambiguous in its epistemology and methodology (Carter, 2008). Teachers should be recognised as intellectuals

whose ideas and opinions have major significance and not just as technical workers in a top-down system. Rather than passive participants, students should be engaged as critical thinkers and active citizens. Science education should develop critical literacy and civic courage in both teachers and students and not simply train workers for employment in the commercial order (Aronowitz & Giroux, 1993).

The education system, in its present form, is falling short of the Government's 'Education for All' ambitions and to my mind this is having a significant impact on the socioeconomic welfare of the young people and on the nation as a whole. Allowing student voice through a critical pedagogy would, I believe, lead to an education system that students see as more relevant and find more motivating, resulting in a more science literate and equal society. Teachers can participate in transformative schooling to prepare their students for an ever-changing society as they assist students in their realization that they have choices, can make a difference, and are in control of their lives. Teachers can improve the lives of their students through relevant teaching that openly deals with issues of race, culture, and gender. This research piece should allow those involved in science education to move to a place where conversations about how effective teaching will develop creative, critical thinkers who will help enliven this country's democratic mission (Lynn et al., 2006).

In considering the most suitable educational environment for ensuring critical thinking through the science curriculum in Trinidad and Tobago's secondary schools I suggest that the ideals outlined in the following framework allow for an assessment of the quality of:

1. the syllabus documents
2. the schemes of work and the nature of the lessons derived from the syllabus documents and
3. the critical thinking exhibited by the students as a result of the 'received curriculum'.

2.5.1 Science curriculum design

- a. The goals of the science curriculum would embrace a political agenda which sees a critical pedagogy as necessary for developing critical thinking for social justice (Bonikowski, 2004).
- b. A level of autonomy would be seen in education policy, science syllabus documents and schemes of work, which would reflect a value for teachers' professionalism and a respect for student voice as young people develop as citizens within a democracy (Ares, 2006).
- c. A scope of study would engage genuine student interests, encouraging students to come to a realization of the nature of science and how it fits into their lives as young people who live within a postcolonial society subject to global influences (Zembylas & Avraamidou, 2008).
- d. Sufficient time would be available to adequately address the learning needs of a diverse range of learners to engage in higher order challenges and critical thinking without the undue pressures resulting from high stakes examinations (Janesick, 2007).
- e. Authentic assessment of students' critical thinking skills would be present to enhance their ability to transfer learning to contexts in which they can plan and take action to bring about changes that will improve their communities (Janesick, 2007).

2.5.2 Elements for teaching for critical thinking

- f. Teachers have an appreciation for and expertise in critical thinking for social justice and critical pedagogies. This literature suggests that teachers do not have to act as agents of an oppressive system, but can humanize students through their culturally responsive and politically imbued teaching methods (Ladson-Billings, 1995).
- g. Teachers with the relevant knowledge of science and their students to support their students in their development as critical thinkers (Danielson, 2007; Basu & Calabrese Barton, 2010).
- h. Creative use of all the relevant resources available in terms of: textbooks, online or other materials which provide: supporting techniques and advice; information communication technology; practical equipment; physical space; true-to-life experiences and time (Stanley et al., 2012).
- i. An environment that will support authentic critical analysis. This would mean that teachers and students would demonstrate mutual respect. The classroom atmosphere would be a

stimulating one where students of diverse backgrounds and needs feel at ease and have the confidence to engage in in-depth dialogue with their teachers and peers on analysis of issues and plans for and actions taken to bring about change that will improve their circumstances and those of their communities (Chubbuck, 2007).

- j. The quality of questioning and learning tasks organised by students and teachers would allow for comprehensive enquiry into problems and issues in science of a social/political nature (Danielson, 2007; Ofsted, 2013; Tofade et al., 2013).
- k. Teaching designed to develop students' critical thinking skills, addressing their cognitive skills through support of effortful cognition, instruction in critical thinking skills and trans-contextual transfers (Halpern, 1998).
- l. Teaching designed to develop students' strengths in the affective domain and the psychomotor skills that will support their ability to participate in ethical, meaningful investigations (McBride & Gabbard, 1990; Littledyke, 2008).
- m. The organisation of high quality teacher, peer and self assessment and feedback to support cognitive monitoring for improved critical thinking (Halpern, 1998; Danielson, 2007; Rourke, 2013).

With this framework in place I see students as being helped to manifest the following characteristics that demonstrate their critical thinking abilities in science.

2.5.3 Students as critical thinkers

- n. Students will show growth in cognitive skills as they progress through secondary school science, demonstrating greater effortful cognition, improved techniques in the management of analysis and problems solving, and better trans-contextual transfer and cognitive monitoring (Butler, 2012).
- o. Students will show development in the affective and psychomotor domains, demonstrating increasing levels of motivation and enthusiasm alongside the psychomotor skills that will

support their ability to participate in ethical, meaningful scientific investigations with greater critical engagement (McBride & Gabbard, 1990; Littledyke, 2008).

- p. Students' abilities to apply their knowledge and confidently question and debate issues will show overall improvement. An element of this would be students' abilities to freely and astutely select the manner in which they choose to communicate (Emdin, 2010).
- q. Students' abilities to create solutions to problems in science relevant to them and their communities will progress.
- r. Students will develop their abilities to judiciously manage the resources made available to them.
- s. Students will develop their confidence and abilities in terms of activism as they identify, implement and assess the impact of their actions and plan for continued action and evaluation taking into account consequences while considering contexts, assumptions, data, and evidence.

CHAPTER 3 Methodology

As a consequence of my literature review, the **main research question** ‘To what extent do the pedagogical methods employed in secondary school science in Trinidad and Tobago enable students to engage as critical thinkers?’ was identified.

In attempting to determine the extent to which the pedagogical methods employed in secondary school science in Trinidad and Tobago enable students to engage as critical thinkers I believe that one has to determine the factors which lead to the selection of these methods. In the main, the selection and fidelity with which the methods are employed are shaped by the characteristics and identities of the curriculum designers and teachers, and the pressures that come to bear from the perceived needs, concerns and expectations of the schools, employers, politicians, parents and students. Fitzhenry (2013) found that teachers’ methods were most influenced by the culture set by school administrators, teachers’ self-efficacy and student personalities. Students’ development as critical thinkers comes with their learning as they and their teachers co-construct knowledge and meaning through social interaction (Cummins et al., 2007). Engagement taps into students’ intellectual, emotional, and spiritual understandings and is therefore based in a naturalistic paradigm (Martin, Franc & Zounková, 2004). These aspects of the main research questions direct me to a constructivist rather than positivist form of investigation.

3.1 Case study – St Francis School (pseudonym)

Yin (1989) advocates case study as a means of illuminating the complex array of factors which combine to produce a unique situation. This method of investigation accommodates a research design in which a variety of data collection techniques can be applied (Corcoran et al., 2004). As a Principal I saw the need to reduce the influence that may arise from my position on the outcome of my research findings (Denscombe, 2005). One of my first challenges, as a result, was that I felt that I would have to work outside of my school since both the teachers and students in my own school may not have felt free to express their true thoughts.

This case study was designed so as to provide an insight into how the teaching of the National Curriculum for science in schools in Trinidad and Tobago affects students' critical thinking development. It takes the form of the analysis of the science syllabuses which are designed to drive the teaching and learning at St Francis. These are then compared with the schemes of work which teachers compile from the syllabus documents for organising their teaching. The application of these schemes of work is then tracked in the classroom through lesson observations and students' experience of these lessons through interviews and evidence from their exercise books. The subsequent development of students' critical thinking skills are investigated through their engagement in lessons and the skills that they demonstrate via focus group interviews. To understand the teachers' approaches to the teaching of science at St Francis, individual interviews were undertaken with them.

Acknowledging that every school is different I believed that the conditions at St Francis would be mirrored in the majority of the schools in the country except for the fact that the Secondary Entrance Assessment at St Francis meant that there was an over-representation of higher attaining students. St Francis' CSEC examination results fall within the top 20% of the education district, with 88% of the students gaining five or more subjects in the June 2010 round of examinations (Ministry of Education, 2010). In keeping with Bassey (1999), I see this case study as serving to tell the story, draw the picture and evaluate the way in which critical thinking is taught and learned through the science curriculum delivered in this school. The processes that inform practice are both technical, in determining how to achieve the stated goals, and normative, in considering what those goals should be (Robinson, 1993). The cultural systems which influence student engagement will involve not just the characteristics of the individual actors but the combined actions of groups within the school that have an influence on one another (Corcoran et al., 2004).

3.2 Triangulation

I was motivated to complete this study based on my interpretation of what I had experienced as a science teacher in the United Kingdom and as a Principal in a secondary school in Trinidad. I therefore do come to the work with my own perspective, but as a qualitative researcher I see the teachers and students also having their own points of view. As described in my considerations for taking on a case study, I had similar concerns in a school where I was not Principal in terms of ‘response bias’ in which participants tell you what you want to hear. It was not possible to disguise the fact that I was a school Principal even when I asked the gate keeping school officials to refrain from sharing that information. A triangulated approach allowed for a system of validation through a combination of subjects reporting on their experiences and expressing their views via interviews alongside my reporting on my observations. In an effort to describe the fully contextualized situation that influences student engagement with critical thinking in science, I used varied methods which included semi-structured and focus group interviews, lesson observations and the content analysis of documents. In the process I tracked how goals and intentions changed from the original curriculum documents to what was provided for students and how the delivered curriculum was received by them.

In determining if the curriculum has any effect on students’ critical thinking it was my intention to first ascertain whether there was a significant development in the students’ ability to think critically as they progress through secondary school. I originally investigated the use of a tool which could directly measure critical thinking ability. I first considered triangulating my findings in the cognitive domain using the California Critical Thinking Skills Tests (CCTST) with those in the affective domain, using stimulus and focus group interviews. However, the CCTST did not allow me to determine which variable, be it curriculum, age, experience, parental involvement or social class, to name but a few, would be directly linked to any change that it measured in the students’ thinking. The idea was also set aside as it was felt that for this method to work well I would have to engage in a longitudinal study in which one group is followed through from Form 1 to Form 5. Instead, the focus group interviews with the students between Form 1 and Form 5 were undertaken to determine any link between the students’ critical thinking abilities and their progress through school.

Teachers were interviewed to determine what they understood critical thinking to be and whether they felt equipped to assist in the development of this skill. A feedback loop was set up where teachers were asked to comment on student responses. This helped to validate and flesh out issues as teachers gave their interpretations on students' feelings about science and reflected on students' ability to be critical.

Content analysis of curriculum documents, lesson observations reports and exercise books was undertaken in order to determine the extent of the critical pedagogy employed in science teaching and to evaluate its effectiveness. In organizing the data from exercise books into themes I drew on Kangai et al. (2011), asking a second person to code 10% of the data. After discussion, we determined the final themes to be used in coding the content from the students' exercise books.

Textbooks were examined but not in as much depth as the aforementioned texts because, even though they were an available resource, they did not necessarily describe the activities that were actually used to engage the students.

3.3 Sampling

Purposive sampling was used, aiming to be representative of the pedagogical experience of Form 1 to Form 5 science students, with ages ranging from 12 years to 16 years respectively.

- St Francis College, a long standing mixed government school with students from a range of social and racial backgrounds and good examination results
- Forms 1 to 5
- Science classes running on the mornings that I visited St Francis College. This amounted to 15 lesson observations over two school terms.
- Individual structured interviews with seven of the nine science teachers at St Francis College

- 27 exercise books from the lower school, that is, Forms 1 to 3, including a range that represents students of top, middle and lower attainment
- 26 exercise books from upper school, that is, Forms 4 and 5, across Chemistry, Biology and Physics, including a range that represents students of top, middle and lower attainment
- Textbooks used in lower school
- 1 lower school workbook
- Textbooks used in upper school, that is, 1 Biology text, 1 Chemistry text and 1 Physics text
- A total of 5 focus group interviews with 15 top students from each of the 5 form groups, as identified by text scores, with the intention that they would demonstrate the best examples of critical thinking skills. The students were interviewed within their year groups.

The Form 1 to 3 year groups follow the NCSE syllabus and the Form Fours and Fives following science syllabuses produced by the CXC for the CSEC examinations under the different science areas which included Chemistry, Physics and Biology. At St Francis College students follow an Integrated Science course in the lower school and at the end of Form Three select from Biology, Chemistry and Physics as part of their CSEC Course. There is no expectation that they will necessarily take up a science course at the CSEC level. The Science Department also offers Food and Nutrition and Home Economic Management at CSEC. I have focused my analysis on the Integrated Science Course in Lower School and follow through to Biology, Chemistry and Physics in the Upper School.

3.4 Data collection

3.4.1 Content analysis of curriculum documents

The aims and objectives, range of topics and suggested activities were examined in the syllabus documents. These were compared with those in the schemes of work in place in St Francis College in order to track how well the objectives and activities conformed to these. A note was made of how these plans linked with the development of critical thinking through the engagement of higher order thinking and relevance to students' lives.

3.4.2 Lesson observations

In the first instance, lesson observations took place on Friday mornings. The school ran on a 6-day timetable which meant that different science lessons were being conducted when school visits were made. School events and teacher absenteeism sometimes interfered with my viewing lessons. In order to increase the numbers of observations I spent an entire week at the school. The teachers were told beforehand that I was coming to observe their lessons and it was made clear to them that the observations were to be recording in an anonymous fashion and were not going to be a judgement on them but would contribute to my understanding of how critical thinking was being developed in and across the school. They were told that I would not be reporting my observations on individuals' lessons to any school or ministry officials. They were not required to produce or present to me any lesson plans, as different teachers may translate stated plans differently according to their perceptions (Ulichny, 1996). During the lesson I noted the time and corresponding activities of both the teacher and the students and any incidents or behaviours that were of interest to me (i.e. relevant to my research questions). I also recorded the number of students, their gender and what I thought was their racial spread, that is, Afro-Caribbean, East Indian or mixed. Copies of the scripts from lesson observations were offered for review by the teachers to check for any inconsistencies or problems they could have with what was recorded.

3.4.3 Analysis of lesson observations

The nature of activities, pedagogical methods and quality of questions and dialogues and the nature of relationships were examined through lesson observations. Three tools were used in my

evaluation of the lessons observed. The first was based on the Ofsted (2013) evaluation schedule, the second on the taxonomy described by Krathwohl (2002) (Appendix 11) and the third on the framework designed by Danielson (2007) with criteria from Halpern (1998) on teaching critical thinking. The first tool allowed for observation on the general quality of the standard of teaching, the second on the level of critical thinking that was supported in the lessons across the cognitive, affective and psychomotor domains and the third provided a more in depth analysis of how critical thinking was developed during lessons. For the first two tools the number of lessons which matched the stated criteria was recorded but for the last tool a narrative describing the different aspects of the observed lessons was outlined on the relevant headings. Halpern's (1998) guidelines on the teaching of critical thinking skills were also used in the detailed lesson narrative as I commented on the extent to which students were:

- encouraged to do 'effortful' cognitive work
- provided with the skills necessary for critical thinking
- trained in the structural aspects of problems and arguments and
- taught the metacognitive aspects of critical thinking, which helps students to check for accuracy and monitor their progress.

3.4.4 Content analysis of textbooks

Observations on the textbooks used in Forms 1 to Form 5 were made. Readability was measured by pasting three sets of three hundred words of text, randomly chosen, into the Flesch-Kincaid Readability Ease software at Readability-Score.com at <https://readability-score.com/> (Added Bytes - Text Statistics Project, 2011). The average scores for Readability Ease and Average Readability Grade were noted. The layout of the book, in terms of the nature of the illustrations, the organisation of the material and the types of activities and questions were recorded. The constraint here was that this software measures readability ease by length of syllables, words and sentences but does not take into account the use of technical language (DuBay, 2004).

3.4.5 Content analysis of exercise books

With the expectation that the exercise books would indicate how well students were supported to fulfil the goals described in the syllabus documents and the schemes of work, the nature of assessments and activities, quality of responses and quality of marking were examined in class tests and exercise books. In surveying the exercise books I noted the activities in which the students engaged. The nature of the note taking, the types of assignments, the nature of the questions in question and answer and examination exercises, the activities related to laboratory exercises, the use of technology, the application of information, communications technology and occurrence of field trips were recorded.

3.4.6 Focus group interviews with students

Although it could be challenging to keep track of the discussion, and some students may be reluctant to express their thoughts in a public forum, focus group interviews were conducted with students as I believed that the interaction within the group would elicit more data on the level of their critical thinking and their feelings and attitudes toward their science education. An effort was made to ensure that all students contributed to the discussion and respected others' right to speak without interruption (Denscombe, 2005).

The initial stimulus for the discussion was the video clip 'Oil Spill Threatens Native American "Water" Village' (National Geographic, 2010). It was selected because I felt that it would be easy for the students to understand and draw out the issues highlighted at different levels, depending on their critical thinking abilities. I thought that they would find the content interesting as its subject was relevant to issues that could touch their lives as citizens of Trinidad and Tobago. The scientific and social knowledge required in analysing and proposing solutions would have been raised at some point during the students' schooling. The five minutes and thirteen seconds video clip is of adequate length for holding the students' attention.

I felt that the students being interviewed by an adult would feel it necessary to give the correct answers to what they may conceive to be a kind of test. The students could also take the opportunity to defend or speak out against teachers of whom they held feelings of like or dislike. An effort was made, in the letters seeking their consent and in the preamble to the interviews, to make clear the purpose of the research exercise, the reason for the interviews and how their contribution would be useful.

The **Focus Group Interview Questions** consisted of the following:

- What do you think and feel about this movie?
- Who was affected? How were they affected?
- What are the concerns or issues?
- What information is necessary for addressing these concerns or issues?
- Who could improve this situation? What could be done?
- What role could you imagine yourself playing if you were involved in a scenario similar to this?
- Do you feel that your training in science would help you to understand the best way to cope with these or similar situations?
- Which science lessons have had the greatest impression on you? Why?
- How do you think the science that you learned while at school will be useful to you after you have left?

Pilot interviews were undertaken. As a result of these interviews I felt that in my paraphrasing I needed to concentrate on having each group of students fully express their views and thinking so that I could compare their very best responses. When asked, ‘Which science lessons have had the greatest impression on you?’, some students tended to speak about topics that they had most recently and so I felt that it was important to encourage them to look across their science careers. I felt that the decision to work with a mixed gender school was important as the responses were skewed in single gender groups.

3.4.7 Content analysis of student interviews

The student interviews scripts were subjected to NVivo coding using NVivo 10 software. The main themes were ‘students’ feelings’, ‘students’ critical thinking skills’ and ‘students’ ability to suggest alternatives’. The first two were further sub-divided. Students’ feelings were separated into feelings of ‘self-confidence’ and ‘feelings about science’. Students’ critical thinking skills was divided into ‘Application of Science knowledge’, ‘Creativity’, ‘Appreciation of social political environmental issues’, ‘Application of non-scientific information’ and ‘Application of science to life’.

The responses for ‘students’ feelings’ came from the questions:

- What do you think and feel about this movie?
- Who was affected? How were they affected?
- What are the concerns or issues?

The NVivo codes for each form group were placed under the Form 1 to 5 headings and colour coded³ as follows:

Affecting food supply

Affecting wildlife

Affecting health

Affecting income

Affecting housing

Affecting cultural activities

Affecting means of transportation

Other socio-political concerns.

³ Colour coding has been maintained through out the thesis for ease of reference.

In an effort to determine whether there was any difference in the sophistication of students' thinking as they moved from Form 1 to 5, Bloom's taxonomical classes were used to classify the responses under the different levels of the cognitive domain. These levels progress through 'Knowledge', 'Comprehension', 'Analysis', 'Synthesis' and 'Evaluation' (Krathwohl, 2002). The responses were also assessed in terms of different levels of the affective domain using the hierarchical units provided by Krathwohl et al. (1956), moving from the lowest level of 'Receiving' to 'Responding' to 'Valuing' to 'Organising' and finally, at the highest level, to 'Characterising by value or value set' (Krathwohl et al., 1956).

To determine students' self-confidence and ideas on activism the NVivo codes to the question, 'Who could assist with this situation?', were further colour-coded as follows:

Students as activists
Government personnel
Persons with scientific expertise
Persons within the community
Persons outside the community
God
The oil company
A combination of all the people.

The NVivo codes for Application of Scientific Knowledge, which came mainly from the questions:

- What information is necessary for addressing these concerns or issues?
- What could be done?
- How do you think your training in science would have helped you cope in this or a similar situation?

These responses were colour-coded according to the following themes:

General suggestion without a reason

General suggestion with a reason

Suggestion based on scientific knowledge but without a reason

Suggestion based on scientific knowledge with a reason

More detailed suggestion based on scientific knowledge with a reason.

In order to understand students' critical thinking in terms of 'students' feelings' and how they see application of their scientific knowledge to everyday life, NVivo codes were retrieved mainly from the questions:

- Which science lessons have made the greatest impression on you? Why?
- Do you feel that your training in science would help you to understand the best way to cope with these or similar situations?

These responses were colour-coded according to the following themes:

General expression of appreciation for science training

Appreciation for scientific training with reference to an area in science

Lukewarm sentiments about science experience

General expression of dislike for science

Challenges that negatively impact appreciation of science training.

No specific question on alternatives to teaching methods were asked but students' vision for how science could be best taught was extracted from the comments that they made when offering alternatives to the present teaching methods. The comments were mainly made in response to the questions:

- Do you feel that your training in science would help you to understand the best way to cope with these or similar situations?
- Which science lessons have had the greatest impression on you? Why?
- How do you think the science that you learned while at school will be useful to you after you have left?

The NVivo codes related to this were themed as follows:

More resourcing in terms of time and equipment

Reorganise the teaching of subject areas

More fun

More field trips

More practicals

More visuals

Less note taking

Clearer explanations

Use Information Communication Technologies

Make relevant to students' lives.

3.4.8 Semi-structured interviews with teachers

Understanding the viewpoints of the various actors engaged in the teaching and learning of critical thinking within science is a necessary step in developing a true appreciation of what influences the outcomes. People in different social locations have different understandings and perspectives (Gillborn, 2006). Semi-structured interviews were used to elucidate how teachers at St Francis saw the teaching and learning of critical thinking through the science teaching that took place at the school. I felt that the flexibility allowed by this technique would allow teachers to fully express their ideas as the responses are open-ended and the interviewees were encouraged to

expand on points of interest (Denscombe, 2005). The challenge in this case was my position as it was difficult to disguise my professional status. It was therefore necessary to emphasize to the teachers the purpose of the interview, the fact that I was interested in their opinions, that there was no expectation of a 'correct' response and that every effort would be made to maintain their anonymity.

The **Semi-Structured Interview Questions** consisted of the following:

- What do you understand by the term critical thinking?
- How much do you believe the science curriculum contributes to the development of students' critical thinking?
- Are there any changes that you would make to the curriculum to assist students' critical thinking?
- Apart from the curriculum are there any other factors that influence your ability to develop the students' critical thinking skills?
- How have you been equipped to assist students in developing critical thinking skills?
- What changes do you think would support you in organising learning experiences that develop critical thinking?

At times it was necessary to get a balance between the length of the interview as with the open-ended nature of the interview there were instances where I had to control the pace of the interview by interjecting with a summary of what was said and moving on to another point.

3.4.9 Content analysis of teacher interviews

The teachers were asked to comment on student interview responses. All the teachers' responses were subjected to NVivo codes with the following themes being derived:

- Definition of critical thinking

- Characteristics of critical thinkers
- Changes to the curriculum
- Factors other than the curriculum which affect critical thinking
- Do the teachers feel personally equipped or able
- Required changes suggested by teachers
- Teachers' responses to video question student responses.

The NVivo codes under 'Definition of critical thinking', 'Characteristics of critical thinkers' and 'Changes to the curriculum' were further divided into sub-themes and the number of teachers making comments under a particular theme was recorded as well as the number of references made to that theme.

The NVivo codes of the other overarching themes were divided into sub-themes with theme descriptors. Reference was made to the teachers who made the comments and how many times the comments were made in order to give an idea of the range of sentiment.

During the course of the structured interviews with teachers I found that they expressed their beliefs about other teachers' values and practice; they commented on how and why their students behaved as they did and gave examples of strategies that they used in their attempts to develop their students' critical thinking skills. These NVivo codes were also grouped under descriptor themes with the teacher reference and the number of references made.

3.5 Ethics

The issues of ethics that arose for me were mainly that of ensuring that the information shared with me by students and teachers was managed in such a way that they were protected from any adverse feedback or other undesirable consequences. In my attempts to gather high quality data, both groups of participants shared information and opinions that they might normally withhold. I therefore had the responsibility to treat sensitive information in a manner so as to maintain the

anonymity and confidentiality of the participants. Some of the students may have been unaware of the potential consequence of sharing information and so I had to be open with them, their parents and the school when seeking permission to carry out my investigations. In using the school as a case within the setting of Trinidad and Tobago the leaking of information could affect the school's reputation and so it was important for me to check the final thesis to ensure that the anonymity of the school was maintained. I used a pseudonym for the school and I needed to ensure that I deleted any identification of the school in the supporting documents.

I paid attention to the way in which the research process was handled so as to ensure that my actions were in keeping with the guidelines provided by the British Educational Research Association (2011). Consent was sought and it was made clear that individuals had a right to refuse participation and a right to re-negotiate their consent. I sought to ensure that no one suffered any adverse consequences in the implementation of my plans (Corti, Day and Backhouse, 2000), including wasting their time or disappointing them. For instance, I ensured that the video material was accessible and age appropriate for the students.

3.6 Securing data

The advice of Corti, Day and Backhouse (2000) was taken in safeguarding the research data. All the data collected was recorded in a digital form. The names and references were coded so that at no time were either the first names or surnames of the participants identified. The information was stored in this digital form and secured with a password. Electronic deletion was used to alter documents so as to disguise any identifying markers such as names and signatures. As it is difficult to anonymize audio recordings they will be destroyed once this project is completed.

3.7 Dissemination of research findings

As a working Principal in a school in Trinidad and Tobago there will be opportunities for me to share my work with local teachers and my peers through staff and fraternity meetings, professional

development training sessions, conferences and workshops. Findings may also be published in the local and regional newspapers as well as in the peer-reviewed periodicals such as the:

- *Caribbean Journal of Teacher Education and Pedagogy*, University of Trinidad and Tobago
- *The Caribbean Teaching Journal*, Education Research Association of the University of the West Indies (UWI), St Augustine, Trinidad and Tobago
- *Caribbean Journal of Education*, School of Education, UWI, Mona, Jamaica
- *Journal of Education and Development in the Caribbean*, UWI, Mona, Jamaica
- *Caribbean Educational Research Journal*, UWI, Cavehill, Barbados

The study may hold interest for stakeholders in education worldwide especially those who have been influenced by the phenomenon of colonialism. It would be therefore prudent to present the findings to an international audience, in the first instance to regions in which Caribbean peoples have settled. This could be done through approaching peer-reviewed journals or using the facility of the worldwide web. I could seek to have the work published on line through the CXC portal, Education Caribbean at <http://educationcaribbean.com/about/default.asp> and The Society for Caribbean Studies (UK) <http://www.caribbeanstudies.org.uk/news/news.htm>.

The findings could be shared with organisations such as the Ministry of Education, the Trinidad and Tobago Unified Teachers Association and the Association of Principals of Secondary Schools. Publications could be offered to university departments such as the Caribbean Research Information Service, School of Education, UWI, St. Augustine and the University of the Southern Caribbean Library.

The University of the West Indies and British Petroleum (Trinidad and Tobago) has been running a Science, Technology, Engineering and Mathematics (STEM) project, STEMagination, which has been endorsed by the Ministry of Education of Trinidad and Tobago. This project has been attempting to train teachers and students to be critical and creative in their work which falls within the STEM areas. I see my work as being relevant in advancing the aims of this programme.

3.8 Introduction to discussion on research findings

In addressing the main research question it was further divided into the following four subsidiary research questions:

- a. To what extent are the aims of the syllabuses fulfilled, as they pertain to the acquisition of critical thinking skills for social justice? A measure of this was based on the content analysis of the curriculum documents analysed under the headings:

Syllabus goals

Level of autonomy

Scope of study

Time and space allowance and

Authentic assessment.

- b. What do science teachers understand by the term 'critical thinking'?
- c. What determines the pedagogical methods employed in science lessons for the development of critical thinking skills?

These two subsidiary questions were addressed through an analysis of teacher interviews, lesson observations and the content analysis of textbooks and exercise books. The discussion on how teachers' understanding of critical thinking and their orientation to critical pedagogies influence the development of critical thinking skills is presented in terms of:

Teacher knowledge

Expertise in teaching for critical thinking

Use of resources

Classroom environment

Quality of questioning and learning tasks

Teaching for cognitive development

Teaching for development in the affective and psychomotor domains

Assessment.

d. To what degree are the aims of the syllabuses fulfilled, as they pertain to the acquisition of critical thinking for social justice? This is mainly ascertained by the analysis of student responses through analysis of the focus group interviews based on the use of a video clip and lesson observations. The outcomes are analysed under the subheadings of:

Development of cognitive skills

Development of critical thinking skills in the affective and psychomotor domains

Development of questioning and communicating skills

Problem solving and creativity

Use of resources

Activism.

CHAPTER 4 Findings on critical thinking in the science curriculum

As outlined in Chapter 2, a curriculum design that supports critical pedagogy must be in place if teachers are to lead students to becoming critical thinkers. This chapter presents the results of analyses to determine the fitness of the curriculum under the areas of syllabus goals, the level of autonomy that teachers and students are allowed, the scope of the courses outlined, time and space allocation and opportunities for authentic assessment. As Bonikowski (2004) points out, simply accepting the objects of a syllabus is to miss the power dynamics that lead to social stratification.

Boschee and Baron's (1993) description of an outcome-based education centred on curriculum planning that takes into consideration a programme that is learner- and learning-centred, focused on achievement of significant outcomes, activity-based, criterion-referenced assessment, and embodies application of learning in authentic contexts and links to society and the world of work fits with the nature of the NCSE and the CSEC syllabuses.

4.1 Syllabus goals

The National Certification of Secondary Education (NCSE) is a national curriculum aimed at lower secondary school students in Forms 1 to 3 whereas the CSEC is a regional Caribbean syllabus which is typically completed over a two-year period by students in Forms 4 and 5. The lower school follows an integrated science course but in the upper school students select from a number of science based subjects. At St Francis, students select from Biology, Chemistry and Physics. The goals outlined in the syllabus documents can be seen as those which the authors see as beneficial to the local and regional communities and therefore requiring the development of individual students by giving them the necessary knowledge and skills. The aims speak to the qualities required of the education system, citizens, workers and scientists for development.

The Ministry of Education through NCSE aims to have:

- Trinidad and Tobago known for excellence in innovation
- a highly skilled, talented and knowledgeable workforce that will stimulate innovation driven growth and development
- the richness of Trinidad and Tobago's diverse culture serve as a powerful engine to inspire innovation and creativity
- citizens with a sense of democracy, respect for the rights of others and elders and with the ability to contribute meaningfully to the social and economic development of the country
- citizens with a strong sense of nationalism and patriotism. (GoRTT, 2008, p. 1)

The opening paragraph on the rationale for each of the science subjects at CSEC states that:

The application of scientific principles and the conduct of relevant research are of prime importance in identifying, assessing and realizing the potential of the resources of the Caribbean territories. Science deals with life processes, the knowledge and understanding which are intended to improve the quality of life. This knowledge should generate awareness of the importance of living things and an attitude of responsibility for the care of the total environment that supports life. A good foundation in the sciences will help citizens of the Caribbean to respond to the challenges of a rapidly changing world. (CXC, 2002a, p. 2)

Ball (2003) explains that educational policies determine acceptable and unacceptable discourses and in so doing interrupt and restructure power relations. The neoliberal discourse has focussed on the development of students' thinking. Feiman-Nemser (2001) makes the point that education reforms aim to expose young people to rich educational content and student-centred instruction, which stresses critical thinking, problem solving and meaningful subject matter. Secondary science has been seen as suitable for providing the kind of experiences that would assist in developing students' thinking. Studies, however, show that many students in secondary and tertiary education are not equipped to demonstrate an ability to participate effectively in activities requiring higher-order thinking skills (Beyer, 2001). The CSEC and NCSE syllabuses are clearly

designed to address these concerns as they highlight the benefits to students becoming competent citizens through a focus on the development of critical thinking through science.

In their aims and objectives both the lower and upper school syllabuses place an emphasis on socio-scientific issues. The extent to which a critical pedagogy is anticipated in addressing these is minimal if one uses Hodson's (2003) community-based, socio-political criteria for examining the intended pedagogy outlined by the documents. The syllabuses focused on having students understand their responsibilities to their communities. The CSEC Biology syllabus aimed to have students develop "an appreciation of humans having a greater influence on their environment than any other species" and to recognise their responsibility to "conserve, protect, maintain and improve the quality of biological environments for future generations" (CXC, 2002a, p. 2). I have not noted any aims and objectives which stressed developing an understanding of the bearing of changes in science on society or a realisation that the decisions which drive scientific development are very often because of particular interests and that when some benefit others may lose. The 'Vision Statement' of the NCSE syllabus includes the intention to promote the "Development of students' critical awareness of the role of science in everyday living" (GoRTT, 2008 p. 21). It does not, however, highlight any element of activism. This syllabus did encourage debates which may have assisted lower school students to develop their own beliefs and value positions. Exercises such as letter writing were also encouraged which may have gone some way to having students understand that there are strategies for taking action if they feel that an issue should be dealt with and that they should take on the responsibility.

4.2 Level of autonomy

Ares (2006) claims that autonomy is a generative process necessary for full participation, as it provides avenues for exercising power and responsibility through inclusion of teacher and students' lived experiences. However from close reading both the NCSE and CSEC syllabus documents adopt the language of an authoritarian and non-participatory epistemology that is characteristic of what Kelly (1999) describes as a 'content and product' model in curriculum

design. The predetermined content of both syllabuses is based on the principle that there is a highly esteemed body of knowledge that is essential for all learners regardless of who they are. Those responsible for designing the syllabus documents direct the cultural capital within science education (Kelly, 1999; Apple, 2004).

The activities suggested in the NCSE syllabus give teachers an extensive range of strategies for having students develop an interest in, manage, analyse and learn the knowledge content required for completing the course. There is no particular pattern observed in the manner in which strategies are recommended across the three years. In addition to the ‘Teaching/Learning/Assessment Activities’ suggested for achieving the specific objectives outlined in the syllabus the teachers are provided with another list of activities which includes: questioning; reading; debates; problem solving; projects; simulations; videos/CD-ROMs; software and computer-based learning and guest speakers. There is not much encouragement of teacher creativity in deciding on appropriate strategies. When tracking some of the approaches that would be helpful in developing critical thinking skills no particular pattern is observed in terms of challenge to students’ thinking across the year groups.

All of the CSEC syllabuses encourage teachers to have their own order of teaching where they link concepts. However, the Biology syllabus goes on to recommend the teaching of Section A, ‘Living Organisms in the Environment’, first. Practical work, employing the methods of science and application to real life situations, is advised in all three syllabus documents. To me, this application to real life situations is not the same as advocating critical analysis of how scientific matters influence students’ real lives. As in the NCSE syllabus documents, teachers are given detailed guidance on the teaching methods to be employed. In CSEC Biology, Chemistry and Physics, students are to submit at least eighteen, sixteen and sixteen practical exercises, respectively, for School Based Assessments (SBA). The examination board has stipulated which topics must feature as part of the submissions since they are considered “essential for the development and evaluation of skills” (CXC, 2002a, p. 36). In Biology the twelve topics from which the eighteen exercises are selected were: Photosynthesis, Respiration, Diffusion and

Osmosis, Food tests, Enzyme action, Transpiration, Response, Locomotion, Growth, Reproduction, Dispersal and Genetics with Field work also being requested. In Chemistry twelve topics are also required, namely Separation, Reactivity series, Acids, bases and salts, Redox and electrolysis, Qualitative analysis, Volumetric analysis, Organic Chemistry, Non-metal, Rates, Heating of compounds, Energy and energetics and States of matter. In Physics only ten topics need to be covered and they were: Measurement, Statistics and dynamics, Properties of matter, Thermal energy, Reflection, Refraction, Action of lenses, Current electricity, Magnetism and Electromagnetism and Radioactivity.

All students are assessed on: ‘Observations’, ‘Recording and Reporting’, ‘Manipulation and Measurement’, ‘Planning and Design’ and ‘Analysis and Interpretation’. Only in Biology are students assessed on Drawing and a report cannot be assessed for ‘Planning and Design’ if the student goes on to report on a full investigation. Again, teachers are provided with detailed guidance with step-by-step instructions on how they should conduct SBAs. They are told that skills are to be developed before their assessment. For example, in Chemistry each skill must be tested at least four times with students making corrections so that misconceptions can be addressed. The teachers are advised to complete the exercises beforehand to prepare checklists for marking. At the end of the two-year course students are to submit laboratory notebooks which include *all* the practical work that was done with the SBA activities highlighted.

The content does not permit much room for allowing the interests, abilities or cultures of the recipients of the curriculum. Through the NCSE’s ‘Instructional Objectives’, ‘Content Concepts’, and ‘Content Scope’ and suggested ‘teaching, learning and assessment activities’ and CSEC’s ‘Organisation of the Syllabus’, ‘Suggestions for teaching’, ‘Certification and Definition of Profiles’ and ‘format for the examinations’, what is to be mastered and how one demonstrates mastery is dominated by the supremacy given to the curriculum authors at the expense of the intellectual autonomy or democratic determination of teachers and students. The content of standard statements, such as ‘Understand Forces and Motion and Their Relationship to Each Other’, which entails the content concept that “Inertia and momentum are both properties of the

mass of a moving body”, “Inertia is a body’s resistance to being moved”, “The larger the mass, the greater the inertia”, “Momentum is a product of mass and velocity”, “The larger the mass, the greater the momentum” and “The larger the velocity, the greater the momentum” (GoRTT, 2008, p. 75), is written in technical language and does not allow much space for negotiating the learning performance, taking into account the characteristics or culture of the young people who are expected to engage with this material. Wallace (2012) argues that highly specific curriculum standards deny learners opportunities to conceptualize the potential for autonomy in learning. The dimensions of these standards include:

i) authoritarianism of action

In order to demonstrate the ability to ‘discuss the impact of diseases on the economy of the country’ students are expected know that “a healthy population is the nation’s greatest resource” by describing that the economic impact of disease, that is poor health, is that it:

1. ‘reduces productive time spent at work’
2. ‘drains the country of its sources of vitality, creativity, and wealth’ and
3. ‘raises health care costs’. (GoRTT, 2008 p. 53)

Once the learners can restate these three, the examiners will be content that students have a full enough appreciation as to why ‘a healthy population is the nation’s greatest resource’, although it is possible that some students may be not be totally convinced of the association that the syllabus demands.

ii) authoritarianism of language

One of the goals precisely outlined in the Physics CSEC syllabus is to “acquire technical and scientific vocabulary” (CXC, 2002c, p. 1). According to Wallace (2012), this is another way in which the curriculum exerts its authority through asking students to reproduce technical language

without having an authentic understanding. Under the ‘Physical Measurements and Units’ area of the Physics syllabus students are expected to come to an understanding of terms with little opportunity to use them in contexts of their choosing. A student must be willing to invest if they are to progress to the elite class who find science meaningful. Gee (2004) postulates that in order to engage successfully in science it is essential to learn the language of science since using everyday language is too ambiguous and imprecise for participants to communicate. He explains that in order for students to learn the language of science they have to be willing to make major adjustments starting with developing the ability to deal with academic language. They should use the new vocabulary in personally meaningful contexts and have access to expert users of the language. Time constraints are mentioned by teachers throughout this study and are seen in the difference in how they allocate time in schemes of work as compared to the syllabus recommendations. The time constraints required for completing the syllabuses packed with specialists’ terms do not allow all students to benefit from this science education.

iii) authoritarianism of epistemology

Some of the content is taken for granted. There is no provision, for instance, for teaching students how scientists came to understand that atoms bond together to form elements, molecules, and compounds. On the other hand, objectives for developing inquiry and process-based skills in the standards are physically linked to the content objectives in the syllabus documents. There is guidance regarding which process skills should be used with which content objectives. The cognitive reasoning skills that are best suited to teach various kinds of science concepts are not left for teachers to determine.

In Kelly’s (1999) ‘content and product’ model the ‘product’ is the achievement of the discrete and de-contextualized behavioural objectives. This model allows policy makers and administrators to hold teachers and schools accountable as the latter are seen to be responsible for the quality of the product. The learning is not placed within a context but rather broken into separate pieces which provide the opportunity for the creation of high stakes testing that disregards the learning context.

Curriculum planners may argue that teachers are encouraged to contextualize the content for individual learners, but the examinations may not necessarily provide the same context (Ball, 2003). Cases in point are as follows: firstly, where the CSEC Biology syllabus advises teachers to expose students to unfamiliar contents and the Physics syllabus advises the opposite as outlined in the 'Findings' when the CSEC syllabuses' 'Suggestions for Teaching' are described; secondly, the spiral nature of the NCSE syllabus, also highlighted in the 'Findings'. In spiral curricula teachers tend to neglect the fact that all students do not have similar backgrounds and as a consequence do not build up to individual students' specific needs appropriately (Snider, 2004).

It is not always clear as to how the strategies articulated by the syllabus support the required learning. The one suggestion for allowing students to be able to "investigate the conversion of energy from one form to another" was to "Demonstrate energy changes in a simple pendulum, microphone, loudspeaker, wound-up toy ..." (GoRTT, 2008, p. 34). To me, there is a mismatch in setting up a demonstration if the outcome is to encourage students to investigate. Giving the appearance of upholding democratic participation, the documents make it clear that these are only suggestions and that teachers are allowed to determine their own techniques. Bianchini and Kelly (2003), Lingard (2005) and Valenzuela (2005) point out that a content heavy curriculum with very specific standards can prevent teachers from employing teaching methods based on creativity and research. In supporting democratic participation, when identifying the appropriate suggested techniques, the curriculum should take into account the legitimate time required for meaningful learning. Demonstrating requires less time than allowing students to investigate.

The content and product model has been criticised in that its authoritarian style makes it a tool for passing on the economic and social aspects of the dominant culture. The apolitical and ahistorical language used in statements such as "specific skills and habits of mind such as accuracy, discipline and integrity in the application of scientific principles" (GoRTT, 2008, p.22) does not make transparent the nature of the authority that is the backdrop for the content and organisation of the syllabus (Apple, 1990, 2004).

Brickhouse et al. (2000), Carlone (2003) and Gilbert and Calvert (2003) have all completed studies which show that an individual's ability to involve themselves in authentic scientific engagement depends on their science identity. To form a social identity one needs to have a vision of oneself in the social world of science. Integral to this is the sense that one has a voice in one's science learning as opposed to having someone dictate what to learn and how to exhibit that learning. The NCSE syllabus proclaims one of its aims as "Empowerment, attained through their knowledge of the role of science in addressing the complex social issues related to the environment". It then includes the instructional objective "design a personal plan for successfully managing body weight" with the students being assessed on knowing that "Achieving and maintaining a healthy body weight is important to good health", and "Eating a balanced diet and exercising regularly is the "secret" to maintaining a healthy body weight", without encouraging a discussion on the difficulties that they as young people may have in procuring a balanced diet (GoRTT, 2008, p. 52). Although the rhetorical language speaks to valuing students' health the instructional objective appears to be value-neutral. Apart from making youngsters more conscious of their weight this dispassionate approach may deter the development of a science identity as it does not entertain their concerns and their values (Carlone, 2003; Thompson & Windschitl, 2005).

Brickhouse et al. (2000) discuss the effect that the curriculum can have as it associates the quality of a good student with science identity. The NCSE syllabus identifies the qualities of a good scientist with 'discipline'. Brickhouse et al. (2000) argue that students with a genuine interest in science but who do not comply with traditional school values maybe dissuaded from pursuing science as their science identities are obstructed.

Teachers and students have little opportunity to interrogate how their science education is associated with other cultural practices which set up unequal relations of power in terms of class, race and gender. Why does scientific knowledge matter? How is knowledge organized within school and why? What are the underlying systems that structure scientific knowledge in relation to other types of knowledge? How is scientific knowledge passed on?

In the ‘content and product’ curriculum model of both the NCSE and the CSEC syllabuses the products are described in terms of behavioural objectives which are discrete and decontextualized. Examples can be seen in “Explain how heat is transferred” (GoRTT, 2008, p. 34) and “Distinguish between metallic and electrolytic conductors” (CXC, 2002b, p.19). This arrangement pays little attention to the concerns, curiosities, aptitudes or cultures of the learner and according to the National Research Council (2007) is not in keeping with how children learn best as students come to their own meaning within a sociocultural context. Highly specific standards and objectives can make it difficult for teachers to change them in order to accommodate the needs of their students (Wallace, 2012). Within the national setting, programmes which address personal learning tend to be seen as second rate compared to academic learning, leaving many students to feel that they are working in vain as they attempt to produce the stated outcomes of the syllabus within the allotted time. Little consideration is given to individual situations (Leacock, 2009). Hanson (1994) points out that young people are being constructed by these types of assessment processes instead of being described by them as they do not fully explain where students are at in their non-linear learning process.

4.3 Scope of study

Zembylas and Avraamidou (2008) highlight that postcolonial theory brings science educators to engage with issues on cultural diversity, identity, globalisation and inclusivity. They believe that this may reveal tensions and challenges in how science is currently taught. The CSEC syllabuses state that the courses are designed for students wanting to pursue the particular area at tertiary level and for those who may not engage with the subject formally after CSEC. The Physics syllabus outlines in the “Candidate population” section the careers for which Physics would be relevant. I wonder if this may be one way to encourage students to embark on this course of study and persist with it even if they are not initially interested.

The syllabus documents are divided into sections. The sections in the Biology syllabus include: Living Organisms in the Environment, Life Processes, Continuity and Variation, Disease and its

Impact on Humans and The Environment and Human Activities. The three sections in the Chemistry syllabus are divided into Principles of Chemistry, Descriptive Chemistry (Organic and Inorganic) and Chemistry in the Home. Physics has six areas, Physical Measurements and Units, Mechanics, Thermal Physics and Kinetic Theory, Waves and Light, Electricity and Magnetism and The Physics of the Atom. These sections are further divided into smaller topic areas. My impression of the overall organisation of the syllabus is that it is designed to provide students with a purely academic exercise aimed at providing the knowledge needed as a foundation for moving into more advanced levels of science education. Apart from the Biology and the ‘Chemistry in the Home’ much of the syllabus appears to be de-contextualised and sterile. No topics that may be seen as exposing students to ideas beyond traditional views, for instance in topics such as evolution versus creationists theories, birth and death of stars, the Big Bang Theory versus Creation, the possibility of life on other planets – are included.

Table 4.1 outlines the extent to which the specific learning objectives are linked to the development of students’ critical thinking skills that will support science learning for social justice.

Table 4.1 Comparison of the number of learning objectives linked to critical thinking, personal or societal issues in the CSEC Biology, Chemistry and Physics syllabuses

	Biology	Chemistry	Physics
Types of critical thinking activities and links to personal or societal issues	No. of learning objectives	No. of learning objectives	No. of learning objectives
Total number of objectives linked to critical thinking or life experiences	109	117	93
Total number of learning objectives	138	201	240

Percentage of learning objectives linked to critical thinking or life experiences	79	58	39
Number of practical activities suggested	49	59	88

When comparing the learning objectives linked to critical thinking or life experiences, the highest proportion in favour of the development of critical thinking was Biology, followed by Chemistry and then Physics. I have noted that the fact that there is a link to everyday life events does not necessarily provide a direct link to students' lives and so may still not hold their interests.

In the analysis of CSEC syllabus content based on School-based Assessments (SBAs), the first four paragraphs of the statement describing the rationale for the SBAs are identical for the Biology, Chemistry and Physics syllabuses. Their purpose is to enhance students' knowledge, skills and attitudes. The SBA activities are linked to the 'Suggested Practical Activities' and so the SBAs should be integral to assisting students to achieve the learning objectives of the syllabuses. Teachers are encouraged to ensure that the exercises used should be relevant to life and meaningful.

Baram-Tsabari and Yarden (2005) conducted a study in Israel which attempted to glean children's interests in science by looking at the questions that they posed to a web site. The findings indicated that Biology, technology, and astroPhysics were the most popular topics among children. In both the NCSE and CSEC syllabuses these three areas are addressed but in a quite dispassionate manner. The controversial topics, such as the Big Bang Theory, Birth and Death of Stars and Evolution versus Creationist Theories, which, in my experience, students of all abilities find engaging as they address the big questions, are not included. Baram-Tsabari and Yarden (2005) also remarked on the difference between the types of questions that students asked, which were

inclined be practical and everyday, and the spirit of the curriculum, which tends to be abstract and general. Although a high proportion of the areas covered in these syllabus documents were designed with the intention of allowing students to make links between science and its applications to the everyday, I question how many of the topics are truly relevant to the students.

Genuine engagement with science normally comes through projects outside the authorised school curriculum. It is seen when students have an opportunity to participate in community projects set in societal values (Roth & Calabrese Barton, 2004). Although the NCSE syllabus seemingly advocates for “authentic” science enquiry (GoRTT, 2008, p. 87, p. 90) and the CSEC syllabus for meaningful practical exercises (CXC, 2002a) neither of them outlines any such activities in their suggested teaching and learning activities. The syllabuses are so laden that teachers would have difficulties fitting in such authentic science experiences.

The NCSE syllabus suggests that the system sometimes venerates science in an effort to attract students to scientific careers and to support economic prosperity (GoRTT, 2008). The achievements of science are praised with reference to the discovery of laws and theories alongside the message that science enables development through inventions that are beneficial to mankind. Both the Chemistry and Physics syllabuses for CSEC credit these areas with having the wherewithal to support, respectively “the search for solutions to societal concerns and problems” (CXC, 2002b, p. 1) and “the development and production of machines and devices that contribute to the technological advance of society” (CXC, 2002c, p. 1). The authors give the unrealistic impression that students will have the opportunity to grapple with the issues involved and come to an appreciation of how they can achieve these lofty goals for the benefit of their communities.

Nadeau and Désautels (1984) describe school science as presuming a naive realism, that is, having the ability to provide a straightforward reading of nature. The instructional objectives and content areas are written in terms of facts that are to be learned. Both NCSE and CSEC syllabuses include the requirement for students to develop skills in ‘the scientific method’. The CSEC syllabus assesses students in their ability to observe record and report, manipulate and measure, plan and

design investigations and analyse and interpret data. The NCSE syllabus aims to train students to “think critically, analyse information, communicate scientific ideas and make logical arguments” (GoRTT, 2008, p. 87). The checking for misconceptions and checklist in the SBA process sends a message to students that science is always meticulous, hypotheses can be irrefutably verified through experiments and scientists are always objective (cf. Nadeau and Désautels, 1984). I have not observed any deliberate effort in the syllabus documents to highlight situations in which the integrity of practices in science was compromised.

There is scarce opportunity provided for teachers and students to be engaged as intellectuals who could question how Western science taught within schools in Trinidad and Tobago, like St Francis, fits into other world views of science. Although the lower school curriculum spoke of students growing to understand the nature of science, this was not interpreted as an occasion to make science knowledge problematic so that teachers and students could evaluate any common sense assumptions and connotations that may contribute to oppression.

4.4 Time and space allowance

Janesick (2007) sees the influence of high-stakes testing as a form of violence as it infringes on class time and imposes emotional pain. She explains that since each learner is at a unique stage of growth and development, it makes little sense to design learning programmes that assume that one size fits all. The NCSE curriculum has a spiral design. It is intended that concepts will be introduced to the students and developed to allow differing outcomes in their level of understanding depending on their age and maturity. However, this design is known to have some drawbacks as repetitions may result in boredom and make it more difficult to stimulate students’ interest in topics that were previously taught. It may reduce students’ ability to manage discussions for higher and more complicated learning. This curriculum design can tend to teachers’ being less specific in planning for students with different backgrounds (Snider, 2004).

The instructional objectives in the NCSE syllabus cover a wide range with the expectation that students will develop skills which will allow them to demonstrate higher order thinking skills, such as the ability to differentiate, investigate and design. As one moves from Form 1 to Form 3 the syllabus details fewer skills under the instructional objectives but an increase in developing students' ability to investigate. At the NCSE examinations at the end of Form 3 students may be expected to be competent in demonstrating all of the skills outlined under these objectives. The pressure of time was often apparent. In the Form 2 lesson on digestion the teacher told the students that the lesson was only for one period and they had less than half left so they would have to write quickly. "That's it. Take it down quickly. I need you to write faster." Examples observed in other lessons were: "I am going to erase it in five minutes to put up the results table" and "Can I take it off now?". In the practical lesson with the use of the callipers, neither the teacher nor students were able to complete the table put on the board by teacher before the period had come to an end.

Each CSEC syllabus document recommends that the course be delivered in 200 hours across a two year period. The Physics syllabus stresses that this time should include time for laboratory work which should be "an integral part of the course" (CXC, 2002c, p. 3). Time allocation is significant to the development of critical thinking skills as teachers may negotiate the use of time to fit with the pressures of other agendas within school life. Although the teachers are encouraged to integrate cognitive skills with content objectives, from my observations, the volume of the curriculum tends to focus teachers on the science content for teaching rather than the thinking skills as they believe that the majority of the content will be tested whereas predicting which reasoning skills will be applied in a particular context is not so apparent. This is evident in the amount of note taking seen in the lesson observations and students' complaints of "sometimes you write six periods of notes".

St Francis draws from the syllabus documents in developing its schemes of work. The schemes of work describe the timing for the teaching the topics dictated by the syllabus and the pedagogical

methods which will be implemented to achieve its aims. My impression is that the schemes of work contain less detail than the original syllabus documents as teachers attempt to fit the curriculum content into the time that is available to prepare for the all-important CSEC examinations. In doing so, some of the activities that would develop particular skills and reinforce the values outlined within the syllabus documents are not entertained. The following comparisons of the syllabuses and the schemes of work illustrate this reduction in the focus on the development of critical thinking skills and on the aspirations of a critical pedagogy.

In Forms 1 and 2 the integrated science course is divided so that Biology, Chemistry and Physics topics are taught in Terms 1, 2 and 3 respectively. In Form 3 mainly Chemistry and Physics are taught as an effort is made to address some of the content required for the CSEC science syllabus. Considering the level of interest that some students may have in particular scientific areas this emphasis may put them at a disadvantage when engaging with science and developing the skill sets that are seen to be integral to a particular subject area.

On comparing the Form 1 schemes of work for Terms 1 and 3 with the syllabus, the Term 1 scheme omits some of the objectives detailed in the syllabus. In some cases objectives are not stated; instead, topic headings such as, SI units, Basic animal and plant cells and Modified cells are used. There are instances where no activity is suggested in the scheme of work although, references are made to activities in the syllabus document. Some topics are rearranged appearing under different areas than in the syllabus, for instance, the syllabus suggests that, ‘unreliability of the sense’ be discussed while ‘explaining concepts of length, mass, volume ...’ but in the Form 1 Term 1 scheme of work this is included under the objective, ‘List two reasons for the importance of measurement’. The Term 3 scheme follows the syllabus more closely, to the point where statements were duplicated. There are still some differences though; for example, instead of ‘Teacher asks students to perform experiments to ...’ the scheme of work states, ‘Conduct labs to ...’. It seems that there is a reduction in the level of challenge outlined by the schemes of work.

The comparison of the Form 2 schemes of work with the syllabus showed that the former is a duplicate of the latter with the exception that content is omitted, under the ‘Activities’ headings. For instance, there are no activities suggested for some areas such as ‘Describe the process of breathing’ and ‘Investigate the relationship between exercise and pulse rate’. ‘Role play’, which is suggested for the achievement of five different objectives in the Form 2 syllabus, was not in evidence in any of the Form 2 schemes of work. Nineteen of the 30 activities under ‘Organ Systems and Specialization’ are omitted as are four of the 27 suggestions under ‘Electricity and Magnetism’. The Form 3 Chemistry scheme of work is not directly linked to the NCSE syllabus but instead is more focused on achieving objectives outlined in the CSEC syllabus. The activities outlined, all practical laboratory exercises, are intended to cover a wide range of learning objectives. For example, in Topic 7, ‘Acids and Alkalis’, only three practical activities were suggested to support this learning.

At CSEC the “FORM IV/V BIOLOGY FORECAST” is a one page document which outlines the order in which the objectives of the syllabus are to be addressed with time lines. By the first term of Form 4, students would have completed, four out of five sections, that is, Sections A to C and E. At the beginning of Form 5, twenty four periods are allotted for the completion of Section D leaving eighteen periods set aside for practicing examination questions using past papers. On the scheme of work disruptions due to Sports, Carnival and Mock examinations are highlighted in the second term of Form 5. Each period is thirty five minutes at St Francis, whereas the syllabus suggests forty-minute periods. Table 4.2 shows the choice that many teachers make to attempt to teach the course content in less time than recommended by the syllabus.

Table 4.2 Comparison of the time allocation in the CSEC Biology syllabus and the scheme of work

Sections in the order that they are taught	Time allocated on Scheme of Work (periods)	Time suggested by the syllabus (periods)
A	12	25

E	18	35
B	162	200
C	36	50
D	24	15
Examination Practice	18	0
Total	270	325

The difference of 55 periods between the time recommended in the scheme of work and that recommended in syllabus indicates that the teachers feel pressured to cover the content in less time than is allocated by the syllabus. One of the reasons is that they feel that time for examination practice is important.

In the Chemistry schemes of work the topics to be covered during the term are listed at the start of the document. The first of these is a 'Review of States of Matter and Separation Techniques'. Objectives aligned to each topic and the syllabus, are then provided with the relevant practical exercises. These experiments are to be written up in students' SBA laboratory books. In Term I of Form 4 the scheme of work states that "Experiments performed in form three Term I will be done by students again and written in SBA lab books as practice in writing up labs". In Term I of Form 4 students are expected to cover twelve practical exercises, five of which are to be submitted as SBAs. In Term III ten practical activities were suggested with five of them being SBAs. The activities are not detailed, for instance, 'Separation of two salts' is used to describe one of the SBAs. The eight objectives under the topic electrochemistry ranging in sophistication from define, to distinguish, to calculate, to discuss had two practical activities attached to them: 1. "Experiments involving electroplating of a coin with copper, electrolysis of copper sulphate solution with copper and carbon electrodes, electrolysis of concentrated hydrochloric acid using carbon electrodes to be demonstrated to the students" and 2. "Students then draw diagram of apparatus in lab books and discuss". In two instances the practical activities listed are "Students

will be given research project on this topic”. In the second instance “Past paper questions will be done on this topic” is also included.

There is little consistency in the layout, time and organisation of materials in the schemes of work across the Form groups, suggesting that there may not be a common purpose within the science department in terms of its philosophy about science education and its expectations except for the need to enable students to be successful at examinations.

Aikenhead (1997, 2001) and Costa (1995) describe the shift that some students make between their everyday cultures into the culture of science class, with its distinct activities, customs and style of communication, as ‘border crossing’. The syllabuses raise topics which lend themselves to critical pedagogy; however, the outline of the instructional objectives and the suggestions adhere to an apolitical approach which does not support ‘border crossing’. For example, the NCSE syllabus does make reference to having students raise their “awareness of social realities” (GoRTT, 2008, p. 22). One of the instructional objectives for the standard: “Understand the Environmental Implications of Human Activities and Steps That May Be Taken to Manage the Environment” is “explain how human activities are changing the environment globally, with serious consequences”. The students are to be assessed on describing the “Causes of alteration of the environment” and “the consequence” (GoRTT, 2008, p. 77). The suggested teaching/learning activity is to “Work in groups to research a topic and do a presentation” (GoRTT, 2008, p. 77). At no point do students have an opportunity to question the results of their search in terms of the politics, of say, the “industrialization” that continues to allow negative effects on the environment or how they, the students, as prospective workers, scientists and ordinary members of the society, may be affected by such politics. If they are not motivated to cross the borders they may see these issues as, beyond them.

Wallace (2012) makes the point that curricula with content and production designs tend to result in less varied, less contextualised and less innovative lessons as teachers are pushed to teach the same subject matter in the same way. George et al. (2003), working with teachers to adapt the NCSE

syllabus, highlight the situation of one teacher with a group identified as having special needs, who felt pressured to introduce all the areas that were intended for the regular Form 1 classes. They conclude that:

1. the national curriculum and officialdom had a stronghold on teachers as the Ministry of Education usually sanctioned changes to the curriculum
2. even experienced teachers have difficulties in taking on new roles, for example, teaching a group with special needs
3. there is a hidden agenda where all students are expected to complete the same curriculum content
4. making changes to the national curriculum in order to meet the diverse needs of students is not a simple matter.

4.5 Authentic assessment

Janesick (2007) advocates authentic assessment as a means for allowing students to explain, apply and critique their own responses and to justify their answers. It is dynamic assessment that looks closely at what students can do and how they are progressing.

There are three profiles in Trinidad and Tobago under which a student's CSEC examination performance is reported. They are: Knowledge and Comprehension, Use of Knowledge and Experimental Skills, abbreviated in the syllabus documents as KC, UK and XS respectively. UK examines the student's ability to apply, analyse and interpret, synthesize and evaluate information. XS covers Manipulation and Measurement; Observation, Recording, Reporting and Presentation and Planning and Design. All three CSEC courses are examined by three written papers and experimental skills which are examined as a school-based assessment. The written papers include Paper 1, a multi-choice examination; Paper 2, structured questions with data analysis and Paper 3, essays. The timings of the examinations range from one hour to an hour and forty five minutes. The forty two different specific learning objectives, which range in levels of competency from

'list' to 'evaluate' are listed in a glossary with their definitions and meanings. Each of these objectives is classified, with 39% of them being KC, 43% UK and 18% XS. At the end of the CSEC course KC attracted 45%, UK 35 % and XS 20% of the allocated marks on examination. The majority of the credit goes to higher order skills but with the given grade distribution it is quite possible to pass the examination with an adequate level of KC but at the time not having significantly developed higher order thinking skills. The knowledge and skills tested are not personal to individual students' lives but are generalisations. I question how much of this knowledge is expected to be for their purposes.

Assessment in schools in Trinidad and Tobago is based on what Ball (2003) describes as performativity, where students are expected to prove their learning by successfully completing tasks which provide evidence of their achievements. This data is also used to hold teachers accountable for their performance, in what has been interpreted as a 'neoliberal cooperate accountability' as opposed to a 'professional accountability' (Ball, 2003). The standards of achievement described by the syllabus documents mainly provide information for school leadership teams, employers and government. At present the agreed image of achievement plays slight regard to the feelings of students and parents who generally accept the present arrangements with very little opposition. They see high-stakes testing as a valid and reliable means by which they can judge schools and teachers. In the elitist system that exists, the results of national examinations support an education market system where these judgments affect parental and student choice (Hursh, 2007). Alongside this, there is a belief that assessments are designed to ensure that all students are provided with the best possible teaching and learning (Valenzuela, 2005). However, there was little use of 'assessment for learning' and formative assessment practices seen during the course of this study. .

4.6 Conclusion – critical thinking in the Trinidad and Tobago science curriculum

The syllabus documents do not emphasize a desire for social justice but they highlight aims directed to a democratic society in which there is respect and that members are able to contribute.

Elements of a critical pedagogy can be detected but this is limited to raising students' political awareness of how science may affect their lives and how they can make a difference. The content heavy documents are written in a prescriptive manner with extensive lists of strategies and stipulations on what students are to do in order to demonstrate achievement in stated learning outcomes. This situation does not encourage teachers to be creative and to work professionally with their students in determining what they feel will be best suited to their circumstances.

The range of topics in the NCSE and CSEC syllabuses is extensive with a high percentage of the objectives being linked to issues that may arise in everyday life. However, the topics may not necessarily be relevant to the lives of individual students or hold their interests. The topics on offer did not appear to engage students in critical assessment of how science influences their lives and the lives of members of their communities. Both teachers and students were stressed in their attempts to cover this extensive syllabus. The end result was that they both did only what was needed to get through the terminal summative examinations, sacrificing the opportunities to fulfil the goals set out by the syllabuses in terms of developing all students as critical thinkers. All assessment methods suggested by the syllabus were geared toward ensuring that students could demonstrate to examiners that they could fulfil the criteria outlined by the syllabus documents. The coursework element of the CSEC SBA is intended to have students build a range of critical thinking skills but they were not set in real life contexts.

The NCSE and CSEC syllabuses in their quest to support science education which develops the required skills to provide competent workers and citizens appear to support the learning of science in a setting that allows for individual development. The NCSE syllabus emphasizes the benefits that should accrue to individual students in terms of developing personal characteristics such as humility and tolerance. The courses are expected to contribute to preparing young people for the work place and to inculcating attitudes that will have them develop as knowledgeable responsible citizens. Students are to be encouraged to develop the skills as practised in Western science as evident in the statement which supports "Mastery of the skills and knowledge required for scientific enquiry" (GoRTT, 2008, p. 25). Developing critical thinking skills is emphasized in the

statement “think critically, analyse information, communicate scientific ideas and make logical arguments” (GoRTT, 2008, p. 87). Both syllabuses intend to engage a critical pedagogy in addressing these aims through authentic activities.

The NCSE and the CSEC syllabuses have been designed for relatively newly independent countries. These nations are also small island states which struggle to compete with more developed economies on which, in some cases, they find themselves dependent in terms of financing and trade. The neoliberal agenda has influenced the leadership of these states and the general population to accept that once their citizens have the necessary human capital in terms of the ‘Ideal Caribbean Person’ and necessary academic qualifications it is possible for the nation and its entire people to progress. As a people who have struggled and resisted imperial domination there is an awareness of the value of a critical pedagogy but this is cloaked in a concern for power and control over the masses who are required in these capitalist societies to produce goods, services and ideas.

CHAPTER 5 Findings on teachers' orientation to and practice of developing critical thinking

From an analysis of the data from teacher interviews and lesson observations this chapter examines the setting for teachers as they attempt to develop their students' critical thinking skills. The areas covered include: teachers' knowledge of science and their students, expertise in teaching for critical thinking, their use of available resources; the fitness of the classroom environment, the quality of questioning and learning tasks, the extent of teaching for development in the cognitive, affective and psychomotor domains and how the teachers organise and conduct assessments.

5.1 Expertise in teaching for critical thinking

If the purpose of education is to shift from a state of affairs where students constructed as 'other' because of their ethnicity, language and/or social class are made to fit into a hierarchical structure that is defined as a meritocracy to one in which the current inequalities are not reproduced, teachers would demonstrate expertise in critical pedagogy. They would show caring, an ethic of personal accountability, and culturally relevant teaching that supports students' competence in not taking their experience of science for granted but critique how it fits within their culture. This assumes that teachers recognise social inequities and their causes. A summary assessment of the lessons demonstrated the lack of fidelity with the teaching methods suggested by the syllabuses. I believe that this is partly because teachers' ideologies and beliefs are significant in their pedagogical choices (Ladson-Billings, 1995). The ways in which the lessons were organized did not demonstrate detailed planning of how the content knowledge was to be delivered. In organising for classroom activities teachers seemed to spend time acquiring test papers and video clips, making notes for instruction and informing the laboratory technician of the practical exercise that was to be run.

There did not appear to be any formal classroom procedures in which lesson objectives were made clear to the students. It was not common practice for teachers to outline to students the objectives

of the lessons and so the knowledge content tended to be detailed by the teachers with no indication as to the level to which the student would be expected to handle the information. In the single instance in which a teacher outlined an objective to the students, 'To learn about moles' there was no evidence of this being the case during the course of the lesson. Classes started promptly on the arrival of the teacher in the classroom. The teacher tended to give a statement to indicate the subject of the lesson. As the lessons progressed the teacher would indicate a change in subject by putting headings on the board. Students rarely worked to any targets except in the case of the SBA test on titration and one of the assessment lessons where the teacher gave them a timed open book test.

Two question and answer sessions were observed that may have been interpreted as starter activities as they were an effort on the teachers' part to remind the students of items that they had met in previous lessons. However, in general, there were no starters or plenaries. Introductions were inclined to be brief statements on what the lesson would be based on, for example, 'Today we will be looking at transpiration rates'. Twelve of the lessons observed could be characterized as 'passive', in that students were not required to demonstrate any type of learning. It was difficult to compare what students knew at the beginning and end of the lessons as 'assessment for learning' practices were not extensively employed. Learning about the complexity involved in using the knowledge came mainly in the form of questions in assessment based or examination practice lessons. In one Form 4 Chemistry class on electrolysis, the teacher provided the answers to a practice test, without seeking the students' input and the students simply recorded the teacher's responses.

The majority of the lessons were teacher-centred with the teachers 'banking' information with the students. The main means of communication with the students was via direct instruction where the teacher told the students what they felt they needed to know. This information came to the students mainly in the form of lectures by the teacher or via video with additional guidelines in the form of drawings, diagrams and tables on the board. In most cases students were expected to take notes. There were cases in which the dictation was so detailed that the teacher used statements like

“Write this down”. In one case the teacher read from the text, stopped to correct an error in the dictation by telling students to remove the comma, completed the sentence and ended with “full stop”. Only in one instance did I see a teacher provide students with hand-outs to assist them in their understanding. Teachers, in the main, did not seem to recognise that knowledge is not static but shared, recycled and consolidated, that knowledge is to be critically reviewed and that scaffolding facilitates learning (Ladson-Billings, 1995).

In assessing teachers’ understandings of the characteristics of critical thinkers the majority of teachers saw critical thinking as being able to “reason things out”. Four of them saw it as a part of “coping with everyday situations” with three saying that it was about depending on oneself. A person’s ability to use English and memory were each mentioned once. One teacher did admit, “I don’t have a definition”. In describing what they understood to be the characteristics of someone demonstrating critical thinking, the characteristic mentioned by most teachers was ‘curiosity’. More teachers recognised critical thinking in their students who were alert, willing to listen and think in order to solve problems and prepared to take risks, that is, ‘willing to step out into the deep’. Fewer of them talked about students’ psychomotor skills in terms of ‘how they carry out the experiment’ and ‘can do two things at the same time’ and students’ confidence when considering their ‘assertiveness’. One teacher explained that “I don’t really consider anybody who comes in front of me as having critical thinking characteristics”.

The majority of teachers at St Francis felt that their students had little facility as critical thinkers. Apart from a belief that:

- gender – “some boys in particular are very interested in how things work” (Teacher A),
- maturity – “What we taught them in Forms 4 and 5 was not actually true and of course they want to know why we lied and we tell them it is easier for you to understand it this way, when you hit Form 6 we tell you the truth. That way, you are mature and experienced enough to understand why” (Teacher D) and
- health – “If the child is not sleeping properly and not eating properly they (are) not nourished so their attention span is short” (Teacher C)

could affect critical thinking development, teachers' feelings could be themed as 'Students are not able to think or use their imaginations' as evidenced by "... to get them to actually think sometimes is difficult" (Teacher F) and "They don't seem to have much of an imagination" (Teacher C). Teachers suggested that this was because of students' lack of reading.

According to Teacher G "They only read what you ask them ...". Teachers also believed that instant access provided by technology – "Everything is on the internet, they go and click and they get it" (Teacher C) – and examination pressure – "... we get accustomed that this is what is going to come for test and just learn the answers" (Teacher A) – contributed to students' lack of critical thinking abilities. Some teachers did appreciate that pedagogical methods are important for student engagement and so could influence thinking abilities. Teacher D explained "Rather than us telling them what is going to happen, let them see it themselves. They seem to like that approach better than us standing in front of them telling them".

The teachers at St Francis appeared to have very different ideas on what is required to develop critical thinking skills. They provided the following list of strategies when asked to identify how they go about teaching thinking skills:

- Give notes
- Spoon feed the students
- Practical exercises
- Influence student choice
- Teach students to read
- Minimize direct instruction
- Encourage students to use their imaginations
- Explain for understanding
- Use questioning
- Use real life contexts.

Some of the methods highlighted, such as give notes and spoon feed, suggest little appreciation of what is required. Teacher C did admit to not being sure of what strategies would be useful: “my style of teaching suddenly has to change and I don’t know what to change”. On the other hand, there were suggestions, such as minimising direct instruction, that indicated that there are teachers within the department who may engage strategies which assist in the development of critical thinking skills. The concern here is that some teachers may have ideas but their capacity to apply the suggested strategies with the required level of expertise is unclear.

In assessing teachers’ understandings of the extent to which the science curriculum contributes to the development of critical thinking, there was only one of the seven teachers who did not think that the science curriculum contributed to students’ critical thinking. The other teachers felt that it did mainly because it allowed students to be curious: “The topics allow students to ask the question, ‘Why?’”. It was felt that there was the opportunity to understand how things work and what they were made of particularly through the study of Chemistry and Biology. One teacher expressed the view that students now had the chance to learn through different media. This made learning easier and more fun.

Teachers, in the main, were happy with the curriculum documents and felt that many of the changes required were in the way in which teachers worked and the conditions of work. Herbert et al. (2009) confirm that teachers speak well of the NCSE syllabus which they consider to be well organised and user friendly. The constraints described were based on class sizes, physical resources, time and the pressures of high stakes final examinations. However, it was felt that if the curriculum was well delivered students would develop as critical thinkers. Teachers referred to the need to be well trained and to pay attention to the syllabus requirements. Teacher B was of the opinion that “sometimes teachers need more guidance in terms of how to teach the particular concept, in terms of methods” and Teacher C felt that “we need to sit down and look at the syllabus and analyse it”. The teachers explained that it was important that they were passionate and showed caring to their students. Their teaching should not be confined to the syllabus content but be meaningful to the students. According to Teacher C “in terms of delivering one has to look

beyond just the scope of the syllabus to see how best to make it meaningful for the rest of the person's life". Teachers wanted to see students involved in more practical exercises and encouraged to be creative through exploration. Teacher A said:

If you go into a lab and you do the lab without doing the theory before, I mean in-depth theory, they can actually learn from their results. So you can push them and say you got this result what does it mean. It is not just about coming and giving children instructions to do an experiment. There are different ways in which you can do an experiment to make it more meaningful, instead of giving the children instructions you could guide them with questions in doing the experiments and they would come up eventually with what the answer is supposed to be. Instead of just giving them the recipe to add this to that and write down what you get.

Teacher C made the comment that "teachers don't like to do too much practicals and there are many who don't like the practical aspect".

During the course of the interviews teachers made several comments on how they felt their colleagues' behaviours and attitudes influenced the delivery of the curriculum. They mainly attributed these behaviours and attitudes to the importance attached to national examinations. They expressed the view that the range of 'teaching methods' was narrow and that "students are not genuinely being taught to understand the curriculum". Teacher A claimed "They are drilling them in particular with multiple choice answers which is forty percent of their exams". Some teachers thought that many of their colleagues' attitudes were based on their personalities as described in "...they are stuck in their ways", have "insecurities", "flawed with humans and ego", as well as their level of training. A couple discussed the impact that teachers' behaviours and attitudes had on students' development as critical thinkers and their ability to apply themselves, making statements such as "Their understanding of what they are teaching is very much influential to these kids" Teacher (D) and "The mere fact that coming early to class would tell them if you are interested or not in teaching them. Children feel it and children notice these things and children plan for it" (Teacher D).

The majority of the teachers did not feel that they were well equipped to teach critical thinking skills to their students. These feelings are reflected in a study by Herbert et al. (2009) who noted teachers saying that they needed to develop thinking skills if they were to assist their students in this area.

Two of the teachers, however, felt that through their own efforts they would have been able to do what was required. They felt that their personal qualities and experience provided them with some of the tools necessary for teaching thinking skills. Three teachers felt that it was their responsibility to equip themselves; as one said: “I get support when I ask, they wouldn’t know unless I ask”. They saw the challenges as time, resourcing and the fact that they were expected to ensure that the students passed their examinations.

The analysis of teachers’ schemes of work, lesson observations, exercise books and teachers interviews led me to conclude that students’ experience of science education was characterised by a narrow range of direct teaching strategies which was mainly the result of examination pressure and teacher quality in terms of pedagogical understandings and attitude. The students’ experience was not in keeping with the ambitions of the syllabus documents. In two of the lessons it was evident that the teachers had employed all the teaching methods that were outlined in the relevant syllabuses. In all fifteen of lessons, the activities that were not witnessed, involved practical activities in the form of laboratory work, presentations, using and making models or discussions. As seen in Table 5.1 there is a mismatch between the expectations of the syllabus and the scheme of work designed by the teachers.

Table 5.1 Frequency of learning objectives in the scheme of work for Form 3 Chemistry as compared to the NCSE syllabus

Learning objectives seen in Form 3 scheme of work produced by teacher	Frequency of mention of learning objectives in the scheme of work	Learning objectives in the NCSE syllabus
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Appreciate	4	
Understand	1	
Define	7	
State	2	
Explain	1	Explain
Give examples	1	
Distinguish	3	Distinguish
Identify	2	Identify
Discuss	2	Discuss
Draw	1	
Relate	1	Relate
Describe	2	Describe
Write	1	
Perform tests	1	
Investigate	2	Investigate
		List
		Demonstrate
		Compare
		Differentiation
		Measure
		Outline
		Construct
		Design

In the scheme of work many of the higher order learning objectives, such as ‘differentiate’, ‘construct’ and ‘design’, are omitted. The learning objective most frequently mentioned was the ability to define. No suggestions were offered to fulfil the ‘Appreciate’ and ‘Understand’ objectives. The activities were listed at the end of a list of objectives and so were not directly linked to individual objectives.

The Form 3 scheme of work for Physics did not outline any learning objectives. The year’s work was divided into nine topics with sub-topics. In Term I: Fundamental and Derived Units, Measurement, Graphic Representation of data and Mechanics. In Term II: Energy, Thermal Energy and Light and Sound. In Term III Electricity and Magnetism are covered. Teachers were referred to one Physics text and the SEMP syllabus.

In the main, teachers at St Francis saw critical thinking in the more conventional sense related to logic and analysis and did not mention social issues when explaining what they understood critical thinking to be or when describing the characteristics that they would expect in someone who was a critical thinker. Five of the seven teachers said that they did not feel well equipped to develop their students’ thinking skills. The data collected from the lesson observations, exercise book audits and interviews gave the impression that the range of techniques used by teachers was insufficient to support a critical pedagogy. This is further underlined by writers who have raised concerns about the relatively high number of teachers within the Trinidad and Tobago system who have not developed the pedagogical methods that are called for when developing students’ thinking skills (Herbert & Rampersad, 2007; Jules, 2010; De Lisle et al., 2010).

Although there is a perception that Trinidad and Tobago’s education system should develop young people who think critically about their role and the role of science in their lives and the lives of others in the society, much of teachers’ and students’ concerns continue to be primarily about gaining economic success and achieving individual mobility. As Teacher D puts it:

Not everyone develops into a human. That's the only way I can put it because society has become selfish and very self-centred in caring for themselves and even if CXC implements it as part of the syllabus I am telling you teachers would be very offended about it. Not everybody teaches like that. Most of them are geared to passing a subject. Science teachers, in particular, are going to feel that it is asking too much of them.

Economics is seen as more important than democratic principles. There was little evidence of teachers having an understanding of how power, ideology, and politics operate in schools so as to weaken the basic values of some communities and democracy. In their drive for excellent examination results teachers in the main are happy with the curriculum. They did not bring up any concerns about school practices that could possibly be promoting failure among any particular groups of young people. There was no consideration for how social class, privilege or other socioeconomic forces could impact students' success in secondary school science.

EMIR (2013) established a link between teachers' thinking styles and their critical thinking dispositions. One conclusion of this study was that if teachers can use their thinking styles in developing their own critical thinking abilities they will transfer these to the classroom. Thinking skills approaches have been seen to support young people's attainment if they are allowed to investigate, inquire, seek clarification, use their imaginations and take intellectual risks. Many trainees and in service teachers in Trinidad and Tobago would not have had these opportunities through the traditional route and so must be provided with the space to engage in similar intellectual exercises. Leacock (2009) points out many teachers model their teaching styles on their own experiences as students. These styles would also be based on observing their colleagues, advice from more senior teachers and their own understanding about teaching and learning. The resulting teacher characteristics are unlikely to support the development of a critical pedagogy in Trinidad and Tobago's classrooms.

5.2 Teachers' knowledge of science and their students

In Basu and Calabrese Barton (2010) it is asserted that students rely on subject matter knowledge in order to bring about change and to address power differentials that influence their lives. In sharing authority and providing the context for complex knowledge and enquiry-based tasks, teachers must have the requisite understanding of their subject matter and their students' situations. In all but one of the lessons the teachers appeared to be familiar with the content knowledge with which the students were to become versed. The teachers were able to respond adequately to students' questions. Their responses were normally in the form of mini lectures as in one case where the students of a shared class said that the other teacher had not told them about Brownian movement. There were a couple of instances where the students pointed out areas in which the teacher did not provide correct information, for example, in a Form 1 Chemistry lesson the teacher told the class that "Any liquid can evaporate but boiling involves heat".

Teachers showed some familiarity with their students by identifying them by name and in one case a teacher did address students' emotional issues. Teachers appeared to be comfortable with their classes but in the single case where this did not occur there were classroom management issues where students were talkative and not paying attention. Student-teacher relationships were fairly fluid with teachers demonstrating a limited connectedness with their students. An awareness of other peoples' worlds was not seen as a priority as little effort was made to set up communities of learners or to encourage students to learn collaboratively and to be responsible for one another (Ladson-Billing, 1995). There was very little evidence of differentiation based on the teachers' knowledge of the abilities and situations of their students. It did not seem that planning was based on thorough and accurate assessment. Teachers rarely used students' responses to guide the lessons. A starter activity was seen only once in a Form one Chemistry lesson but the responses were not used to determine the lesson design. In another Form 1 Chemistry-lesson there was an attempt to make the lesson more student-centred but the support of self-selected peers in group work and the use of notes from exercise books were not sufficient to adequately support the learning needs of all students.

Some teachers acknowledged that students could think but, in general, teachers felt that students' ability to think was not what it should be. Some acknowledged that students can think. They thought that this ability was hindered by their narrow breath of reading, examination pressure, teaching methods and one teacher mentioned the importance of health.

5.3 Use of resources

Freire and Macedo (1987) advise that materials should not be simplistic or patronizing but suited to the students so that they can discover their world and critically examine their own social situations. One teacher in St Francis commented on the lack of resources: "You are limited and that is one of the reasons why I have always stayed with the traditional, call out, draw and write" (Teacher C).

Teacher G commented that "we just don't have the equipment so all we would do is look at the text books". The textbook series used in the lower school are designed to fulfil the requirements of the SEMP syllabus as evident by the matching chapter headings and the knowledge content. However, as an enhancement, snippets of interesting information not required by the syllabus are included. Each of the books is attractive and colourful with illustrations that reflect life in Trinidad and Tobago. Pictures are used in activities, for example, students are asked to select, from a set of pictures, ones that show a misuse of science. The instructions for practical activities are illustrated. Each chapter begins with an outline of the learning objectives that are to be achieved. Information is well laid out using bullet points and tables. A list of key points is provided, in each chapter, which summarises the main concepts and principles. Questions are posed in different ways. There are questions which ask students to recall, think and apply information; others that involve calculations or conversions; review questions at the end of each chapter and opened ended questions that are designed to provide students with the opportunity to think critically and creatively (Hoong, Leng & Khang, 2003). Readability measured 54 on the

Flesch-Kincaid Reading Ease Scale⁴ with the average grade level as 10.4. In addition, to the main textbooks, students also have access to workbooks, that they are encouraged to buy, which give them practice in recording, drawing graphs, interpreting, explaining and drawing conclusions (Hoong, Leng & Khang, 2003).

The teaching of CSEC Chemistry begins in Form 3. The Chemistry textbook used in Form 3 covers the topics outlined in the CXC syllabus. It is not one of the books on the recommended reading list for CSEC Chemistry. The book has coloured attractive illustrations which reflect students' life experiences and culture. The book has a clear layout with each section described in the syllabus divided into separate chapters. The Flesch-Kincaid Readability Ease measures 65.9 with an average grade level⁵ of 9.6. The objectives are outlined at the beginning and there is a chapter summary at the end of each chapter. Examination questions, similar to those that would be in the CSEC examination are included to close each chapter and each section with the relevant mark allocations. Activities are included which support students practice in achieving the skills required for SBAs. The appendix at the end of the book includes: an example of a SBA practical test; a chart which matches SBA skills to activities outlined in the text; examination type questions; examination tips; answers to numerical questions; safety symbols and an index (Clark & Oliver, 2004).

Those students who have selected Chemistry as one of their CSEC subject choices in Forms 4 and 5 are moved on to another Chemistry text. This text is on CXC's recommended reading list for this subject. This new text has no coloured diagrams and fewer illustrations than the text used in Form 3. It was explained to me, by a Chemistry teacher, that in making the Form 3 book more attractive and student friendly, space for detailing knowledge had been sacrificed. The Flesch-Kincaid Readability Ease is 64.9 and the average grade level is 7.7. The Chemistry text used in the upper school is divided into blocks which are further sub-divided into chapters. These are

⁴ On the Flesch-Kincaid Reading Ease Scale a higher score indicates easier readability; scores usually range between 0 and 100.

⁵ Average grade level provides the average reading level in terms of year groups. The averages are based on the Flesch – Kincaid, Gunning – Fog, ColeIman-Liau Index, SMOG Index and Automated Readability Index. In this case grade 7 will be equivalent to Form 1.

clearly not aligned to the syllabus. Each chapter has a heading but the learning objectives are not outlined at the beginning. Some main points are captured in boxes in the margins of the book. There are chapter summaries at the end of the chapters. In the layout use is made of bullet points and tables. There are experimental procedures outlined with additional activities, most commonly, in the form of questions and calculations which are intended to guide students to appropriate conclusions and to build interpretative skills. Each chapter concludes with review questions which require students to demonstrate a range of skills which include: recall, problem solving, interpreting and explaining. The questions progress from simple ones to ones that more resemble those that students would encounter in an examination (Lambert & Mohammed, 1993).

The Biology text used in Forms 4 and 5 measures 60.7 on the Flesch-Kincaid Readability Ease Scale and suits an average grade of 9.5. It is not on CXC's list of recommended text. It has an attractive layout with coloured diagrams and pictures reflecting indigenous flora, fauna and cases of interest to the students. There is some inclusion of foreign examples as in the case of a picture illustrating patients having blood transfusions. The use of tables, bullet points and bold type make the subject matter easy to follow. The text is laid out in line with the Biology CSEC syllabus with corresponding sections and chapters linked to the subsections. Each chapter begins with learning objectives. As the chapter's content knowledge is outlined there are questions within the margins which are designed to allow students to test their understanding, of the material, through recall and explanation. The answers to these are placed close to the end of the chapter before the chapter summary and followed by examination type questions (Atwaroo-Ali, 2003).

The Flesch-Kincaid readability ease scale gives a reading of 63.6 for the Physics text used in Forms 4 and 5 with an average grade of 9.9. This book is not one recommended by the CSEC Physics syllabus (CXC, 2002c). The text has a soothing feel as it is mainly a black and white text with sky blue highlights. The book is entitled 'Physics for CSEC' and includes the subject matter required of the syllabus but it does not follow the outline as syllabus document as in other texts. Each chapter is divided into subsections with individual lists of objectives. There are monochromatic pictures and diagrams on every page but there is no emphasis on local examples or

people. Key facts, activities to support the acquisition of SBA skills and worked calculations are placed in the margins close to the relevant factual material. At the end of each chapter there are examples of examination questions. The book concludes with a chapter on SBA, tips on preparation for examinations and answers to calculations found in the book (Avison, Henry & Neeranjan, 2007).

The activities seen in the exercise books could be classified as Notes, Assignments, Questions and Answers, Examination Questions, Labs, Use of Technology and Field Trips. 'Notes' were provided in different forms as the teachers provided examples; however, the majority were in the form of written notes that were either copied from the board, other text or dictation. After written notes, 'Illustrations/Pictures/Diagrams' were the most popular means of students recording information provided by their teachers. 'Tables' were used to organise information and used for showing comparisons, advantaged/disadvantages and classifications. In the lower school 'Definitions' and key words were often highlighted. Notes also included guidelines in the form of rules or the statement of techniques most often in the context of examination preparation. In the fifty three exercise books observed there were thirty two incidents of untidy notes, indicating to me a lack of interest. The subject areas seen in the exercise books were the same as those outlined in the SEMP and in the CSEC syllabuses with the majority of them having a link to everyday life. Of the notes provided, seventy five percent could be described as having direct relevance to everyday life.

When looking at 'Assignments' students were mostly asked to search for information. Forty six assignments were seen with the next most popular type of assignment being seen in the seven incidents of 'learn'. Activities such as 'make a model', 'write an essay', 'engage in discussion', 'summarise' and 'present' were cited only once.

In the 'Questions and Answers' tasks 'problem solving' was seen fifty nine times compared to the next popular being 'recall' which was seen twenty four times. There were thirty two instances of

students marking their own work as compared to seventy seven of their work being marked by the teachers. There were only four occasions where comments were placed on these exercises.

In the 'Examination Questions' that were being practised, the majority, that is, fourteen, asked for 'recall' as compared to four requiring application and three sighting demands for understanding and logic.

Of the laboratory exercises observed, twenty laboratory reports were written up. There were forty three sightings of 'observations' and forty of 'discussions'. There was only one sighting in which students were asked to plan an investigation.

The use of technology was minimal with teachers providing video material in some cases but at times encouraging students to refer to web sites. Although all the Form1 and Form 2 classes were issued with laptops from the Ministry of Education, the only use of technology observed was the use of video material in the teaching of electricity and digestion to students in the lower school. The opportunity for field trips was not frequently mentioned as only one occurrence was noted.

The teachers related a range of factors outside the curriculum which they thought had an effect on the development of students' critical thinking skills. Some acknowledged that teachers were responsible and that a range of teaching strategies needed to be employed. Three of the ten themes were centred on teachers' work, with Teacher A referring to "stimulate all forms of learning" and Teacher B to "creativity in terms of how you teach". Teachers' personalities were also seen as important as it was noted that "they (the students) actually sign off on a subject especially if the teacher is not approachable or the teacher is not making them feel comfortable enough" (Teacher D).

Teachers discussed the need for teachers and students to be furnished with the necessary technical equipment and personal support including parental support. Teacher F recognised the "need to be exposed to more computers". In terms of support from other people, Teacher B mentioned "Use of

mentorship” and “networking between schools”. Teacher G expressed the view that “Parents don’t really help in ensuring that they do what they are supposed to do”. Teachers also felt that students had a role to play in term of their level of patience. Teacher C noted that students wanted “instant gratification so you are not encouraged to wait for anything, you are not encouraged to long for anything, you want it go get it”.

In concluding the discussion on resources the teachers talked about the support that they felt that they needed to facilitate student learning of critical thinking skills. They again spoke about the need for information, communication technologies. Teacher F wanted “easy access to PCs” and Teacher C raised the point that “We don’t have internet servicing the entire school”. They mentioned improvement of the physical plant. Teacher A said that “When the rain is falling they (the students) get wet” and complained that “our classrooms ... are very hot”. Teachers also had issues with the bureaucracy involved in doing what they felt was necessary for supporting students’ critical thinking. Teacher G explained that “the red tape and a lot of stuff you have to go through”. As far as addressing the support required in term of organising for teaching and learning, teachers wanted:

- time and smaller class sizes (Teacher G)
- shared good practice – “get all the teachers at least in our department to start working together and not have the situation where “they believe that their intellectual property is being stolen” (Teacher D)
- improved cross-curricular links – “we have been trying to link the topics, link the subjects. It’s not a formalized thing” (Teacher D)
- improved assessment methods – “make sure they have a wider pool (of examination papers) and ... change it every year” (Teacher A)
- the opportunity to learn from students – “I realize teaching is about learning from the students as well and developing and not just teaching a curriculum” (Teacher F)
- The support for teacher training was again mentioned by Teacher C who described the level of support by “I think we have had one or two (curriculum officers) visit

but I am not always aware because it is not like they come and see me teacher or anything”

The nature of the required resourcing outlined was in the areas of conditions of work, improved pedagogical methods and building teacher capacity. When considering the conditions of work Herbert et al. (2009) found that teachers complained of limited resources. The stress from high stakes examinations, was mentioned but it was also felt that there was a need to invest so that the content of lessons was meaningful as Teacher D explains: “something they have read, something they are curious about and they want to know”.

5.4 Classroom environment

Ardizzone (2007) asserts that true education is a result of stimulating a student’s power as demanded by social situations. She explains that these powers are what make youth behave as members of a unified group; they can start to see themselves as part of and instrumental to the welfare of the entire group. The institutional setting contributes to the context that influences students’ learning experiences. The context should encourage students to reflect so as to shape their beliefs, values, attributes and ways of thinking that lead them beyond knowing, to taking action (Chubbock, 2007). This section seeks to describe how well the classroom setting encourages this type of student reflection at St Francis College.

Clayton (2002) claims that a stimulating classroom environment gives students the opportunity to learn from their peers and to appreciate the work of others. It can assist in developing the affective domain by nurturing empathy, respect and a sense of classroom community. The classrooms at St Francis tended to be bare, containing only chairs facing forward with tables in rows. There were posters on display in some of the laboratories but these tended not to be relevant to the learning focus at the time. In a Biology lesson on cells the teacher brought in a poster, done by a student, to demonstrate the differences between egg and sperm cells.

In some of the laboratories there were shelves designed to hold chemicals. The position of these sometimes prevented the students from clearly seeing what was happening at the front of the classrooms. In one Form 5 Biology class there were six students standing in their attempt to copy notes from the board. The laboratories were air conditioned so as to cool the rooms but this was not the case in the classrooms which, as previously mentioned by Teacher A, could be quite hot and uncomfortable.

Teachers were respectful towards the students using non-threatening tones which made them approachable but they rarely demonstrated a belief that students could contribute any knowledge to the lesson. Questions from students were not discouraged but at the same time not actively encouraged. There was one occasion, during the course of a Form 2 Physics lesson, where the teacher did answer most of the students' questions but did not answer "What is thunder fall?" and "Miss does the rain charge the lightening?". The few discussions that did take place involved the whole class with students calling out responses if they knew the answers to particular questions or if they wanted to make a contribution. In the Form 3 Physics lab on measurement and Form 4 Chemistry open book 'assessment' the teachers did respond to students' questions as they roamed the classroom. In this Physics class the teacher invited "Any questions?" One student asked a question on the number of decimal places that should be stated in the answer. In responding the teacher added "I have said this enough times."

On the whole the students were compliant and motivated to learn. There were some off task activities in some of the groups which were ignored by the teachers if they were not felt to interrupt the running of the lesson. As a headteacher, I was particularly concerned about some of the Afro-Caribbean cliques in terms of how they engaged with their science lessons. There were no indications of overt disrespect. In one instance a student was seen eating and sharing chips in the laboratory as the teacher roamed the room. At one point the teacher called out her name and she responded "What did I do?" as she stood shaking a bottle of drink.

The environment was limited in its support for individualized learning opportunities. However, in the lesson with the SBA Chemistry test, the room was set up so that each student was responsible for his/her titration and calculations. In four of the lessons the teachers roamed the classrooms acting as facilitators to those students who wanted to ask questions but these teachers did not pay close attention to student conversations or to what they had written nor did they interrupt student activity to enquire as to the level of progress being made. In the Physics Form 3 lesson the teacher invited the students to call her over to see what they had done when attempting to measure a block with callipers. This teacher did speak to individuals on the use of the instrument.

Teachers' greatest concern was their students' examination success. They felt that once students had the correct information and studied well this would bring about success for every student. All students were seen as capable and this therefore meant that individual attention was unnecessary. The materials were not differentiated, but in general, appeared to be appropriate for most of the students based on the reading and mathematics scores of the students who did the national Secondary Entrance Assessment tests and had gained entrance into this school. The environment was limited in its support for individual learning opportunities.

It appears that, teachers saw their job, as good teachers, to ensure students understood the information but many of them did not do what was necessary to ensure that the students were indeed fully conversant with the required knowledge, at all levels, as the assessment for learning strategies, on the whole, were not well carried out. Teachers believed that they had a responsibility to teach and students had a responsibility to put in the work needed to learn. Learning the information that was to be examined was best done by rote learning. Any skills, including critical thinking skills, needed in managing different questions would come from answering questions posed by the teacher, text book or examination papers. In going through a past paper question with the Form 4 Physics class the teacher states "We have done this several times so you will be able to do this on your next assignment. We will not be hearing anyone asking for help".

Neither the teachers nor students felt that they had any control over what was to be taught or learnt. This was determined by the examination boards and the syllabus documents. The teacher, however, was expected to know all the information and students had very little contribution to make to what was important learning. In a Form 3 lesson on atomic structure the teacher pointed out, what the CXC criteria was for illustrating electrons in shells and warned students not to use some diagrams that they may find on the internet. There was only one lesson, the Physics lesson on the use of callipers, where the teacher asked the students to explore and report their findings.

The teachers cared about their students and would have liked them to find their science lessons interesting. They were aware that the students enjoyed practical lessons, looking at video recording and school trips and so these were used as a means of encouraging student interest, mainly in the lower school. In the upper school, there was a greater emphasis on doing what was necessary to grasp the extensive content outlined in the syllabus documents and so the focus was on lectures, examination practice and completing school based assessment exercises. A Form 5 lesson on the school-based assessment designed to develop students' scientific skills was scripted in every detail. The students were to do the practical exercise the following week and in this lesson the teacher gave notes on what was to be included in the report on osmosis. The teacher provided the aim, the list of apparatus, a step by step method and even dictated to them the conclusion in which she defined osmosis and described how the concentration of the solution would affect the movement of water in the potato tissue. She reminded them that the write up was to be in the past tense and held up one student's book as an example of how neat the presentation should be.

English language has global status but at the same time there is the realization that the subaltern has attempted to resist its imperialist and colonial nature (Kumaravadivelu, 2003). The NCSE syllabus recognizes that:

the student of Trinidad and Tobago functions in a bidialectal context, that is, the natural language of the student, the Creole, differs from the target language and language of instruction, Internationally

Accepted English. The philosophical position taken in the national curriculum is that both languages are of equal value and worth, and both must be respected. Students use their own language as a tool for interpreting the content of the curriculum and for mastering it. In addition, they must be taught to use the target language as effectively and effortlessly as they would their natural language (GoRTT, 2008, p. 13).

To me this statement is problematic in that the ‘language of instruction’ is different from the language that students use to ‘interpret the content of the curriculum’. Language is ideological and dominant ideologies work to bring about norms within classrooms (Degener, 2001). Macedo (1994) makes the point that when great importance is placed on learning to speak, read and write in the standard language this delegitimizes the language that students bring. Students, as encouraged by the NCSE syllabus, need to see that their teachers value their language and, in turn, their ideas. Evidence from students’ exercise books shows the importance of good English grammar and the passive voice being emphasized by their teachers. There is therefore the risk that non-standard English speakers may be devalued and become passive participants. Degener (2001) argues that the curriculum should be grounded in the students’ languages if they are to interpret the world and take part in its transformation. A balance has to be struck. Freire and Macedo (1987) do consider the need for students to have an appreciation of the dominant language. Shor (1992) believes that the importance of Standard English must be recognized and suggests that students are given opportunities to use and study the language and not be restricted to their own dialect.

Shor (1992) is convinced that students lose their motivation to learn if they are expected to work in an environment that makes them feel that their backgrounds, experiences and ideas do not count. Dialogic communication is suggested by Freire as an important route towards actively involving students in a personal, meaningful education. He believes that dialogue which requires critical thinking allows students to become critical thinkers and that true education only comes through dialogue (Freire, 1998). The NCSE syllabus (2008) does suggest ‘Discussion’, ‘Questioning’ and ‘Debating’ as strategies and the CSEC syllabus claims to be “designed to allow students to work ... with others” (CXC, 2002c, p. 1); however, very little of this type of democratic discourse was

observed via lesson observations. In their suggestions neither teachers nor students seemed to place a high value on dialogue as a means of learning. In the exercise book audit there was only one instance of discussion and teacher F did indicate an awareness of the need to “learn from students”. A classroom in which there is discussion and everyone shares their opinions is not necessarily a dialogic classroom (Macedo, 1994). Activities and conversations are to be genuine ones in which students are happy to express themselves and teachers fully engage in what students have to say (Freire, 1998).

5.5 Quality of questioning and learning tasks

The quality of learning tasks is important for assessing students’ knowledge, improving comprehension and promoting critical thinking. Well designed questions can allow for new insights, generate dialogue and allow for the comprehensive study of subject matter. Poorly constructed tasks can diminish learning by causing confusion, intimidating students and reducing creative thinking (Tofade et al., 2013). At St Francis assignments were mainly based on searching for and learning information.

Questioning was used as a means of introduction as opposed to a means of assessment. Students were asked closed questions but their responses were not used to develop their learning. In a Form 1 Chemistry class:

Teacher: Please remind me of what is an element.

Students shout out definition.

Teacher: What is an atom?

Students shout out definition.

Teacher: What is a compound?

Students shout out definition

Teacher: I gave homework. What was it?

Students: To learn the first twenty elements in the periodic table.

Teacher: What is the first atom in the periodic table?

Students recite the first twenty elements.

Teacher: Today we are going to look at atomic structure and atomic mass.

In two of the lessons students were asked to attempt timed questions and these were then discussed. In one Chemistry-based session the teacher rarely asked for student feedback but simply gave the answers. In the example of a Form 4 Physics lesson the teacher gave the students ten minutes to complete a question but within five minutes the students were being taken through the geometry. This teacher did ask the students questions to help them to understand the solution as opposed to simply telling them the answer.

Student A: Sir, do you need values?

Teacher: You do not need to have values. What kind of triangle?

Student A: Isosceles.

Teacher: What does that mean? What is the relationship? What will you do next?

Student A: Use Snell's Law.

The teacher asked Student A not to answer in order to allow another student to make suggestions. The teacher then asked "Is she correct?" to which Student A responded "No".

This Physics teacher also posed questions with the expectation that the students would provide the answers without his prompting.

Teacher: At this point you are going to work this on your own and you will tell me what value you get for r ?

Student B: r is 14.7.

In most of the lessons, teachers questioned students as a means of reminding the students of material that they had already covered or as an introduction to a topic. For example, in the Form 2 lesson on electricity the teacher asked "Who can tell me what is AC and DC?" One student responded "What?" and the teacher then went on to give the definitions. In a Form 2 Biology class

the teacher used questioning during her lesson and references to homework as a means of reminding students of the previous lesson as opposed to making any assessment. She went through the class signing off homework as having been seen but at that time did not check to see what level of understanding was reflected by what the students had written.

In most cases, questions tended not to be probing ones and the students' responses were not used to develop their thinking or understanding. Questioning sessions were brief with students calling out responses. In a Form 3 Chemistry lesson the teacher reminded the students that they had taken notes on acids and bases. She then asked them what the symbols, aq, g, l and s represented and in unison some members of the class shouted out the correct responses. She told them "Now we are doing 'Alkalis'. This is a next sub-topic." As the teacher was writing the note on alkalis, the students were copying it but the teacher simultaneously asked students questions on bases, carbonates and acids. She told them "You are fumbling a bit and so you need to go back and revise. It is important that you revise your notes as you need that foundation".

At times there would be the same few students answering the questions or engaging in the discussion. In a Form 4 Biology class the teacher asked "What is humidity?". One student responded. The teacher considered the response and clarified. The teacher then drew an illustration of transpiration on the board and asked "How do you think humidity affects transpiration?". One student responded (no feedback from the teacher). The teacher then said "Head up humidity (Instruction to students to write 'Humidity' as a title) and take down this diagram". All the students sat quietly, copying the diagram. The teacher then asked "Are you ready now?". Some of the students called out "Yes Miss" and the teacher went on to dictate, from a textbook, the definition of humidity and its effect on the rate of transpiration.

In a Form 2 Biology class the following question and answer sequence took place:

Teacher: What does flagellum mean?

Class: Helps the cell to move forward.

Teacher: (No response to student questions) but immediately follows with “We are going to draw the sperm cell”.

Following on, based on the question ‘What happens to the other cells when only one fertilizes the egg?’ asked by a student in the class, I felt that students would have appreciated more flexibility in the discussions with their teachers. As in the work by Herbert and Rampersad (2007), much of the questioning observed was used to have students recall knowledge from previous experiences, sometimes as a scaffold for introducing new knowledge but very little of the probing questioning which develops students’ thinking.

Teachers sought to gain student interest through the use of video material, practical exercises, field trips and emphasizing the importance of the information to their examination success. In one Form 2 class on digestion the teacher explained to me that the students were excited because they had seen a video clip in the previous lesson. The video clip shown on electricity to a Form 2 class presented authentic situations and the students were inspired to ask questions about events relevant to their lives. Some of these were:

If you are struck by lightning will you live?

How much does copper cost?

What do they want from the wire?

What is a filament?

What is the difference between old and new light bulbs?

In a Form 2 Physics lesson a teacher reminded the students that she allowed them to role play (not seen in any of the fifteen observations) because they liked doing it and went on to tell them “Instead of chalk and talk I’m showing you a video”. This teacher also felt the need to explain to her class that “This term everything is practical”. The class was also reminded of the field trip that it had made to Niherst (The National Science Centre). Students were always excited at the prospect of doing a practical exercise. Of the two observed, one was a test and the other was based on learning how to use callipers. In the later there were varying degrees of engagement, based on

whether the students were being adequately supported at the time. For example, at one point some students were taking measurements while others were waiting for the equipment. The latter group engaged in private, off task conversation.

In two of the lessons based on the development of examination techniques the teachers made sure to direct the students to the examination papers from which the questions were taken, indicating their awareness of students' interest in looking at the questions later on and others like them. In lessons where examination techniques were being taught the students were very attentive and ensured that they copied the answers provided by their teachers even though it was not always clear that they all fully understood what was being explained. Students appeared to be well motivated to be successful at examinations and were keen to be well prepared for them. In a Form 1 integrated science lesson student comments included "Miss do we have a test?" and "Miss for end of term we have to learn off the whole table?". After being told by the teacher that they were to list the first twenty elements with atomic and mass numbers one student asked "Miss we have to learn that too?".

Students engaged enthusiastically in problem-solving exercises, especially those that were supported by their teachers so that they did not spend long periods of time floundering, which would result in their losing interest. Students rarely had an opportunity to engage in authentic discussions on real life problems. The example of the SBA was not set in a real life context but students were expected to answer closed questions with no link to application in society.

In their study on the promotion of thinking skills in lower school science in Trinidad and Tobago Herbert and Rampersad (2007) describe similar findings in terms of teachers' abilities to orchestrate discussions which promote critical thinking through the use of appropriate questioning techniques and practical exercises such as laboratory work and group work. They found that teachers did not handle students' high order questions well. As seen in this study, it was pointed out that the purpose of practical work was mainly to confirm ideas outlined in previous lessons. They observed that there were few cases in which teachers used analogies, visual aids or models,

concept mapping, exploration and the application of concepts to promote higher order thinking skills.

Teachers' thinking and beliefs are thought to influence the way in which their students' thinking develops. It has been pointed out that teachers may believe that learning is efficient when they transmit it through direct instruction, such as lecturing, but, as reflected in the teacher interviews, they do see the importance of active learning. In a situation where both trained and untrained teachers contribute to a mainly passive, teacher-centred environment it appears that there may be a conflict between teachers' expressed views on teaching and learning and a subconscious influence which has resulted from their exposure to a more traditional way of attaining academic success (Zohar, 2004). Teachers also have to manage resistance from students who have also grown accustomed to 'chalk and talk' as noted by the teacher who complained that her students were impatient with collaborative, interactive methods which forced them to spend time learning to think as opposed to being given solutions immediately (Snell, 1999).

In keeping with observations made by Herbert and Rampersad (2007), the level of questioning, the lack of active student involvement, the nature of teacher-student interactions, the choice and frequency of teaching strategies and the limited demonstration of process skills conducive to the successful development of critical thinking skills for the majority of students and the situation raises even greater concerns if one considers the advancement of a critical pedagogy. Compared to other teaching activities there was a relatively high number of opportunities to problem solve in the lessons that were observed. The concern is that even in these cases teachers did not use probing questions effectively nor use strategies that could encourage students' questions. There is little data showing teachers to have developed the questioning techniques required to support their students in achieving higher order thinking skills. Millar (2004) suggests that although teacher training courses may encourage hypothetico-deductive reasoning, many teachers, because of their embedded understanding of the nature of science, continue to have an empiricist/ inductivist approach to science. Some teachers, according to Rudduck and Flutter (2000), may not comply with curriculum reforms for developing critical and creative thinking if they have been socialised

into long-established ways of teaching. Weaknesses in questioning observed in science lessons may be due to top-down approaches in professional development where teachers are unable to square issues that come up as challenges in the classroom with those perceived as experts (Koballa & Tippins, 2001).

5.6 Teaching for cognitive development

Krawthwohl (2002) revised Bloom’s taxonomy which focuses on learning goals that are arranged hierarchically in terms of cognitive challenge. This means that more complex thinking requires greater cognitive skill (Lynch & Wolcott, 2001). The fifteen lessons were analysed in order to ascertain how much they support students’ cognitive development in terms of the challenge that they offered. The findings are outlined in Table 5.2.

Table 5.2 Assessment of lesson observations in terms of exposure to opportunities to develop different levels of cognitive learning

Levels of cognitive learning	Sub-levels observed	Number of lessons providing opportunities
Knowledge	Facts	15
	Ways of dealing with specifics	8
	Universals and abstractions	5
Comprehension	Translation	10
	Interpretation	2
	Extrapolation	1

Application		7
Analysis		0
Evaluation		0
Creation		0

The majority of lessons focussed on the importance of remembering facts and dealing with specifics, for example in the Form 4 Chemistry class where it was explained to students how to work out Rf values. Opportunities for the learning of universals and abstractions were seen in lessons on atomic structure, the particulate nature of matter and when considering the principles linked to Snell's Law. No lesson was seen in which students were encouraged to analyse, evaluate or create. In those lessons where students may have had an opportunity to analyse they were merely applying information as teachers provided so many examples of the form of analytical questions that students in the main were applying knowledge. Students were expected to demonstrate their comprehension of the information that they had received from their teachers. In the Form 4 Physics lesson on Snell's Law students were asked to extrapolate as they were asked to demonstrate their understanding of the significance 'isosceles triangles' in this instance.

Halpern (1998) asserts that critical thinking can be learned through guided teaching that consists of:

- i. Dispositional component to prepare learners for effortful cognitive work

The questioning techniques used by teachers did not on the whole provide high levels of challenge or encourage students to grapple for any length of time with problems. Where scaffolding was used, in that teachers did ask questions or allow for peer support or time to come to a solution, this still tended not to fully support students' thinking, mainly because the teachers provided the answers and the students were aware that the answer would be provided. The questioning

techniques did not lead students to put in the step-by-step thinking work needed to get to the end result.

The majority of the lessons entailed note taking which did not support effortful cognitive work. A Form 1 lesson, based on an open book test, provided some challenge mainly because the students were unaccustomed to the vocabulary being used. The students therefore had to use their research skills to answer the questions. However, the questions only required them to recall and show their understanding and did not push them to develop higher order thinking skills. In one Form 4 Chemistry lesson one group remained off task but was willing to update their scripts when the teacher provided the answer.

ii. Instruction in the skills of critical thinking

The opportunity for the development of critical thinking skills occurred mainly through practising examination questions. In a Form 1 Chemistry lesson students were observed using their verbal reasoning skills as they worked in groups to calculate the values for different atomic particles. When describing to students the solution to examination questions teachers modelled how these situations were to be handled. In a Form 4 Chemistry lesson in which students were completing past examination questions on electrolysis of a chloride salt solution the teacher gave pointers on how to get the maximum number of marks. She pointed out to them that she had been marking for CXC for fifteen years and so they must listen when being told about marks. She later provided the answer to a question, saying “Write this down. You will always have to write this so learn it as it is”.

iii. Training in the structural aspects of problems and arguments to promote trans-contextual transfer of critical-thinking skills

In a Form 4 Chemistry lesson based on electrolysis the questions were on real life contexts. In the three test questions the students were required to look at electrolysis in three different real world

settings. They were provided with information from which they had to decide what was relevant and make decisions on what needed to be done with the information in order to come to a solution. These questions required thoughtful analysis and synthesis. However, the students were not encouraged to address the questions in a meaningful way since the teacher provided the solutions with not much effort on the part of the students.

In answering these questions on electrolysis, students did have an opportunity to demonstrate an understanding of the structural aspects of problems and allow for the contextual transfer of critical thinking skills. In a Form 2 lesson on electricity the video clip encouraged students to see how the topic of electricity related to real life settings. However, the questioning was not effective in enabling students to make connections necessary for critical thinking. In a Form 1 assessment of students' understanding of states of matter one of six questions required students to apply their knowledge to real situations. Only some of the students attempted this question as it was the fourth out of six. At one point the teacher addressed the class: "Someone just asked me how gas turns into liquid. Think about it". The teacher then gave an explanation to those who were willing to listen. The students were not encouraged, through guided questioning, to think of adequate responses. In a Form 1 Chemistry class on atomic structure students were provided with a table where they were to fill in the missing spaces. The calculations required were basic addition and subtraction and therefore the level of challenge did not assist students in developing an understanding of the structural aspects of problem solving but it did allow them to make connections.

In a Form 4 Physics class the teacher pointed out on two occasions that it was necessary for the students to apply their mathematical skills to solving Physics problems as they worked through examination questions on reflection and refraction: "You have to use your knowledge of geometry and triangles. At this point it does not really have much to do with your science but more to do with your maths". In this lesson the teacher did model for the students how this type of calculation was to be addressed. However, students did not complete the calculations on their own to be followed by meaningful feedback from the teacher. There was no evidence in the other lessons of

training students in the structural aspects of problems and arguments so as to promote trans-contextual transfer of critical-thinking skills. No observation was made of any deliberate attempt at teaching critical thinking.

- iv. Metacognitive component that includes checking for accuracy and monitoring progress towards a goal

In one Form 4 Physics lesson the teacher attempted to pose questions which supported students' ability to approach problem solving in a metacognitive way as the teacher modelled how to tackle a particular examination question. Apart from this example no other observations were made in which teachers required students to monitor their thinking process or to make decisions about time and the use of their mental effort. There was also some student-student interaction in four of the lessons where students worked together to find the answers to questions. An example of this was the Form 3 practical Physics lesson in which students attempted to determine how callipers worked.

5.7 Teaching for development in the affective and psychomotor domains

Littledyke (2008) argues that the cognitive and affective domains need to be explicitly integrated in science education if students are to learn to take informed action. In addition, Mc Bride et al. (1990) emphasize the importance of thinking across psychometric domains for critical thinking. Table 5.3 outlines how well the fifteen lessons observed gave students an opportunity to develop their critical thinking affective domain.

Table 5.3 Assessment of lesson observations in terms of exposure to opportunities to develop different levels of affective learning

Levels of affective learning	Number of lessons providing opportunities
Receiving	15

Responding	12
Valuing	2
Organising	0
Characterising	0

In the majority of lessons as shown in Table 5.3 students did pay some attention to what their teachers were attempting to do even if it was only sufficient for them to take notes. In 12 of the 15 lessons there was some level of student response as the students focused on taking notes, completed the tests or asked questions for clarification. There were three lessons in which students only took notes and there was no engagement outside of that activity. The emotional responses observed were on two occasions: one where the student was shocked that cheek cells could be removed and in the second case where the student rejoiced as the lesson came to an end. There was evidence that students valued those lessons where visuals such as video clips gave them an insight into how their scientific knowledge had real life application. This was observed in the Form 2 lessons on digestion and electricity.

Developing critical thinking skills in science includes practical aspects which are influenced by students having opportunities to focus on their psychomotor abilities. Table 5.4 gives a measure of how well the fifteen lessons observed provided those chances to students at St Francis.

Table 5.4 Assessment of lesson observations in terms of exposure to opportunities to develop different levels of psychomotor learning

Levels of Psychomotor Learning	Number of Lessons providing opportunities
Perception	2
Set	2
Guided Response	2

Mechanism	1
Complex Overt Response	1
Adaptation	0
Origination	0

In both the Form 3 practical exercise on measurement and the Form 5 titration students were given the opportunity to use visual cues that influenced their actions, that is, at the level of perception. In these lessons the teachers supported some of the students so that they were willing to take on the set tasks of measuring with the callipers or titrating.

5.8 Assessment

Rourke (2013) asserts that learning can be achieved through reflecting on assessment outcomes and assessment strategies but this means that assessment has to be embedded in the learning to clearly give feedback on students' potential. Teachers at St Francis College were mostly willing to respond to students' queries. Queries, however, were invited only in terms of "Is everyone okay with this?", "Do you all understand this?" and "How is this for you?". In a Form 3 Chemistry class the teacher asked "Do you all understand? Do you all understand? You look lost". Some students called out "Yes" with one student giving explanations. The teacher then went on to give homework.

There appeared to be a concern from teachers that students always have the correct information to learn. However, there was little evidence of teachers using the feedback to alter the nature of the classes. No lesson was observed where a teacher found it necessary to re-teach a topic as a result of former assessment.

In most cases the teachers' assessment for learning strategies did not ascertain who in the class had or had not achieved a clear understanding. As a result there were students who had correct

responses in their exercise books, because the teacher had provided the answers, but did not fully comprehend the concepts. Attempts at assessment for learning were attempted, as in a Form 4 Chemistry lesson when the teacher facilitated groups as they worked out responses to questions at the start of the lesson. From earlier observations the teacher called out reminders to the class. Students were prompted to balance their equations: “Correct bad spelling, everyone should spell properly” and “Don’t mix up chlorine and chloride”. In the case of a Form 1 assessment that was given to determine how much the students understood of the previous lesson which was conducted by another teacher the students were allowed to work in groups using their books and consult the teacher. The concern here was that this exercise did not allow the teacher or the students to truly assess the status of their learning. In a Form 4 Physics class the teacher told the students “I want to see your books to see that you are writing up what you should be writing up”. The important thing was that the students had the correct information for learning and not so much what they had learnt. In this Form 4 class on reflection and the open book tests on electrolysis and states of matter the teachers collected responses to see what was written and to check that students understood the material or had copied the correct notes. On the lesson on digestion the teacher followed up the video clip with dictated notes to ensure that the students would be in possession of the correct information.

Apart from attempting examination questions students were required to complete question/ answer activities. The majority of these involved problem solving. Teachers were responsible for much of the marking although there was evidence of students marking their own work at times. This marking took the form of ticks and crosses or the teachers’ initials. Scores were given for some exercises but relatively fewer comments were provided, some of these being related to grammatical errors. Some of the marked work was scored. A high proportion of the work was not marked by teachers or the students. There were no examples of peer- or self-assessment. Any comments tended to be brief, as in, ‘not good enough’. Assignments in examination practice were also seen in the exercise books mainly in the form of structured questions requiring recall, problem solving and the application of knowledge

My assessment of the fifteen lessons using the criteria provided by Ofsted (2013) led me to conclude that all the lesson ‘required improvements’ in some areas with four of them being ‘inadequate’. The present reliance on a content and product assessment process focuses schools on examination success. Teachers feel pressured to push students to fulfill the requirements of examinations. As Ball (1995) recognized, the discourse of effectiveness now contributes to the public’s perception of how well schools are working. The Minister of Education has shared with the public the importance of statistical analysis in reviewing, developing and evaluating performance from primary to the completion of secondary schooling (Gopeesingh, 2013b). Teacher B describes the lack of respect that is felt by those teachers who feel judged in the statement “we are very result oriented in this country, the ones and the scholarships. If you are not getting this amount of passes then you’re not good”. Teachers then teach to the test even when in their professional judgment it does not fulfill the student’s needs (Ball, 2003).

5.9 Conclusion – teachers’ orientation and practice of developing critical thinking

In addressing the research questions on what teachers understood by the term ‘critical thinking’ and what determines the pedagogical methods they employ to develop critical thinking skill in their students it was noted that teachers at St Francis were not focussed on organising their teaching for developing critical skills and had a narrow view of the nature of critical thinking which did not include ideas of social justice and activism. In the main teachers did not recognise their students as critical thinkers and they did not feel that that they had the expertise required for developing critical thinking skills in their students. Many teachers felt that the curriculum on offer was sufficient but that the teachers themselves did not have the necessary skills or attitudes and that the focus on examination success was not helpful. The teachers at St Francis tended to have the required subject knowledge to support their students but this did not appear to extend to their knowledge and understanding of their students. The teaching was organised in a one size fits all manner with the expectation that all students would take on the responsibility of ensuring that they had the required knowledge and skills.

The teachers complained of not having sufficient material resources. The majority of the textbooks available were suited in layout and presentation to the particular age groups. They contained activities that would support the development of critical thinking but on looking at the activities in which students actually engaged one did not find the wealth of diverse activities reflected in them. It can only be assumed that teachers did not value the resources available or did not have time to take advantage of them. There was little use of the technology that was available and practical exercises and field trips were rare. Teachers felt that they needed greater support in terms of training and different expectations for student learning outcomes.

The classroom environment was one of mutual respect although it was not particularly stimulating for the students and no attention was paid to their diverse backgrounds and capabilities. The students felt at ease, were compliant and motivated to achieve. The teachers cared for and had high expectations of their students. They provided them with what they both believed to be what was necessary for their learning. This did not include authentic dialogue, where teachers encourage students to engage in thinking through issues that affect them and their communities.

The questioning and learning tasks rarely allowed students to explore issues in science. Questions and class activities seemed in the main to be set up as a means of introducing new material, reminding students of past information or as examination practice. In the majority of cases teachers were not flexible in their approach so as to accommodate students' learning needs or ask probing questions where the feedback would inform how they progressed with the lessons. Where practical exercises did take place they were used as a means to reinforce theoretical principles as opposed to having students develop their critical thinking skills. In the few examples where role play, field trips and the use of technology were mentioned these were seen simply as ways to encourage some student interest.

The majority of lessons were organised so that students were able to develop some competence in acquiring scientific knowledge. This was mostly in the form of learning facts and coming to understand and apply this knowledge. There was little chance of them developing the higher order

skills as teachers tended to provide the solutions to problems without giving students the necessary support, time and resources for exploring problems and finding solutions. There was some instruction in critical thinking skills but this tended to be confined to examination practice.

Most of the lessons allowed students to gain facilities in the two lowest levels of the affective domains, that is, 'receiving' and 'responding'. Only two lessons addressed any aspects of the psychomotor domains. Teachers were concerned that students should have an interest in science lessons but the lessons were not designed to support students in developing these aspects of their critical thinking.

Summative assessments that supported students' examination techniques were given the greatest priority. Assessment for learning was minimal with teachers not engaging in any detailed assessment of their students' capabilities during the course of normal lessons. Activities completed during class time were rarely marked by teachers or students and when this was done it was normally with the purpose of ensuring that students were working with the correct information. The brief comments that were seen did not inform students on how they should alter their approach. There were no examples of peer or self assessments which could support students' critical thinking skills.

According to Apple (2000), the State does not inevitably serve the interests of a unified dominant class as it is a site of intra-class and inter-class struggle and cooperation over property versus person rights. Political action allows the interest of dominant groups to be partially institutionalized and realized. The State tends to balance the opposing interests. Apple explains that there are therefore times where educational policy will be genuinely progressive and allow compromises which provide some victories to less powerful groups. The science syllabuses in Trinidad and Tobago do demonstrate some aspiration to critical pedagogy which may be a reflection of the sentiments of a people with a colonial past. Herbert and Rampersad (2007) introduce their study by expressing the concerns of many teachers, employers and other persons with a vested interest that graduates of the secondary schools in Trinidad and Tobago are unable to

think critically. According to these researchers these young people function, in the main, at low-order cognitive levels of knowledge and comprehension where they recall and explain but are less able to critically analyse ideas, solve problems and produce logical lines of reasoning. In this work, student interviews based on the video clip “Oil Spill Threatens Native American “Water” Village”, gave the impression that students’ ability to apply their scientific knowledge to thinking critically about social issues improved as they progressed through school but that progress was not dramatic. Form 5 students seemed to be able to respond with greater detail because of knowledge they had gained through more experience working with scientific information. On the whole the teachers were disappointed with the students’ responses as they found them too vague. Apart from the Form 1s the students did not see themselves taking action to improve the situation for the people in the video but had ideas about who could give assistance. As they progressed through the years, science appears to have less appeal, become less relevant to their daily lives and does not give them the confidence and tools for engaging in activities which addressed social issues. .

This inequity may also be partly explained by an education system which does not allow for true meaning and relevance for all students. Although students are encouraged to associate their science knowledge with issues in the community they are not making links between what they learn in science and how it fits in with struggles in the wider society. Who benefits from the production and validation of school knowledge? There is no effort to promote an ethic of civic responsibility that hinders privatized and narrow interests that threaten the public good. The State’s philosophy appears to be based on a view that school science is about individual achievement and satisfying industrial needs rather than on principles of critical literacy and civic courage. It is a challenge, therefore, to put a case for science education that develops political and ethical sensitivities.

In keeping with observations made by Herbert and Rampersad (2007), the level of questioning, the lack of active student involvement, the nature of teacher-student interactions, the choice and frequency of teaching strategies and the limited demonstration of process skills conducive to the successful development of critical thinking skills for the majority of students and the situation

raises even greater concerns if one considers the advancement of a critical pedagogy. Compared to other teaching activities there was a relatively high number of opportunities to problem solve in the lessons that were observed. The concern is that even in these cases teachers did not use probing questions effectively nor use strategies that could encourage students' questions. There is little data showing teachers to have developed the questioning techniques required to support their students in achieving higher order thinking skills. Millar (2004) suggests that although teacher training courses may encourage hypothetico-deductive reasoning, many teachers, because of their embedded understanding of the nature of science, continue to have an empiricist/ inductivist approach to science. Some teachers, according to Rudduck and Flutter (2000), may not comply with curriculum reforms for developing critical and creative thinking if they have been socialised into long-established ways of teaching. Weaknesses in questioning observed in science lessons may be due to top-down approaches in professional development where teachers are unable to square issues that come up as challenges in the classroom with those perceived as experts (Koballa & Tippins, 2001).

While teachers are seen as agents of change, globally high stakes testing and accountability systems are noted for reducing teacher professionalism and agency as they attempt to interpret curricula with the needs of their students in mind (Meier & Wood, 2004; Lobascher, 2011). The teachers at St Francis felt the need to cover the content needed for the CSEC examinations which, to them, mattered more than the NCSE tests in Form 3 and so the schemes of work were altered to ensure that students would be well prepared for the examinations at the end of Form 5. Lingard (2005) observes that teachers subject to the challenges that come with large class sizes, the demands of modern day education policies, examination policies and concerns with covering the curriculum in a particular time are prevented from providing their students with exercises that are intellectually engaging and address issues on social justice.

CHAPTER 6 Findings on students' voice and possibilities for critical thinking

This chapter attempts to elucidate how well students demonstrate their abilities to think critically as they progress through St Francis. This is assessed by examining how well they communicate their critical thinking skills through dialogue, their engagement with the science curriculum and their approach to solving problems. The analysis is outlined in terms of: development of critical thinking in the cognitive, affective and psychomotor domains; questioning and communication skills; problem solving and creativity; use of resources; and students as activists.

6.1 Development of cognitive skills

Butler (2012) talks about the importance of determining the cognitive development of students as they are educated to manage real-world scenarios. Similar levels of knowledge and comprehension were seen across all year groups. Forms 1, 4 and 5 demonstrated the ability to apply their knowledge. In the case of the Form 1s, their application was based on their general knowledge, for example, the contribution of social services – “the environmental services could take out the people for about five months and have a clean up of the whole community”, whereas in Forms 4 and 5 there is evidence of the application of scientific knowledge, for example as Form 4 discussed the influence of climate change – “climate change would add to the water level so that there wouldn't be any space and their houses could be destroyed” – and Form 5 talked about how the process of scientific investigation could assist the people affected by the oil spill – “you need to find out how long the situation has been occurring, how long the oil spill was there and what they were doing so far, the possible things that could take place like total destruction of the Bayou itself, so you could present that to them”. In coming to conclusions, Form 1 and 2 students only used the information provided by the video clip in their analysis. These students were able to suggest that “they can get sick from eating the fish, their children would not be able to go to school because they would not be able to afford books, too much oil, their houses are collapsing, the wildlife might die, the young children might die from starvation”. In the case of Form 4 they used some general information outside of that provided by the video clip that was used in the

interviews, so that they spoke of the possible effects of the Bayou people having to move. They explained that:

they can't bathe in the water. I think that will result in them moving because if the food supply is decreasing and all this is going on they would eventually have to move from the area if they can. They would have to resort to a nomadic approach to life as before because if they land locked to the water rising around them and if they keep fishing or hunting in that area they face depleting the native species in that area and they would have to move to find new food.

This can be compared with a Form 4 Physics lesson on reflection and refraction that required the students to solve problems. The problems were discussed in class with individuals being called upon to respond. At times, several students would call out what they felt was the correct answer. Their abilities to apply the relevant knowledge varied.

The Form 5s in their analysis of the video clip on the Bayou disaster, apart from being able to discuss the importance of gathering and presenting scientific data, as evident in the statement “test for a change in how the animals look, like the fishes might change color or there would be a change in the colour of the eyes or the size”, were the only form group to provide any evidence of synthesis and evaluation as they suggested ways forward for the community and the importance of gathering as much data as possible in order to make judgements: “The same thing goes for if their primary food source was vegetation ... find out what that plant needs to survive in that area and fix the area to sustain that plant life”

Herbert and Rampersad (2007) introduce their study by expressing the concerns of many teachers, employers and other persons with a vested interest that graduates of the secondary schools in Trinidad and Tobago are unable to think critically. According to these researchers these young people function, in the main, at low-order cognitive levels of knowledge and comprehension where they recall and explain but are less able to critically analyse ideas, solve problems and produce logical lines of reasoning. In this work, student interviews based on the video clip “Oil Spill

Threatens Native American ‘Water’ Village”, indicated that students’ ability to apply their scientific knowledge to thinking critically about social issues improved as they progressed through school but that progress was not dramatic. Form 5 students seemed to be able to respond with greater detail because of knowledge they had gained through more experience of working with scientific information. On the whole the teachers were disappointed with the students’ responses as they found them too vague.

When teachers were asked to comment on students’ responses to ‘What have you learnt in science that would have helped?’, they made observations which supported my findings as a result of the focus group interviews with the students. None of the teachers were satisfied with the students’ responses to this question. Some of them were disappointed, saying “The Form 5s, after going through so many levels, why weren’t they able to say something? They should have at least known the different methods to separate oil from water and it could have been a little better”.

Three of the teachers felt that the students were to blame and made the following statements: “I think they weren’t paying enough attention”; “The Form 4s and 5s have no excuse because they have learnt all of this”; “We are teaching these children but they don’t know how to apply what they are learning to everyday life, which is sad”; “... because at this stage in their lives they don’t care about anybody else but themselves” and “students these days don’t read anything”. However, all the teachers recognized that the teaching staff have a role to play in how the students engaged with the question of how their knowledge of science could be applied to a real life environmental issue. Some admitted: “... we are falling short”, “We are not developing these children to think”, “I say the delivery of it [the curriculum] is what makes the difference”, “How wide is our own teaching, our own thinking? How wide is our own development?” and “not everybody cares”. One teacher felt that “... most people teach it as concept and they are not putting themselves in that position” and this explained the reason for students not being able to apply their science to everyday events to a greater extent. As far as one teacher was concerned, the schooling situation did not allow for developing this ability in students. It was said that “... the way we would teach our science, it’s not geared or pointed in a direction of something like that”, “you can’t blame

students because they are not trained in that direction”, “We do science from a different angle” and “... a lot of those things you wouldn’t bother to get into because you are trying to teach geared to the exams”.

6.2 Development of critical thinking skills in the affective and psychomotor domains

The cognitive and affective domains need to be integrated in science education if students are to be taught to develop caring attitudes that inform responsible actions (Littledyke, 2008). Students across all the form groups expressed an appreciation of how food supply (human and wildlife), health, income, housing, cultural activities, transportation and other socio-political factors were affected by the oil spill and impacted the lives of Bayou people. Experience in science did not appear to have an effect on the quality of responses.

All the students paid close attention to the video clip and so demonstrated that they had all achieved the minimum level of the affective domain of receiving. They all responded as they expressed some level of sadness, annoyance or amazement at how the Bayou people had been subjected to and were affected by the oil spill. In terms of responding the Forms 1 and 4 expressed concern as in the following statements:

- Form 1 – “I feel sorry for them because they live on the fish in that area and now because of BP’s oil spill they are unable to fish because the fish is being killed by the oil.”
- Form 4 – “I feel amazed by the fact that natural disasters could have such a toll on someone’s life.”

Form 2, 3 and 5 students, however, did articulate their feelings, in that they thought that the situation was unjust. The Form 3s talked of ‘cultural genocide’ and the Form 5s discussed hardships imposed by people in “It is touching because you are seeing people going through hardship and the problem is man-made which means that they could curb it but it is just man’s

way”. None of the Form groups made statements that could be classified at the higher levels of the affective domains of ‘Organising’ or ‘Characterizing’.

In analysing students’ thoughts on how they felt their science experience had impacted their lives, the following range of themes emerged:

- Expressions linked to enjoying science – “All (all types of science). It is like you are learning something new” (Form 1).
- Areas of science with the greatest impact – “how the world started” (Form 1), “learn about things you can’t see with your naked eyes”, “how things work in the body” (Form 3) and “seeing sodium in water blowing up” (Form 5).
- Vague ideas on the benefits of science – “you learn about things in general in the environment” (Form 3) and “learning about certain chemicals in things and how they are made” (Form 4).
- Dislike for science with no reason – “I don’t like Biology” (Form 3), “I am not doing physics because I never really liked it” (Form 4) and “I don’t like science” (Form 5).
- Dislike for science with a reason – “they don’t make it fun like in music or art or English literature” (Form 3) and “we don’t really do exciting stuff” (Form 5).
- Level of challenge – “all you have to do is read the textbook; the hardest part is remembering to draw everything and putting the labels” (Form 4) and “In order to understand you have to go home and really go over it” (Form 5).

When addressing how science had influenced their lives, students at St Francis tended to refer to areas that they had been recently covering at their level, as in the case of the “digestive system” and “how all the organs fit” in Form 2 and “bonding in Chemistry” in Form 3, which brings into question the long-term impact of their science lessons.

Across all age groups students had varying feelings of how the science teaching they had experienced had impacted their approach to real life situations. There appeared to be a reduction

in the level of enthusiasm for studying science as students moved from Form 1 through to Form 5. The Form 1 students were more explicit when discussing why they liked science, e.g. “science can let your imagination soar beyond” (Form 1), than the older students who spoke in more functional terms, e.g. “like to know how things work” (Form 4). The Forms 1 and 2 did not refer to any areas in science that they disliked. From Form 3 to Form 5 there were instances where students complained about a range of issues across all subject areas. Some of the Form 3 students complained of boredom – “it is boring”, “boring teachers” – and difficulty – “lot of big words and numbers and a lot of things you have to remember”. The Form 4s also spoke about boredom and irrelevance: “it’s irrelevant to where I want to go in my life”. The Form 5s had similar complaints as the Forms 3s and 4s but they also discussed having the difficulties that they encountered in attempting to complete the requirements for the CSEC examinations: “we are just trying to rush down labs and not really doing the labs”. Students in the examinations forms, Forms 4 and 5, addressed the level of challenge that their courses imposed. They discussed the importance of applying oneself and mentioned that Physics required less note taking. In both Form 1 and Form 5 there were students who could not clearly associate their work in science with their everyday lives. When asked about how their science would have assisted them a Form 1 responded “I don’t know” and a Form 5 student said “somewhat”. There were instances in exercise books of incomplete and untidy work with deteriorating hand writing which indicated to me a lack of engagement and boredom (Appendix 13).

Two teachers offered solutions: “Teachers themselves are the ones who need to be trained in this. We need to show children that what they are learning in school they are capable of using it and making a better life for themselves”. One of them suggested the implementation of the Health, Family and Life Education curriculum as “it combines science with social skills which is not being done”. However, there was some pessimism. One teacher felt that:

Even if the teacher does it the children are focused on passing an exam. They don’t care literally ... if CXC implements those programs to get them to think and to get them to want to apply ... it is (already) done ... they get the children to think about the impact that they have on society based on what they do. Children can’t

really respond to those things. They don't think like that. They honestly don't. (Teacher D)

Students made suggestions for enhancing their science learning experiences, including:

- More resourcing in terms of time and equipment
- Reorganise the teaching of subject areas
- More fun
- More field trips
- More practicals
- More visuals
- Less note taking
- Clearer explanations
- Use Information Communication Technologies
- Make relevant to their lives.

Across the year groups students made suggestions on how science could be more engaging. The suggestions could be categorised as an increase: in time for science lessons, apparatus, practical exercises, visual and real life presentations, project type work, use of technology and field trips. The Forms 2, 3 and 5 wanted a reduction in the amount of note taking that they were required to do. Both the Form 2 and Form 4 students desired fuller explanations to aid their understanding. They wanted science to be fun and exciting. Students did communicate their enthusiasm but this was rarely taken advantage of by their teachers. In one Form 2 lesson the teacher was speaking to one student about scraping cheek cells. Another student commented “Miss for them to do that to me I have to be dead”. Lots of hands were up with “Miss, Miss”. The teacher ignored them explaining that “We have to continue now”. She then continued with dictating the note that she was giving before the conversation. The students made efforts to ensure that they had recorded the notes exactly as outlined by their teacher.

Many of the students' suggestions overlapped with those expressed by teachers in their wish to remove of examination pressure, improve teaching strategies and resourcing in terms of materials and time so as to make science more interesting and a more creative enterprise that added meaning to their lives. According to Teacher A, "They (the students) used to say the class is boring and I would tell them I know the class is boring but that is on your syllabus and you have to do it".

The teachers were not surprised at the subject areas that the students selected as having the greatest impression on them. One teacher said "I find it typical that they would say reproduction. What they really love is reproduction, diseases and things that deal with the body. For Chemistry they love reactions especially if they see them in a lab. When they see colour changes and precipitates, they love that". This teacher felt that the areas were consistent with students of different gender. She went on to say "They spoke about reflection and refraction (but) they didn't say much about Physics ... some boys in particular are very interested in how things work. Girls from what I have seen over the years are not interested in that. Girls tend to like Biology and Chemistry".

Three teachers felt that the methods used would have had an effect on how students felt about science. Two of them felt "that science is boring and that has a lot to do with what we have ... 'chalk and talk' as compared to the use of computers". One teacher was of the opinion that having "showed them the video ... grasp their attention". Another teacher explained that "... we are just giving children notes as science. That is why most of them don't like science because if you sit down in a class and you are just writing notes the children are going to get bored and they won't find science interesting. Science is about doing stuff and that is how I see it. From the children's responses you are seeing that coming out". One teacher expressed the view that "teachers don't like to carry the lower forms to the lab ... many times, especially if it is the younger teachers, a lot of them have problems in terms of management of the class ... it seems easier to just let them sit in the class and give them notes because they keep quiet that way and you get through the period".

Another concern for teachers was that their students "don't have the self-motivation". One teacher said "sometimes I think they were forced to do sciences to be doctors or for other careers through

family”. However, even if the teachers feel that it is against the students’ best interest to admit the student to a CSEC science class they are unable to do so because “if there is a vacant position in the class we cannot turn down the child. It is the ministry’s rule”.

There was more recording of practical exercises in lower school exercise books as the upper school had specially assigned books for their SBA assignments. There were instances, in the upper school where the draft SBA was first recorded in their exercise books. Most of the reports described as 'Investigations' mainly detailed exercises where the methods were provided and guidelines were provided into what should be included in the 'Discussion' section. Appendix 14 shows an example of a SBA mark scheme and Appendix 15 shows a marked SBA. The expectation in all cases, except for the titration practical exercise, was that students stayed seated for the full lesson. However, in three of the lessons there were instances of students wandering within the classroom but this movement did not appear to be supportive of any kinaesthetic strengths. Of the fifteen lessons observed only two of them had a practical element which allowed an opportunity for students to demonstrate abilities in the psychomotor domains. It was only obvious, in Form 4 when the students were undertaking the titration exercise, that the students had developed some level of expertise at using the equipment. In this school-based assessment most of the students were able to manipulate the equipment and complete the calculations associated with the exercise. In exploring how to measure with a pair of callipers some Form 3 students were motivated to use the written information and the assistance provided by the teacher to help them in working the machine. In this latter case, there was no observation of the development of expertise but this may have been due to the organisation of the lesson not giving the students sufficient time.

6.3 Development of questioning and communication skills

Emdin (2010) asserts that questioning, sharing one’s thoughts about a concept, argumentation and debate are activities that indicate true engagement in science. The quality of teachers’ and students’ questioning is central to achieving effective dialogue. As Herbert and Rampersad (2007) also observed, the quality of questioning seen in lesson observations and evident in exercise books

tended to be low-level, with little evidence of in-depth probing based on open-ended questions. With teachers as role models, time has to be provided for students to reflect, think, imagine, create and evaluate. Reciprocal questioning encourages students to formulate questions and develop questioning behaviours (Qatipi, 2011).

On the whole, students felt comfortable asking questions to increase their knowledge but there was little opportunity for them to do so. The students would raise their hands or call out to the teacher in order to get attention when they wished. In a Form 2 class on the reproductive system the following exchange occurred:

Teacher: Head up CELLS. Definition of a cell. “It is the basic unit of all living things, full stop”. “It is the smallest part of a living thing which is fully alive, full stop”. Do you all think that you all are made up of cells?

Student: Miss after alive is a full stop?

This student did not feel the need to attempt to answer the teacher’s question; rather, the focus was to ensure that every detail of what the teacher said was recorded. The students felt that it was important to get the notes and information provided by their teachers and so tended to be attentive in lessons. When it was difficult to concentrate they would talk to their peers but took on board that it was their responsibility to work hard for their success. They wished that their lesson would be interesting but tolerated uninspiring lessons as a sacrifice for their success. Students assessed their teachers’ abilities but accepted that they would have to make the best with what they had and that it was not the teacher’s responsibility to ensure that he or she was learning. If there were others in the class who could cope that meant that he or she should also be able to cope. There was no expectation that they should know the objective of a lesson, be aware as to whether or not they had achieved it and ask questions that deepened their understanding or engagement.

The closed questioning used by several teachers did not support students in genuine dialogue that would allow for freedom of expression and the development of students' questioning skills. The following exchange in a Form 1 Chemistry class was not atypical:

Teacher: Please remind me of what is an element.

Students shout out definition.

Teacher: What is an atom?

Students shout out definition.

Teacher: What is a compound?

Students shout out definition

Teacher: I gave homework. What was it?

Students: To learn the first twenty elements in the periodic table.

Teacher: What is the first atom in the periodic table?

Students recite the first twenty elements.

Teacher: Today we are going to look at atomic structure and atomic mass.

6.4 Problem solving and creativity

As students develop their critical thinking skills, they should be expected to demonstrate creative responses which are novel, appropriate and valuable for managing the problems with which they are presented (Marakas & Elam, 1997). Macedo (1994) supports the view that the classroom environment should be one of political analysis which speaks to the concept that knowledge, including scientific knowledge, is socially constructed and so is up for questioning (Horton & Freire, 1990). As students learn to analyse and critique their situations they will grow to appreciate that they have the power to bring about change (Degener, 2001). The science curriculum should equip students to be rigorous, as they share their own ideas, grapple with uncertainties and test assumptions.

In analysing the extent to which students applied their scientific knowledge to a real life event the students provided an array of suggestions which ranged from ideas with no reason to ones based on more scientific detail. Forms 1 to 3 provided general suggestions on how they could improve the situation of the community. The Form 1s spoke about moving the people away and cleaning up the area in statements such as “provide a place for the people who are living there”. The Form 2s gave suggestions on what the community, government and scientists could contribute in order to clean up and protect the people, e.g. “the environmental services could take out the people for about five months and have a clean up of the whole community”. The Form 3s were concerned with gathering information so as to have a clear understanding of the situation in terms of removing the oil and difficulties being experienced by the people. They proposed that it was to know “how they are going to drain out the water ... where the water would go to ... how was the oil spill caused ... the source of the problem ... how much spill took place”. No reasons were given with these suggestions provided by the Forms 1 to 3s but one could see a trend from more concrete to more abstract ideas as in the instance where Form 1 suggested “they can get scientists to figure out what to do and when to do it”, and where Form 3 considered “the concerns of the citizens”. The Forms 1s, 3s and 4s provided general suggestions with reasons as in the case of Form 4 where they said “ ... you need to know what resources you have left and whether it is enough to support the community”. The Form 5 students did not provide any general suggestions. Across the year groups students gave suggestions based on their scientific knowledge. They provided reasons for some of these. There was an increase in the scientific insights provided which appeared to be linked with the students’ exposure to scientific ideas as they moved through school. The comparison can be seen in “We learnt a lot about plants so we could help by re-cropping the community so that they could start farming and have goods and food” (Form 1) and “The same thing goes for if their primary food source was vegetation, find out what that plant needs to survive in that area and fix the area to sustain that plant life” (Form 5).

6.5 Use of resources

Shin (2000) points out that teaching should not be a litany of facts but relevant to the personal geo-

economic and political needs of the society, taking into consideration local environments. Students should appreciate that their unique situation may call for unique solutions where they creatively use the material and human resources available to them. When students were asked about what could be done to assist the Bayou people, their responses tended to become more sophisticated as one moved from Form 1 to Form 5. The Form 1 students tended to see resources in terms of people in general such as a “clean up team”, people with expertise in the form of “scientists” and an appreciation of scientific knowledge, for example “weather forecasts”, but they did not detail any direct application of a scientific resource. At the Form 5 level students’ responses were not so much in terms of materials but they showed a more precise awareness of what may be required. They therefore suggested “separation techniques”, “ecology”, “fractional distillation” and “knowledge of habitats”. There was, however, no detailed description where scientific knowledge and required physical resources were outlined.

Three of the teachers were satisfied with the students’ responses with one of them saying “I can’t think of anything else”. With one of them adding that “they really looked up to people”. Four of the teachers felt that although the students’ responses were wide ranging they tended to be vague. Two teachers noticed that the students did not seem to think that they could assist. One explanation proffered was that “not everybody in a school has the opportunity to be a part of an environmental group” and if not exposed “not everybody feels like I could do something”.

6.6 Activism

Social activism becomes more tangible to students who learn to strategize around social issues (Hormel, 2009). Hormel advocates a need for students to be given opportunities to loosen their dependencies on others to tell them what they should care about and what they can do. All the students were of the opinion that government agencies, scientists and a combination of all types of people could help to solve the problems faced by the community because of the oil spill. Only the Form 1 students felt that they would be able to contribute themselves. The Form 2s and 3s said that the oil company should be called upon to assist and the Form 3 was the only group that did not

speak of the members of the community working together to rebuild the Bayou. The Form 1s and 2s referred to divine intervention, talking of “God” in the case of the Form 1s, and “Jesus; they could pray” (Form 2). I conclude that the students, in general, do not see themselves as individuals who are able to make meaningful contributions to solving problems that affect a community.

Two teachers were pleased with the students’ responses in that they found them “wide and covered all aspects”. However, another two added suggestions of how their responses could have been improved, including getting support from Non Governmental Organisations and the authorities responsible for infrastructural work in the area. Two teachers said that they recognized that the students were making an effort to think although one of them felt that they “didn’t follow through with their answers”. Two teachers appreciated that “one person can’t do much” and so the students “need to be realistic”. They could understand why the students “feel that it has to be the government or somebody else has to go and help them”.

Apart from the Form 1s the students did not see themselves taking action to improve the situation for the people in the video but had ideas about who could give assistance. As they progressed through the years, science appears to have less appeal, become less relevant to their daily lives and does not give them the confidence and tools for engaging in activities which addressed social issues.

6.7 Conclusion – students’ abilities as critical thinkers

In answer to the research question ‘To what degree are the aims of the syllabus fulfilled, as they pertain to the acquisition of critical thinking for social justice?’, students did show some improvements in their cognitive abilities as they progressed through school as they were seen to apply more detailed scientific knowledge. Their responses, however, did not indicate significant improvement in the other indicators of cognitive development in terms of effortful cognition, trans-contextual transfers and cognitive monitoring.

Students' enthusiasm for science appeared to wane as they moved from Form 1 to Form 5. As a result they were able to demonstrate abilities at the lower levels of the affective and psychomotor domains but no progress was observed in the organising and characterizing levels of the affective domain where one might expect to see the effects of their scientific experiences influencing their characters and their view of the world. There was little demonstration of students' psychomotor skills being developed so that they learned to manipulate scientific equipment creatively as they used it in their investigations. Any use was seen in terms of producing the 'correct' values for examinations.

Students' questioning and forms of communication were not in depth or detailed and so their use and demonstration of culturally relevant media was not evident as they worked to understand how science worked and was relevant to their lives. They acted mainly as passive receivers with very little extensive dialogue and debate. As students progressed through school they appeared able to apply more detailed scientific information when discussing solutions to problems. These suggestions, however, tended to be concrete sketchy proposals which were not linked to comprehensive plans. It is possible that under different circumstances students may have offered more, for instance, having them write an essay as opposed to being involved in a focus group interview.

Students did show some appreciation of the importance of natural resources to people. They recognised from the video clip on the Bayou that interference in the environment could have dire consequences. As far as making appropriate use of resources, students were able to suggest how people could help and what general areas of scientific information would be useful but they did not suggest any creative use of scientific knowledge, equipment or techniques. The students at St Francis did not appear to have a keen sense of activism. They saw improving issues that affect a community to be mainly under the control and the responsibility of 'other people' and divine order. They were not confident that they could make a difference and it appears that many of their teachers agreed with them.

The aspirations of the NCSE and the CSEC syllabus do not appear to be providing all students with the skills of critical thinking. Excellent examination results were given higher priority than developing critical higher order thinking skills and civic behaviour within science classrooms. De Lisle et al. (2010) conclude that lack of data, the lack of a quality national evaluation system, and ineffective policies or policy implementation have been responsible for the inequitable attainment observed in schools in Trinidad and Tobago.

This inequity may also be partly explained by an education system which does not allow for true meaning and relevance for all students. There is scarce opportunity provided for teachers and students to be engaged as intellectuals who could question how Western science taught within schools in Trinidad and Tobago, like St Francis, fits into other world views of science. Although the lower school curriculum spoke of students growing to understand the nature of science, this was not interpreted as an occasion to make science knowledge problematic so that teachers and students could evaluate any common sense assumptions and connotations that may contribute to oppression. Teachers and students have little opportunity to interrogate how their science education is associated with other cultural practices which set up unequal relations of power in terms of class, race and gender. Why does scientific knowledge matter? How is knowledge organized within school and why? What are the underlying systems that structure scientific knowledge in relation to other types of knowledge? How is scientific knowledge passed on? Although students are encouraged to associate their science knowledge with issues in the community they are not making links between what they learn in science and how it fits in with struggles in the wider society. Who benefits from the production and validation of school knowledge? There is no effort to promote an ethic of civic responsibility that hinders privatized and narrow interests that threaten the public good. The State's philosophy appears to be based on a view that school science is about individual achievement and satisfying industrial needs rather than on principles of critical literacy and civic courage. It is a challenge, therefore, to put a case for science education that develops political and ethical sensitivities.

CHAPTER 7: Conclusion

7.1 Main inferences

A number of researchers have expressed concerns about the general quality of education that is provided for students in schools in Trinidad and Tobago (Herbert & Rampersad, 2007; De Lisle et al., 2010; Jules, 2010) and based them on the consequences of its colonial and postcolonial history. In focusing on the main research question in this study, ‘To what extent do the pedagogical methods employed in secondary school science in Trinidad and Tobago enable students to engage as critical thinkers?’, globalisation and a hegemonic neoliberalism are seen as supporting a view of critical thinking which minimizes the role of the affective domain. In this system, critical thinking in science education is aimed at having students develop the skills required to work in traditional Western science and to add to the knowledge economy. Although both the NCSE and the CSEC syllabuses are based on a content and product model with the philosophy of authoritarianism to which that model subscribes, there is an attempt to advocate some level of critical pedagogy, probably influenced by a history of resistance, a desire to make science more interesting and to raise the level of attainment by adopting a student-centred approach. Hickling-Hudson (2006) discusses the contribution that critical theorists like Freire have made to education in the Caribbean region. In my view, the time, space, teaching suggestions and assessment techniques needed for the authentic learning that encourages student engagement are not fully provided by the syllabuses.

Even so, this thesis demonstrates that the extent to which the aims of the syllabuses filters through, so that students become engaged as critical thinkers, is minimal as the strategies suggested by the syllabuses are rarely implemented because success is seen to be best achieved through direct instruction and rote learning. Under these circumstances, any movement to teachers and students interrogating the nature of the science to which they are exposed and engaging in praxis that transforms their society to one that is more socially just requires political will and the development of human capital through adjustments to the syllabus content, professional development and teacher training programmes.

7.2 The way forward

In considering the way forward it is essential that Gillborn (2006) is heeded to ensure that when working to change the system its essential shape and character is not taken for granted. Work in bringing about change in Trinidad and Tobago's education system so that students' critical thinking skills in terms of social justice are enhanced and given priority will mean that the school and the school system has to be fitted to the students. There has to be an examination of the existing broad social inequalities and the courage and will to undertake comprehensive change (Orr et al., 2002).

7.2.1 Education policy

Since Independence there has been vast investment in Trinidad and Tobago's education system but the outcomes have not been proportionate. The budget allocation for education in 2014 has been about 1.6 billion USD (GoRTT, 2013). This is 7% of Trinidad and Tobago's estimated 23.99 billion USD GDP (World Bank, 2014). Considering this expense, of the 17,000 students accepted into secondary schools each year only one third of them leave with a full certificate, that is, grades one to three in five subjects including English and Mathematics (Gopeesingh, 2013b). Jules (2010) has suggested that the system requires radical change as opposed to the tinkering that has taken place over the years since many recognize that it is not working for the majority of our young people. It is important for all concerned with education to have a clear understanding of its purpose and what I see as, the essential role of science education for social justice. A critical pedagogy must be fully integrated into a congruent education system which takes into account transition across different levels of bureaucracy, financial and human resourcing, culture, past experiences, forecasting of requirements, the interests and dreams of stakeholders, the best use of time, supporting structures and materials, diversity and issues of equity. Opportunities for continuous dialogue must therefore be included when planning so students, teachers, parents, researchers in education, religious establishments, commercial interests, trade unions and

politicians can exercise their democratic right to voice their ideas and concerns and know that their views will be truly valued and that education is not a case of one size fits all. An education system which seeks to transform society necessitates consistent struggle at every point. This speaks to valuing the community and its contribution to an emancipated people.

In the present setting, The Ministry of Education will have to lead and endorse the necessary changes if critical education is to be taken as the norm in schools. At present there is no formal school evaluation tool used in schools in Trinidad and Tobago. Schools are judged on the quality of their examination results and there is no other support provided for assessing the quality of the provision on offer. Such an instrument would allow schools to participate in self evaluations using feedback from students, parents, teachers, ancillary workers and others who have an interest in schools. Both qualitative and quantitative data from schools would assist in providing adequate resourcing for the unique situations in which individual schools find themselves. Part of this process would involve the support of action research undertaken by both teachers and students.

7.2.2 Teacher character and training

The information on teacher effectiveness does suggest that teacher training both with pre-service and in service teachers continues to be an area that needs to be addressed. Leacock (2009) is of the opinion that effective training is needed for a major impact on both teachers' perspectives and practices. Teachers cannot facilitate young people's understanding of social and political inequities if they are unaware or do not comprehend these themselves. Teachers need to develop the political clarity which brings the realization that concerns in the wider society influence what goes on in schools. These teachers have to be made aware that reformation of the school culture must take place if schools are to avoid reflecting the inequalities of the larger society (Freire & Macedo, 1987). Teacher training programmes should give teachers the opportunity to see Western science in the context of world science and acknowledge the benefits and contributions of other indigenous sciences. Carter and Smith (2003), through their course designed for trainee teachers who did not view their experience of school science positively, allowed them to looking at

Western Science differently. Issues surrounding sustainability may provide an opportunity to cultivate a clearer understanding of the role of Western Science as students and teachers focus on creating a more just and sustainable future (Carter, 2008).

The culture and structure of training programmes will need to accommodate the space and time for teachers to come to terms with the theory and application of critical pedagogy. In providing learning for teachers to participate in, what for them is, a new culture, trainers may consider the benefits of organising placements in community-based organisations where a critical pedagogy is practised. Similar strategies should be put in place since giving verbal instructions on critical pedagogy is unlikely to be very effective (Duncan-Andrade & Morrell, 2008).

A re-constructivist approach would allow teachers and teacher educators to collaborate in the design of training courses for building the capacity of teachers in the science classroom (Beck & Kosnik, 2006). Teachers will be able to reflect on their own behaviours, attitudes and beliefs as they work towards building a course which takes into account their and other teachers' experience with critical pedagogy alongside their history and culture. The reflective habit will provide information for future activities and improve the quality of science teaching (Lincoln, 2001). As transformative agents, teachers should be contributing to research efforts as they work with tertiary education establishments and their communities to develop a body of knowledge that supports the development of a critical pedagogy. In these partnerships participants have to be mindful of the power differentials that are constituents of these arrangements. The building of trust and effective communication is essential in situations where the knowledge brought by one partner may be perceived as having greater value than that of another (Herbert et al., 2009). Some teachers and individuals with experience in curriculum development were contributors to the NCSE and CSEC syllabuses (NCSE, 2008; CXC, 2010). This form of collaboration and negotiation has to continue. It may be an idea to have teachers and teacher-researchers as the main contributors to syllabuses with scientists and politicians having minor roles. Teachers need to be aware from a social, professional and personal perspective of the developments in curricula. The process of curriculum development should be transparent to all (Wallace, 2012).

7.2.3 Pedagogy

Critical pedagogy in the classroom can offer students the opportunity to come to an understanding of structural violence and related issues, and so serve as an impetus for both personal and social change. The youth may be led to see the relationship between the micro and the macro, and recognise the importance of their role as activists and peace-builders. By giving young people the chance to be activists, to direct their learning and to critically explore issues of concern, teachers may find that students become motivated to pursue their own learning (Ardizzone, 2007). Critical pedagogy consists of action and reflection, that is, praxis in which participants make theory as they critically analyse their place in society and take steps towards transformation. There is an assumption, here, that students do have concerns about their own growth and development and about what is moral and ethical (Wallace, 2012). Science classrooms for social justice are characterised by activities centred on the social and political environments and the needs and interests of the young people in them. This is a democratic setting in which they can use their developing critical thinking skills to understand cultural assumptions and biases in science and to challenge the status quo (Degener, 2001).

Shor (1992) explains that education is a political activity as it controls the type of questioning and in turn the critical relationships that students have with school and society. Trinidad and Tobago's history has been one in which education has been a route to resistance and social justice. However, the postcolonial legacy has also left its mark. Courses that would help students to develop not only academically but also personally may have little currency and may be considered inferior compared to a fully academic path, no matter the projected advantages to lifelong learning (Leacock, 2009). This legacy has affected:

- the relationships between teachers and students
- students' and teachers' understandings of the nature of scientific knowledge and

- the role of examinations in their lives. In the main neither students nor teachers are accustomed to an arrangement whereby students' voices have been valued. They may both find it challenging to share power (Shor, 1992).

Any change to this hegemony will require gradual implementation, time, patience and adequate resources (Degener, 2001). In the implementation of a critical pedagogy consideration has to be given to changing the focus from transmitting knowledge to helping students develop skills for accessing and evaluating knowledge. The extraordinary pace at which knowledge is produced suggests that it would be beneficial for students to build confidence as learners who can pursue knowledge which matches their needs, circumstances and perspectives. Teachers' and students' management of the vast array of knowledge also underscores the benefits of systems for lifelong learning and a seamless education which supports students' self-confidence and allows them to see themselves as valuable contributing members of society (Leacock, 2009). Both the teachers and the students made reference to the use of the internet for accessing information. On two occasions the teachers spoke of their personal use but they referred to student use of the internet five times. Student reference to the internet was only noted once. One teacher commented "Actually a lot of what is in science is being challenged by the students we teach currently. I don't know if it's because of what is on the internet or the influence of their friends or access to information but they seem to want to question everything" (Teacher D).

Open-ended research projects that include elements of activism motivate young people and assist them in coming to a fuller understanding of societal issues while developing analytical skills. They are helped to answer "Why am I learning this stuff?". Exercises which inspire students to think through problems, seek solutions and raise awareness increase their self-efficacy as they develop as critical thinkers. For the best results the system has to establish activism as part of the ethos so that programmes are geared towards social transformation and both teachers and students feel comfortable to commit translating socio-scientific education into social action (Bencze et al., 2012). In describing 'The Characteristics of a Good Scientist', the NCSE syllabus highlights attitudes and process skills such as observation, classification, communication, measurement,

estimation, prediction and inference. For schools in Trinidad and Tobago this would be a major cultural change from the present examination orientated system that now exists.

The changes to pedagogy outlined here require a new look, from all quarters, as to why and how we teach science and how this is accepted by stakeholders and rolled out. Reiss and White (2013) have suggested starting with an 'An Aims-based Curriculum' for science focused on 'Equipping every child to lead a personally flourishing life' and 'Equipping every child to help others to lead a personally flourishing life'. Through a wide-ranging consultation within Trinidad and Tobago the six 'Essential Learning Outcomes' which are supportive of a critical pedagogy were coined (GoRTT, 2008). However, the sign posting of these outcomes within the science curriculum document is not evident and so if there is supposed to be an emphasis it is not clear to teachers and students in the everyday working of the curriculum. The aims of the CSEC syllabus do not take as their starting point the "needs and wants of students" (Reiss & White, 2013, p. 1), but instead explain the benefits of the study of the subject to the student. For example, "The study of Chemistry is intended to assist students to: ... see the relevance of Chemistry to everyday life" (CXC, 2002b, p. 1).

7.2.4 Assessment

Consideration has to be given to the role of assessment in Trinidad and Tobago. Our assessment methods are deeply ingrained within a postcolonial culture and mindset which do not support social justice for our young people. Assessment policies have to be re-contextualised and guided by indigenous knowledge as supporters of the present elitist system will defend it regardless of the merits or demerits (De Lisle, 2012). Bold decisions, as those taken in Hong Kong and Shanghai, may have to be made. These jurisdictions have attempted to produce a system that supports massive popular education that highlights learning rather than teaching, learning capacities and not rote learning, individual needs and not economic needs (OECD, 2011). The challenge is that as a small island state it is difficult to implement an educational paradigm designed to suit national needs that does not complement dominant global systems. Competition among OECD countries

has constructed a western academic hegemony that is influencing trends and the educational models (Jules, 2010). Degener (2001) makes the claim that there are situations in which programmes must use non-critical, standardised assessment in order to receive funding.

The New Zealand Curriculum is highlighted at this point as it is designed to give schools the flexibility to create personalized curricula. The curriculum standards offer examples of more open-ended objectives which could provide an environment for more democratic contribution from both teachers and students (Ministry of Education, New Zealand, 2007). Ideally, the system would be flexible enough to allow teachers to set long-term contextual goals for students which reflect individual student needs and gives teachers the opportunity to make changes when needed. Students should be able to set their own goals, the outcomes of which are evaluated both by them and their teachers so as to give feedback to students, teachers and administrators. In this process students would see how their input affects the course of study as they work with their teachers as active participants. For this process to be effective the evaluations would be more useful as narrative as opposed to standards-based examination scores (Degener, 2001).

According to Ranson (2003), teachers, parents, students, school administrators and government should have a shared understanding of achievement. An effort is being made to consult with stakeholders as policy makers seek to improve the education system in order to ensure that Trinidad and Tobago is globally competitive. The ministry is at pains to assure the public that new curricula will be “grounded in sound educational theory, and targeted research and evaluation of our local educational context” (Gopeesingh, 2013b). In the most recent consultation, in November 2013, a series of questions was asked about the organization of the curriculum but none of them addressed overhauling of the means of assessment in any detail (Gopeesingh, 2013b). The parents, students and the teachers were not introduced to alternatives to the present system and so their input may not be supportive of the cultural change that is necessary for bringing about social transformation. From New Zealand’s experience it is reported that there were even school Principals who were unsure of how formative assessment could be implemented to successfully improve learning (Ministry of Education, New Zealand, 2007).

7.2.5 Example of critical pedagogy

Oil is central to the Trinidad and Tobago economy contributing to this country's listing in the top 66 High Income countries in the world. Its growth has been fuelled by investments in petrochemical, oil and natural gas. The Oil Industry is a topic that allows for a wide range of areas where students may see links to scientific, social, economic and cultural issues. Students may be encouraged to consider questions such as 'Who benefits from the Trinidad and Tobago's oil industry?', 'Why is the oil industry important to you?', 'Where is oil and gas located?', 'How did it get there?', 'How is gas and oil located and retrieved?', 'How is oil processed?', 'What are the issues that arise with oil exploration, retrieval and processing?' and 'How can we preserve our oil and gas resources?'. Through a series of projects students may learn process skills used in scientific investigations as well as skills which support their ability to think critically about situations relevant to their community and develop the means to bring about transformation through effective activism.

Using the Essential Learning Outcomes as described in the NCSE syllabus, one of the projects could be set up so that students' critical thinking abilities could be assessed under the headings of Aesthetic Expression, Citizenship, Communication, Personal Development, Problem Solving and Technology Competitiveness, with Activism being emphasized within the area of Citizenship.

The proposal is that this project starts with a news article, 'Ocean Fish and the Oil Industry - Conflict Brews as the Trinidad Tobago Fishing Community Stands Up to Big Oil', www.huffingtonpost.com/candace-calloway-whiting/title-fish-oil-ocean-righ_b_4312329.html. In this article fishermen are protesting about a drop in fisheries over a ten year period which they believe is due to gas and oil exploration which employs sound waves in seismic investigations. Sound waves are bounced off underground rock formations. The reflected waves are captured by recording sensors normally carried on research vessels. The analysis of the time the waves take to return provides information on rock types and possible gases or fluids in rock formation. The

affected fishermen have been offered compensation by the oil companies but are petitioning for sustainable practices to tackle the problem (Huffington Post, 2013).

Students would be asked to prepare a portfolio of work in which they investigate the impact of air guns on fisheries around the coast of Trinidad and Tobago. They would also be expected to take some action which they feel would contribute to improving the situation for the parties involved. Through discussion, students would negotiate with their teachers the best way to do this. They would work collaboratively with their teacher and peers in order to fulfil the objectives that they set themselves. Activities could include:

- Designing and carrying out interviews and surveys to involve parties on all sides of the dispute
- Library and media searches on fish Biology, the nature of sound waves and earth science
- Visiting fishery and research vessels
- Sharing findings, feelings and opinions in attractive ways that will appeal to a wide audience
- Scientific investigations into the use of sound waves and how they could affect fish and their habitats
- Debate and discussion
- An act of activism that students see as contributing to improving the conditions that resulted in the conflict between the oil company and the fishermen.

The possible outcomes could be described under the Essential Learning Outcomes (GoRTT, 2008, pp. 6-11):

Aesthetic expression

1. Development of artistic and literacy skills

Citizenship and Activism

2. Development of social awareness

Communication

3. Development of investigation skills
 - design interviews and surveys
 - statistical analysis
 - interpretation of graphs and charts
4. Development of interviews skills – fishermen, scientists, ministry officials
5. Development of debating skills
6. Development of presentation skills

Personal Development

7. Acquisition of knowledge in ecology and sustainable development, looking at fish habitats and behaviours
8. Acquisition of knowledge on sound and seismic waves, fish biology
9. Career development
10. Development of leadership and team working skills
11. Development of ethical sensitivities
12. Development of confidence to work as agents of change

Problem Solving

13. Development of investigation skills

- design, conduct and report on investigations into the effects of seismic waves on fish habitats
- design, conduct and report on investigations on the movement of sound through different substances
- design, conduct and report on investigations into the behaviour of p and s waves

Technology competence

- 14. Development of media research skills
- 15. Develop skill in use of equipment used in scientific project and the use of relevant software packages

The assessment of the critical thinking skills within this project may be based on ‘The Critical Thinking’ Rubric provided by Washington State University (2013) with the inclusion of an eighth item on activism as indicated in Table 7.1 that would include addition criteria such as ‘Identifies, implements and assesses actions that they believe would have a positive impact on a social issue or issues’.

Table 7.1 Suggested extension of Washington States University’s Critical Thinking Rubric

Emerging	Mastering
Fails to identify or implement actions that would impact an issue.	Identifies implements and assesses the impact of their actions and plans for continued action and evaluation taking into account consequences considering context, assumptions, data, and evidence.

7.2.6 Assessment tool for critical thinking in secondary science education

As a result of this thesis on the extent to which the science curriculum in Trinidad and Tobago engages students as critical thinkers, the following assessment tool is proposed as a means

whereby the curriculum, teachers' orientation and practice as well as students' learning in terms of critical thinking skills can be examined. Each section is divided into four levels with a judgement at Level 1 being recognised as 'Outstanding', Level 2 as 'Good', Level 3 as 'Requiring improvement' and Level 4 as 'Inadequate'. The descriptors for the tool is as follows:

1. CURRICULUM DESIGN

A. CURRICULUM GOALS

Level 1: The stated goals in the curriculum documents clearly advocate a political agenda that supports a critical pedagogy for social justice.

Level 2: The stated curriculum goals do not emphasize an agenda for social justice but give some emphasis to a critical pedagogy through the engagement of scientific study in areas that students may encounter in their everyday lives.

Level 3: The curriculum goals do not support a critical pedagogy but make links to the application of science in everyday life.

Level 4: The curriculum goals support schooling in science that is abstract and does not aim to demonstrate the relevance of science in students' lives.

B. LEVEL OF AUTONOMY

Level 1: Stated educational policies, the administration of the education system and curriculum documents heavily advocate support for teacher and student input into the nature of the curriculum with evidence that they are able to negotiate the elements of the curriculum.

Level 2: Education policies and curriculum documents acknowledge the importance of teacher and student autonomy and some systems are in place to support this.

Level 3: Stated education policies and curriculum documents are designed to allow for some teacher and student autonomy but this is not encouraged in its administration.

Level 4: Education policies, curriculum design and administration actively discourage a sense of autonomy. Teachers and students strictly follow the guidelines provided by the curriculum documents.

C. SCOPE OF STUDY

Level 1: Syllabus documents cover a wide range of subject areas which students appreciate as important for directly influencing their lives and the communities in which they live.

Level 2: Syllabus documents cover a wide range of subject areas which students see as linked to their lives.

Level 3: Syllabus documents cover a range of subjects which students often see as abstract and not linked to their lives.

Level 4: Syllabus covers a narrow range of subject areas which students see as abstract and not linked to their lives.

D. TIME AND SPACE ALLOWANCE

Level 1: The timing of assessments always takes into consideration the learning needs of students.

Level 2: The timing of assessments sometimes takes into consideration the learning needs of students.

Level 3: The timing of assessments rarely takes into consideration the learning needs of students.

Level 4: The timing of assessments does not take into account the learning needs of students.

E. AUTHENTICITY OF ASSESSMENTS

Level 1: Assessment methods are such that students are always assessed on topics that are significant to them and allow them to clearly demonstrate the knowledge and critical thinking skills that they have acquired.

Level 2: Assessment methods sometimes examine students on topics that are significant to them and allow them to demonstrate the knowledge and critical thinking skills that they have acquired.

Level 3: Assessment methods rarely examine students on topics that are significant to them and allow them to demonstrate the knowledge and critical thinking skills that they have acquired.

Level 4: Assessment methods are such that students are never examined on topics that are significant to them and allow them to demonstrate the knowledge and critical thinking skills that they have acquired.

2. TEACHERS' ORIENTATIONS AND PRACTICES

A. EXPERTISE IN TEACHING FOR CRITICAL THINKING

Level 1: Teachers have a keen appreciation of and expertise in how critical pedagogies may be used in science education to support the thinking which brings about activism for social justice.

Level 2: Teachers have an appreciation and knowledge of the use of critical pedagogies in supporting their students in developing the critical thinking skills that allow for effective activism for social justice.

Level 3: Teachers have a limited appreciation and knowledge of the use of critical pedagogies in bringing about critical thinking for social justice.

Level 4: Teachers are unaware of critical pedagogies and have no interest in or commitment to using them in science teaching to develop the thinking that may lead to social justice.

B. TEACHER SUBJECT AND STUDENT KNOWLEDGE

Level 1: Teachers have an expert knowledge in the areas of science for which they are responsible and have an in depth knowledge of the learning situations of their students.

Level 2: Teachers have a good knowledge in the areas of science for which they are responsible and know their students' learning situations.

Level 3: Teachers have a satisfactory knowledge in the areas of science for which they are responsible and some awareness of the learning situations of their students.

Level 4: Teachers' science knowledge is poor and they are unaware of their students' learning situations.

C. USE OF RESOURCES

Level 1: Teachers always make creative use of all the resources available to them to provide students with the authentic, relevant and interesting experiences of science that will support the development of their critical thinking skills.

Level 2: Teachers make some use of the resources available to them in order to provide their students with some authentic, relevant and interesting experiences of science that support the growth of their critical thinking skills.

Level 3: Teachers rarely make use of the resources available to them to provide experiences in science that would develop their students' critical thinking skills.

Level 4: Teachers do not make use of the resources available to them to provide experiences that would develop critical thinking skills in their students.

D. CLASSROOM ENVIRONMENT

Level 1: The classroom procedures always allow for mutual respect, encouragement, engagement with quality provision in terms of classroom activities and high expectations of all students and teachers regardless of ethnicity, gender or social class.

Level 2: The classroom procedures sometimes allow for mutual respect, encouragement, engagement with quality provision in terms of classroom activities and high expectations of students and teachers regardless of ethnicity, gender or social class.

Level 3: The classroom procedures rarely allow for mutual respect, encouragement, engagement

with quality provision in terms of classroom activities and high expectations of students and teachers regardless of ethnicity, gender or social class.

Level 4: The classroom procedures never allow for mutual respect, encouragement, engagement with quality provision in terms of classroom activities and high expectations of students and teachers regardless of ethnicity, gender or social class.

E. QUALITY OF QUESTIONING AND LEARNING TASKS

Level 1: The questions and learning tasks provided for students are of excellent quality and designed to support students' engagement with scientific issues which are of a socio/political nature.

Level 2: The questions and learning tasks provided for students are of good quality and sometimes designed to support students' engagement of scientific issues which are of a socio/political nature.

Level 3: The questions and learning tasks provided for students are of satisfactory quality but not designed to support students' engagement of scientific issues which are of a socio/political nature.

Level 4: The questions and learning tasks provided for students are of poor quality and not designed to support students' engagement of scientific issues which are of a socio/political nature.

F. TEACHING FOR COGNITIVE DEVELOPMENT

Level 1: Activities and teaching methods give students excellent opportunities to learn how best to approach problem solving, monitor their thinking and develop their strengths in effortful cognition and the contextual transfer of their thinking.

Level 2: Activities and teaching methods give students some opportunities to learn how best to approach problem solving, monitor their thinking and develop their strengths in effortful cognition and the contextual transfer of their thinking.

Level 3: Activities and teaching methods rarely give students opportunities to learn how best to approach problem solving, monitor their thinking and develop their strengths in effortful cognition and the contextual transfer of their thinking.

Level 4: Activities and teaching methods never provide students with opportunities to learn how best to approach problem solving, monitor their thinking and develop their strengths in effortful cognition and the contextual transfer of their thinking.

G. TEACHING FOR DEVELOPMENT IN AFFECTIVE AND PSYCHOMOTOR DOMAINS

Level 1: Activities and teaching methods provide students with excellent opportunities to develop their values and critical thinking skills in the affective and psychomotor domains with students showing a deep appreciation for ethical, meaningful scientific practice.

Level 2: Activities and teaching methods provide students with some opportunities to develop their values and critical thinking skills in the affective and psychomotor domains with students showing an appreciation for ethical, meaningful scientific practice.

Level 3: Activities and teaching methods rarely provide students with opportunities to develop their values and critical thinking skills in the affective and psychomotor domains with students showing little appreciation for ethical, meaningful scientific practice.

Level 4: Activities and teaching methods never provide students with opportunities to develop

their values and critical thinking skills in the affective and psychomotor domains with students showing no appreciation for ethical, meaningful scientific practice.

H. QUALITY OF ASSESSMENT

Level 1: A wide range of excellent formative and summative assessment activities which allow for teacher, peer and self assessments to support cognitive monitoring for improved critical thinking.

Level 2: A range of formative and summative assessment activities which allow for teacher, peer and self assessments to support cognitive monitoring for improved critical thinking.

Level 3: Formative and summative assessment activities that only allow for teacher assessment.

Level 4: A narrow range of summative assessment activities that are only undertaken by teachers and examiners.

3. STUDENTS' CRITICAL THINKING FOR SOCIAL JUSTICE

A. DEVELOPMENT OF COGNITIVE SKILLS

Level 1: Students demonstrate a wide range of cognitive skills which show outstanding improvement in effortful cognition, management of analysis and problem solving, thinking in differing contexts and cognitive monitoring as they progress through secondary school.

Level 2: Students demonstrate a range of cognitive skills which show good improvement in effortful cognition, management of analysis and problem solving, thinking in differing contexts and cognitive monitoring as they progress through secondary school.

Level 3: Students demonstrate a range of cognitive skills which show some improvement in effortful cognition, management of analysis and problem solving, thinking in differing contexts and cognitive monitoring as they progress through secondary school.

Level 4: Students demonstrate a narrow range of cognitive skills which show little improvement in effortful cognition, management of analysis and problem solving, thinking in differing contexts and cognitive monitoring as they progress through secondary school.

B. DEVELOPMENT OF CRITICAL THINKING SKILLS IN THE AFFECTIVE AND PSYCHOMOTOR DOMAINS

Level 1: Students show outstanding improvement in levels of motivation and engagement with all aspects of science through the development of critical thinking skills in the affective and psychomotor domains as they progress through secondary school.

Level 2: Students show good improvement in levels of motivation and engagement with all aspects of science through the development of critical thinking skills in the affective and psychomotor domains as they progress through secondary school.

Level 3: Students show some improvement in levels of motivation and engagement with aspects of science through the development of critical thinking skills in the affective and psychomotor domains as they progress through secondary school.

Level 4: Students show little or no improvement in levels of motivation and engagement with all aspects of science through the development of critical skills in the affective and psychomotor domains as they progress through secondary school.

C. DEVELOPMENT OF QUESTIONING AND COMMUNICATION SKILLS

Level 1: Students expertly use their indigenous language and culturally appropriate approaches to question, fully conceptualize and communicate issues in science.

Level 2: Students are good at selecting and using culturally appropriate approaches to question, gain conceptual understandings and communicate issues in science.

Level 3: Students use some culturally appropriate approaches to question, gain an understanding and communicate issues in science.

Level 4: Students are inarticulate when communicating issues in science.

D. CREATIVITY

Level 1: Students use their knowledge of science innovatively when addressing improvements or solving problems that may affect them, their communities and the environment.

Level 2: Students apply their scientific knowledge when addressing improvements or solving problems that may affect them, their communities and the environment.

Level 3: Students sometimes apply their scientific knowledge when addressing improvements or solving problems that may affect them, their communities and the environment.

Level 4: Students show little facility to use their scientific knowledge in problem solving.

E. RESOURCE MANAGEMENT

Level 1: Students highly value and are creatively judicious in their use of the resources available to them.

Level 2: Students are very careful in the use of the resources made available to them.

Level 3: Students use the resources made available to them with some care.

Level 4: Students have little appreciation for and waste the resources made available to them.

F. STUDENT ACTIVISM

Level 1: Students confidently use their in depth appreciation of how their scientific knowledge can impact socio/political situations to bring about significant changes within their environment through praxis.

Level 2: Students always use their knowledge of science to support activities that would improve their communities.

Level 3: Students sometimes use their knowledge of science to support activities that may bring about improvements in their communities.

Level 4: Students have little or no engagement in activities which may improve their communities.

7.3 Implications for further study and improvements

According to Kincheloe and Mc Laren (2005), critical theory has the ability to challenge the status quo and in doing so brings about highly charged emotions because of the tensions seen between its normative approach and empirical approaches. Critical theory provides a means of interrogating the power relations within society that support an elitist education system which has relatively little focus on developing social conscience. I was tempted to assess students' critical thinking abilities using a test that would provide a more technical analysis of students' critical thinking skills development. In developing this research project further, I would consider tracking students' critical thinking abilities as they progress through school. I would, however, continue to be challenged in determining the factors impacting the development or lack of development observed. I have not found an instrument that can directly measure students' ability to think critically in situations where their processing would contribute to a more just society. The technique employed here allowed me to use students' quality of responses to determine how their science education assisted in how they approached solving problems, their empathy for others and their confidence to take action when the need arose. I am aware that my assignment of responses to different levels within cognitive and affective domains can be criticized as subjective and it may have been helpful to have others' interpretation.

Apart from issues of 'othering' as described in Chapter 1.2, the use of postcolonial theory may result in my contributing to reinforcing neo-liberal views within the education system as individuals grapple with radical suggestions on how education could be administered. Appealing to the ruling classes who organise the system presents a challenge in that it requires the setting aside of an elitist system which advocates that once individuals work to the best of their ability they will succeed. On the other hand, many writers on the Caribbean education system apply postcolonial theory in their analysis as they find it an appropriate tool for discussing many of the issues linked with social justice (London, 1997; Lewis, 2007; McCarthy & Sealey-Ruiz, 2010).

Having completed the case study, using St Francis College, the data did allow me to draw a clear picture of the situation within schooling in Trinidad and Tobago more generally as it relates to the development of critical thinking skills. However, the information that would be obtained from

doing a similar investigation in a range of schools with different gender and race mixing and economic backgrounds would further clarify what is required to provide a service that delivers critical thinking skills to all. The trial of the 'Assessment tool for critical thinking in secondary science education' within other schools would assist in evaluating its usefulness.

Through my interviews and observations with teachers, more so than with students, I felt that my role as a school Principal did influence the nature of our interactions. On occasions it seemed likely that teachers were anxious to say 'the correct thing'. They tended to ask for my advice and to enquire into how I had evaluated their lessons. They appeared to become more relaxed as the number of my visits to the school increased. They were assured by my emphasizing the purpose of my study, the fact that I was mainly interested in how they felt and that I was not expecting any particular responses. My consulting them on what I had recorded and my description of the manner in which the data would be managed helped to gain their trust.

The video clip on the oil spill worked well as a means for stimulating conversation with students on how they saw themselves applying their science knowledge to social issues. I would have liked to compare their responses to a case where the situation was more familiar to them, for example, where they were not distracted by the difference in the way the people spoke or the fact that it was a foreign country with which they were unfamiliar and where the people lived on the water. I am also curious to know whether the responses would have been different with single sex groups who might have different interests and so focus on different areas.

In conducting the focus groups, I felt challenged with being consistent in the way in which I managed the interviews as I moved with one form group to the next on different days. Although the interview questions were the same, the paraphrasing and methods used to encourage more detailed responses may have affected the students' abilities to share how they felt. I believe that my skills improved as the interview series progressed.

In assessing students' responses I felt that I had to work out what a clear demonstration of each of the traits that I was judging would entail. The resulting classification of traits was decided by me based on the work of Krathwohl (2002) and Krathwohl et al. (1956) but could be further refined by consulting those in the fields of cognitive, affective, social and critical thinking skills development.

One of the issues that became apparent to me was the range of teacher attitudes and abilities as these pertained to the development of critical thinking skills. Herbert and Rampersad (2007)'s data on the quality of questioning and my findings have led me to believe that a focus on questioning through the implementation of action research in science lessons would assist teachers as they are encouraged to develop the skills necessary for a critical pedagogy.

The content analysis of exercise books was adequate for this exercise in that it gave a clear idea of the range of activities that students recorded daily and data on the frequency of such activities. A more in-depth analysis of textbooks would have given additional information on the quality of the activities undertaken by students and the extent to which teachers took advantage of the exercises outlined in textbooks and their reasons for selection or rejection of what was on offer.

In conducting the teacher interviews, again, my skill as an interviewer no doubt had had some influence on the discussions. One of the challenges was the duration of the interviews. There was one teacher who had very much to say and I allowed her to speak as much as she wanted so as to obtain as much rich data as possible. It might have been possible for me to have had greater control of her interview by making a judgment as to whether the information provided was supporting my aims as directed by my research questions.

Providing teachers with the opportunity to comment on student responses allowed me to develop an understanding of teachers' expectations of students' knowledge base, attitudes and ability to think critically. Apart from this, the teachers reflected on their roles and on how the education system influenced the students. It would have been useful to have the students comment on the teachers' responses but it was difficult to get support for such an activity in terms of time and

teachers' permissions. Such an activity would allow for student voice and exposing a point of view that would inform steps for developing a critical pedagogy within the Trinidad and Tobago context.

7.4 Implications for my role and professional context

This study has focussed on science education. I am aware, however, that many of the issues raised in terms of the political setting affect not only science education but other areas. As a Principal, I have become, as a result of this study, more sensitive to the factors that influence my stresses and behaviours and those of staff members and students as we all concentrate on making the experience of school a successful enterprise.

The challenge for me is how to go about sharing my learning in a traditional cultural setting that is very different to my convictions. In my experience, it has been difficult to communicate to teachers that the provision of a high quality education can be congruent with examination success. To many, the authentic experiences necessary for a fine education are all of a pipe dream as it is important to get the students through their examinations. This is especially so at an elitist school where students have the social capital and other resources for playing the examination game successfully. Teachers who work in schools where students are not so well off may be more inclined to participate in these types of activities as they see engagement as a means of containing their students. For all stakeholders, the evidence needs to be clear and I think that one way of providing such evidence is by allowing teachers time to conduct action research type activities which permit them to develop their skills and to see the benefits that accrue through changing their style to accommodate learning in a fashion that is about engaging students. Even with this, however, I may have to convince some teachers that this would be a worthwhile activity and not just more work.

I find that teachers have a great concern about use of time as they are pressured to get through the content of the syllabus documents. They complain when students are removed from the classroom

to participate in activities that they do not see as directly linked to examination success. I feel that dialogue as to the value of these activities and the influence that they have on students, needs to take place so that staff develop an appreciation for the best ways in which they can influence their students to be well educated citizens as opposed to the banking model for which they feel there is no alternative.

The resourcing of good science teaching can be costly both in term of equipment and space. At present, lower school students tend to have less experience of practical science as they have to give way to examination classes when laboratory time is being allocated. In my role I can convince others of the importance of making these resources high priority for all students.

There are policy makers and researchers who are aware of the level of failure in the system. This information and the theories to explain the situation are not highlighted in the public domain. The general population buy into the neoliberal concept of personal responsibility and so it is evident to me that the radical changes that are advocated for the development of the education system and the teaching of science must be discussed with stakeholders in a setting that is not subject to political bias and control. In staff and parents meetings it is possible to introduce topics on school improvement and our aspirations for the qualities that are desirable in our citizens.

7.5 Dissemination of findings

As outlined in Section 3.7, I see this report being useful to researchers, policy makers and curriculum planners who are particularly focussed on education in the Caribbean and internationally. Senior school managers and teachers should find that this thesis sheds light on what influences the way in which they work with young people and helps them to re-consider their desired outcomes in the interest of communities and society as a whole.

This thesis should emphasize to government and Ministry of Education officials the importance of providing effective teacher training and upgrading the system so that the quality of teaching in science and other subjects is improved in all schools by providing the appropriate resourcing,

monitoring and support for schools. A focus on ensuring that equity policies are fully implemented would go a long way to having all students develop their criticality, as teachers would be supported in providing for the learning needs of all students.

Politicians, Ministry of Education and school officials who are sensitive to the pressures of globalisation need to be made aware of how their actions function, in setting an agenda, which results in the marginalisation of a great number of Trinidad and Tobago's young people. This thesis should aid in demonstrating the value of an emancipatory way of thinking, particularly in a country whose national anthem sings, 'Forged from the love of liberty'.

For teachers and curriculum designers, a view is provided of how programmes supporting a critical pedagogy can be designed. This work highlights how a critical pedagogy can provide a breadth and depth of experience and assessment techniques that can enhance learning.

7.6 Implications of publication or dissemination

As a qualitative piece, other researchers will determine the usefulness of using critical theory and postcolonial theory in analyzing the results of a case study that attempts to describe how well students develop critical thinking skills within the context of addressing social justice. My belief is that this work adds to a body of knowledge that supports a radical change in the way in which the education system is organised and how the content of syllabuses, teaching and assessment techniques are selected. It, therefore, will support greater use of critical pedagogies within science and education as a whole within Trinidad and Tobago and, I hope, internationally.

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APPENDICES

APPENDIX 1:

Letter seeking permission to collect data from the Ministry of Education

17 Gulf View Drive
Glencoe
Republic of Trinidad and Tobago

12th January 2012

Ms. Sharon Mungroo
Chief Education Officer
18 Alexandra Street
St. Clair
Port of Spain
Republic of Trinidad and Tobago

u.f.s. Mr xxxxxxxxxxxxxx
School Supervisor III
xxxxxxxxxx

Dear Ms. Mungroo

I am seeking permission to conduct a research project at xxxxxxxx College in xxxxxx. I am a Doctor of Education student at the Institute of Education, University of London. My work is centred on the development of critical thinking skills. I am looking to elucidate the extent to which the science curriculum that is used in Trinidad and Tobago assists in the development of students' critical thinking skills.

I have attached an outline of rationale for my investigations and how I intend to go about collecting and analysing my data. I have already approached the Principal at xxxxxxxx College and explained my purpose. His initial response was positive.

I would therefore be grateful if you could support me in this endeavour.

Yours respectfully

Perle Brewster

APPENDIX 2:

Letter seeking permission from employer to have time off for collecting data



Bishop Anstey High School East
Address: #1 College Avenue, Trincity
Phone: 868-640-8685, Fax: 868-640-8468

27th April 2012

Mrs. Paula Daniel
Director
Bishop Anstey and Trinity College East
1 College Avenue
Trincity

Dear Mrs. Daniel

As you are aware I am a student at the Institute of Education, University of London, where I am participating in the Doctor of Education Programme. I recently completed the 'Institution Focussed Study' stage of the degree and I am about to embark on the data collection for the Thesis. This thesis is based on critical thinking in Science Education. The proposal accepted by the University, involves a case study of a science department. I have been given permission to collect this data at xxxxxxxx College. I am therefore seeking your permission to go into xxxxxxxx, once my schedule allows. I am hoping to start on Friday 4th May and continue preferably on Friday mornings, once weekly, until the end of this year, 2012.

I would be grateful for support in this endeavour.

Yours respectfully

Perle Brewster (Ms)

APPENDIX 3:

Reply from employer giving permission for time off to collect data



Bishop Anstey High School East
Address: #1 College Avenue, Trincity
Phone: 868-640-8685, Fax: 868-640-8468
Email: info@ba-tc.edu, Website: www.ba-tc.edu

4 May 2012


Ms. Perle Brewster
Principal
BAHSE
#1 College Avenue
TRINCITY

Dear Ms. Brewster

Correspondence date 27 April 2012 refers:

Approval is granted for your absence once weekly on Friday mornings starting Friday 4 May 2012 to visit the Science Department of xxxxxxxx for the collection of data in support of your Thesis for the Doctor of Education Programme.

Sincerely


Paula Daniel, M.O.M.
Director

APPENDIX 4:

Letter seeking permission to carry out research exercise at St Francis College

17 Gulf View Drive
Glencoe
Republic of Trinidad and Tobago

12th March 2012

Mr. XXXXXXXXXXX
Principal
XXXXXXXXXXXXX
XXXXXXXXXXXXX
Republic of Trinidad and Tobago

Dear Mr. XXXXXXXX

I am seeking permission to conduct a research project at your College. I am a Doctor of Education student at the Institute of Education, University of London. My work is centred on the development of critical thinking skills. I am looking to elucidate the extent to which the science curriculum that is used in Trinidad and Tobago assists in the development of students' critical thinking skills.

I have attached an outline of rationale for my investigations and how I intend to go about collecting and analysing my data.

I would therefore be grateful if you could support me in this endeavour.

Yours respectfully

Perle Brewster

APPENDIX 5:

Reply from Principal of St Francis College giving permission to collect data

XXXXXXXXXX

XXXXXXXXXX

XXXXXXXXXX

Republic of Trinidad and Tobago.

20th March 2012

Dear Sir/Madam

I hereby authorize, Perle Brewster, student of the Institute of Education, University of London, to conduct a study entitled, 'To what extent does the National Science Curriculum in Trinidad and Tobago as presented by teachers engage students as critical thinkers?' at XXXXXX. Permission has been granted for her to do lesson observations and to interview teachers and students. As a case study that may affect our school's reputation it has been agreed that the anonymity of our school is maintained.

It is hoped that the results of the study will improve our approach to science teaching.

Yours sincerely

APPENDIX 6:

Letter to parents seeking permission to interview students

17 Gulf View Drive
Glencoe
Republic of Trinidad and Tobago

25th April 2012

Dear Parent/Guardian

I am seeking permission to interview your son/daughter for a research project at XXXXXX. I am a Doctor of Education student at the Institute of Education, University of London. My work is centred on the development of critical thinking skills. I am looking to elucidate the extent to which the science curriculum that is used in Trinidad and Tobago assists in the development of students' critical thinking skills.

I would therefore be grateful if you could support me in this endeavour. Please indicate your wishes by completing the tear off slip at the end of this letter.

Yours respectfully

Perle Brewster

I give permission for my child _____ to participate in the research study exercise, 'To what extent does the National Science Curriculum in Trinidad and Tobago as presented by teachers engage students as critical thinkers?'

Parent's signature _____ Date _____

APPENDIX 7:

Abbreviations

CARICOM	Caribbean Community and Common Market
CSEC	Caribbean Secondary Examination Certificate
CXC	Caribbean Examination Council
GCE	General Certificate in Education
GDP	Gross Domestic Product
GoRTT	The Government of the Republic of Trinidad and Tobago
ILO	International Labour Organisation
IMF	International Monetary Fund
KC	Knowledge and Comprehension
NJAC	National Joint Action Committee
OECD	Organisation for Economic Cooperation and Development
PAHO	Pan American Health Organisation
PISA	Programme for International Student Assessment
PNM	People's National Movement
SBA	School Based Assessment
SEMP	Secondary Education Modernization Programme
UK	Use of Knowledge
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNICEF	United Nations Children's Fund
UNC	United National Congress
U.S.	United States
USA	United States of America
USAID	The United States Agency for International Development
USD	United States Dollar
UWI	University of the West Indies
WHO	World Health Organization
XS	Experimental Skills

APPENDIX 8:

The Ideal Caribbean Person

The Ideal Caribbean Person should be someone who among other things:

- is imbued with a respect for human life since it is the foundation on which all the other desired values must rest;
- is emotionally secure with a high level of self-confidence and self-esteem;
- sees ethnic, religious and other diversity as a source of potential strength and richness;
- is aware of the importance of living in harmony with the environment;
- has a strong appreciation of family and kinship values, community cohesion, and moral issues including responsibility for and accountability to self and community;
- has an informed respect for the cultural heritage;
- demonstrates multiple literacies, independent and critical thinking, questions the beliefs and practices of past and present and brings this to bear on the innovative application of science and technology to problems solving;
- demonstrates a positive work ethic;
- values and displays the creative imagination in its various manifestations and nurture its development in the economic and entrepreneurial spheres in all other areas of life;
- has developed the capacity to create and take advantage of opportunities to control, improve, maintain and promote physical, mental, social and spiritual well-being and to contribute to the health and welfare of the community and country;
- nourishes in him/herself and in others, the fullest development of each person's potential without gender stereotyping and embraces differences and similarities between females and males as a source of mutual strength.

(CARICOM, 1997)

http://www.caricom.org/jsp/communications/meetings_statements/citizens_21_century.jsp?menu=communications

APPENDIX 9:

Example of notes on a lesson observation

Form 2 Teacher E
 Subject: Integrated Science – Reproductive System

Time	Teacher Activity	Student Activity
9.52	Shows poster of Male Reproductive Organ Dictates notes on each part Homework: Draw the male reproductive organs “You can get a picture from the internet and stick it in your notebook.” “What is the male reproductive cell called again?” Dictates note	Students copying dictated notes “The sperm” Students writing notes Students laughing and being unsettled at times
9.56	Dictating notes “What does flagellum mean?” “Helps the cell to move forward.” (No response to student questions)	“What happens to the other cells when only one fertilizes the egg?”
9.58	We are going to draw the sperm cell. Teacher drawing diagram	Student asked if they could copy the diagram on the poster and they

	<p>“Copy my diagram. Those labels (on the poster) are too complicated.”</p> <p>Teacher speaking to individual students</p>	<p>were told no.</p> <p>Students having individual conversations.</p>
<p>10.07</p> <p>10.12</p>	<p>“What is a cell?” Different type of cell</p> <p>Not linked to memory It is not an organ but it is tiny</p> <p>Head up CELLS:</p> <p>Definition of cell. Basic unit of all living things ‘full stop’. It is the smallest part of a living thing, which is fully alive ‘full stop’ Do you all think that you all are made up of cells.</p> <p>It is the smallest structure that is capable of basic life processes No life</p> <p>Some cells Some cells are multicellular and others unicellular? What does this mean?</p> <p>Anyone any that are unicellular? Do you know any yet?</p> <p>Ever heard of an amoeba?</p>	<p>“Something that carries blood?”</p> <p>“A tiny organ”</p> <p>Something that contains DNA</p> <p>Something that contains memory know? Student taking notes</p> <p>YES</p> <p>Miss after alive is a full stop</p> <p>Basic light?</p> <p>Write that?</p> <p>Shouting out</p> <p>More than one. Human beings</p>

<p>10.17</p>	<p>Multicellular</p> <p>“Let’s take a note, new paragraph”.</p> <p>I have a picture of an amoeba cell in my book.</p> <p>She walks through the class showing a coloured picture of the amoeba.</p> <p>Next paragraph – Living things which are made up of more than one cell are called multi</p>	<p>Miss do we have to write that.</p>
<p>10.21</p>	<p>Note</p> <p>Class disturbance</p> <p>There 20 trillion cells in a human being</p> <p>New Heading- Animal and Plant cells</p> <p>Starting with animal cells</p> <p>Talking to one student about scraping cells from cheeks to see the cells</p> <p>She ignored them we have to continue now and continued with the note.</p> <p>An animal cell consists of cell membrane, cytoplasm and nucleus.</p>	<p>Lots of discussion among students. A lot of noise. Teacher answering individual questions</p> <p>Students copying</p> <p>“Miss for them to do that to me I have to be dead.”</p> <p>Lots of hands up –“Miss, Miss”</p>

<p>10.31</p>	<p>She is writing the notes on board.</p> <p>“You all took down the notes?”</p> <p>Puts up poster – done by a student in Form 3</p> <p>Asks class from one side of the class to focus.</p> <p>Giving description and explanation of what is in the cells.</p> <p>“Focus here.”</p> <p>Not seeing hands and continuing with the explanations.</p> <p>“We learn what? The cell membrane, the nucleus and cytoplasm – let’s take the note now.”</p> <p>“Come on. Come on. Let’s focus.”</p> <p>“The nucleus controls all the activities of the cell”.</p>	<p>Most students focused- about four of them having private conversations.</p> <p>Students are asking about the other cell in the picture.</p> <p>Students putting their hands up.</p> <p>Silence, as students copy dictated notes.</p> <p>“Miss you going too fast”.</p> <p>Vacuoles - look on the board girl</p>
<p>10.36</p>	<p>Dictating notes Writing spelling for terms on the boards</p> <p>Describes excretory vacuoles that help animals to get rid of waste</p>	<p>Many of the students are distracted. One boy put up his hand then put it down.</p> <p>He put his hand up to rejoice when the class came to an end by the bell.</p>

APPENDIX 10:

Summary assessment of lesson observations comparing levels of exposure in terms of numbers, gender and ethnic composition and activities suggested by the syllabus documents

FORM	CLASS SIZE	*ETHNIC GROUP	GENDER MIX	TEACHER	SUBJECT	AREA OF STUDY	TEACHING ACTIVITIES OBSERVED	ACTIVITIES SUGGESTED BY THE SYLLABUS BUT NOT WITNESSED	ASSESSMENT OF LESSON QUALITY
1	4 6 10 3 4 Total 27	AC AC EI EI M	Male Female Male Female Female	B	Chemistry	Particulate nature of matter	Lecture with questions and answer sessions Group work to answer structured questions	Measure mass and volume • Refer to moon rocks, meteors, substances and materials in the biotic and abiotic environment • Relate properties of matter to everyday use • Perform experiment with teacher guiding discussion of results and explanation	Requires improvement
1	10 6 4 1 1 Total 22	AC EI EI M M	Female Male Female Male Female	F	Chemistry	Atomic structure	Note taking Calculations Draw and examine	Use models and charts in interactive session Build a model	Requires improvement
2	5 6 8 3 Total 22	AC AC EI EI	Male Female Male Female	D	Physics	Electricity	Field trip (before this lesson) Video clip Lecture Note taking	Practical work (intention to complete practical work was indicated)	Requires improvement
2	11 11 5 3 Total 30	AC AC EI EI	Male Female Male Female	E	Biology	Reproduction	Lecture Note taking Tables classifying information Posters	Media presentations, such as a movie PowerPoint presentation Microscopic work	Inadequate
2	4 11 7 4 2 1 Total	AC AC EI EI M M	Male Female Male Female Male Female	F	Biology	Digestion	Note taking Video clip (before this lesson) Practical work - investigation (food tests)	Meal plan • Cartoons • Monologue to narrate digestion of a sandwich	Requires improvement

	29								
3	3 6 8 6 2 Total 25	AC AC EI EI M	Male Female Male Female Female	F	Chemistry	Acids and Alkalis	Note taking	Practical work – observation (promise to do practical work)	Requires improvement
3	1 5 8 8 Total 22	AC AC EI EI	Male Female Male Male	F	Chemistry	Atomic structure	Note taking Diagrams	Use models and charts in interactive session Build a model	Requires improvement
3	3 6 10 7 1 2 Total 29	AC AC EI EI M M	Male Female Male Female Male Female	C	Physics	Limitations on measuring instruments	Practical work - investigation	Discussion on difficulties incurred after doing a variety of measurements	Requires improvement
4	2 12 2 Total 16	AC EI EI	Female Male Female	E	Biology	Transpiration	Dictation Note taking	Practical work – observation Practical work- investigation	Inadequate
4	1 5 5 7 Total 18	AC AC EI EI	Male Female Male Female	G	Physics	Light - reflection	Lecture • Note taking • Teacher demonstration • Story telling	Practical work – investigation observation	Inadequate
4	2 6 7 8 Total 23	AC AC EI EI	Male Female Male Female	G	Physics	Light – Refraction (Snell's Law)	Calculations • Teacher explanations	Practical work – observation investigation	Requires improvement
4	4 4 11 4	AC AC EI EI	Male Female Male Female	B	Chemistry	Separation techniques - chromatography	Practical investigation • Calculations • Lecture •		Requires improvement

	1	M	Male				Teacher explanations		
	1	M	Female				• Note taking		
	Total 25								
4	4	AC	Male	B	Chemistry	Electrolysis	Calculations	Practical work - observations	Requires improvement
	4	AC	Female				• Structure questions		
	11	EI	Male				• Examination practice		
	4	EI	Female				• Teacher explanations		
	1	M	Male						
	1	M	Female						
	Total 25								
4	3	AC	Male	F	Chemistry	Titration (SBA – See Appendices 14 and 15.)	Lecture		Requires improvement
	4	AC	Female				• Practical test (observation, manipulation of equipment, analysis and interpretation)		
	4	EI	Male						
	4	EI	Female						
	1	M	Female						
	Total 16								
5	4	AC	Female	E	Biology	Osmosis	Note taking dictation on how to carry out practical exercise for school based assessment	Practical work - investigation	Inadequate
	11	EI	Male						
	3	EI	Female						
	1	M	Male						
	1	M	Male						
	Total 20								

*Student ethnicity was determined by direct observation.

Key: EI - East Indian
AC - Afro-Caribbean
M - Mixed race

APPENDIX 11:

Definitions of classifications for cognitive, affective and psychomotor learning

Type of learning	Characterization
Cognitive	
Knowledge	Retrieve knowledge from long term memory
Comprehension	Create meaning from instructional messages
Application	Use new knowledge
Analysis	Examine information and makes inferences
Evaluation	Make judgments in terms of validity and quality
Create	Generate, plan, produce
Affective	
Receiving	Willingness to pay attention
Responding	Active participation
Valuing	Attach value
Organising	Build a consistent value system
Characterising	Possess a value system that influences one's lifestyle
Psychomotor	
Perception	Use sensory cues to direct motor activity
Set	Mentally, physically and emotionally ready to act
Guided Response	Imitation and trial and error in the practice of learning a complex skill
Mechanism	Learned responses are habitual, confident and proficient
Complex Overt Response	Skilled performance of complex skills
Adaptation	Adaptable in performing complex skills
Origination	Creative

Krathwohl, D. R. (2002).

APPENDIX 12:

Example of a marked test

Air moves from the outside into the lungs through

- a) Trachea
- b) Alveoli
- c) Mouth
- d) Diaphragm

18
30

What are the tiny air sacs in the lungs called?

- a) Ravioli
- b) Bronchioles
- c) Alveoli
- d) Capillaries

What happens during Gaseous Exchange in the lungs?

- a) Carbon dioxide diffuses into the lungs from the blood
- b) Oxygen diffuses into the blood and carbon dioxide diffuses out of it
- c) Carbon dioxide diffuses into the blood and oxygen diffuses out of it
- d) Both carbon dioxide and oxygen diffuse into the blood

Which of the following equations represents aerobic respiration?

- a) Carbon dioxide + energy \longrightarrow oxygen + water
- b) Carbon dioxide + glucose \longrightarrow oxygen + water + energy
- c) Oxygen + glucose \longrightarrow carbon dioxide + water + energy
- d) Oxygen + glucose \longrightarrow carbon dioxide + water

4.

5. Expired air has _____ than inspired air.

- a) Less oxygen
- b) More oxygen
- c) Less carbon dioxide
- d) Less energy

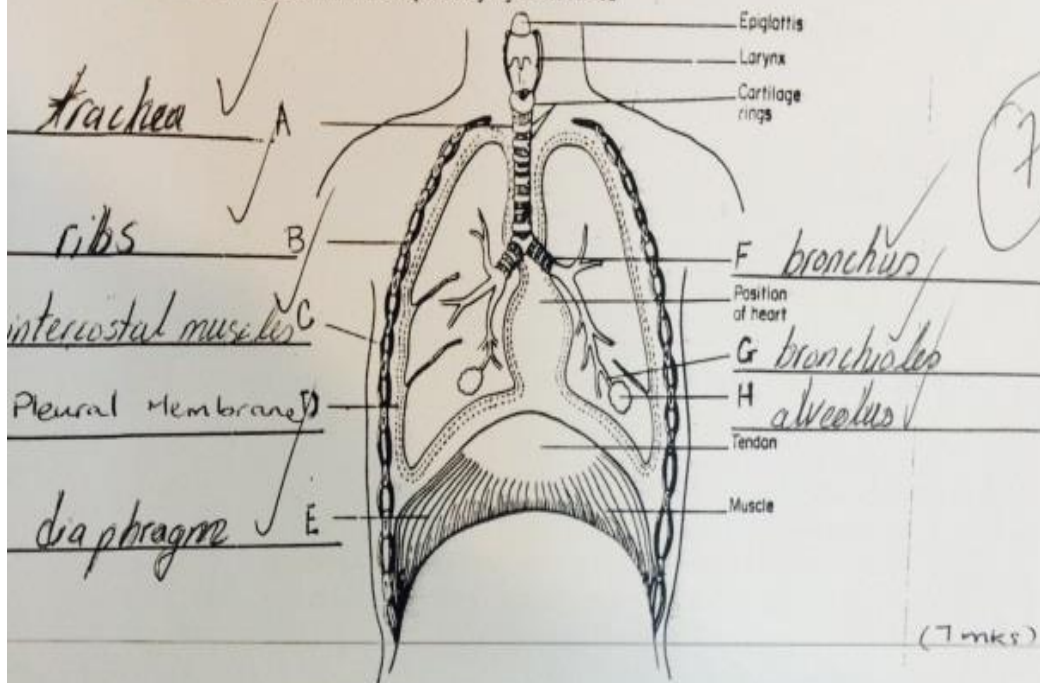
6. All living things obtain energy by breaking down _____ of the air. The chemical process by which _____ is released from the breakdown of _____ or other food substances is called _____.

In anaerobic respiration, glucose reacts with _____ in cells to produce energy. Carbon dioxide and _____ are the _____ products formed.

(7 mks)

SECTION 2

1. Label the parts of the respiratory system A-H



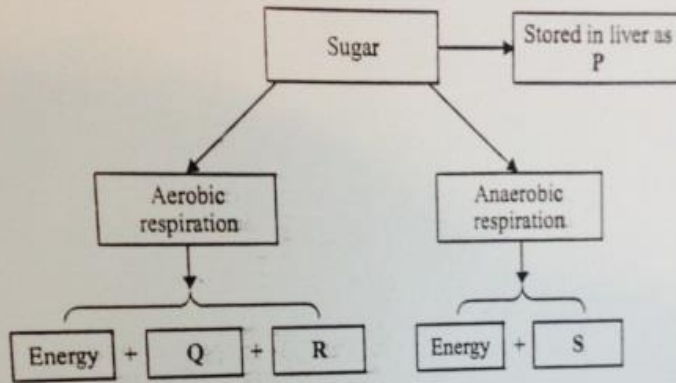
Human respiratory system.

2. Explain what happens during inspiration in the parts of the respiratory system listed in the table below.

Part of respiratory system	Inspiration
1 Intercostal muscles	Intercostal muscles are attached to the ribs. When you breathe in the chest cavity increases in volume and the muscles expand and contract upwards & outwards.
2 Rib cage	The ribcage expands and contracts upwards and outwards during inspiration.
3 Diaphragm	This sheet of muscle is pulled downwards when you breathe in. It separates the thoracic cavity from the abdomen.
4 Volume of thoracic cavity	The volume of thoracic cavity increases when you breathe in. The atmospheric pressure
5 Air pressure in the lungs	The air pressure decreases in the lungs in the thoracic cavity.
6 Movement of air	The movement of air speeds up and gas exchange takes place.

(6 mks)

- (a) The body gets sugar from food. The diagram shows some of the ways in which the body uses sugar.



Name the substances P, Q, R and S.

P. GLYCOGEN

Q. carbon dioxide

R. water vapor

S. acid

(3 marks)

- * (b) State one way in which the body uses the energy released in respiration.

One way the body uses energy is to make the blood flow faster and to be healthy oxygenated blood. (1 mark)

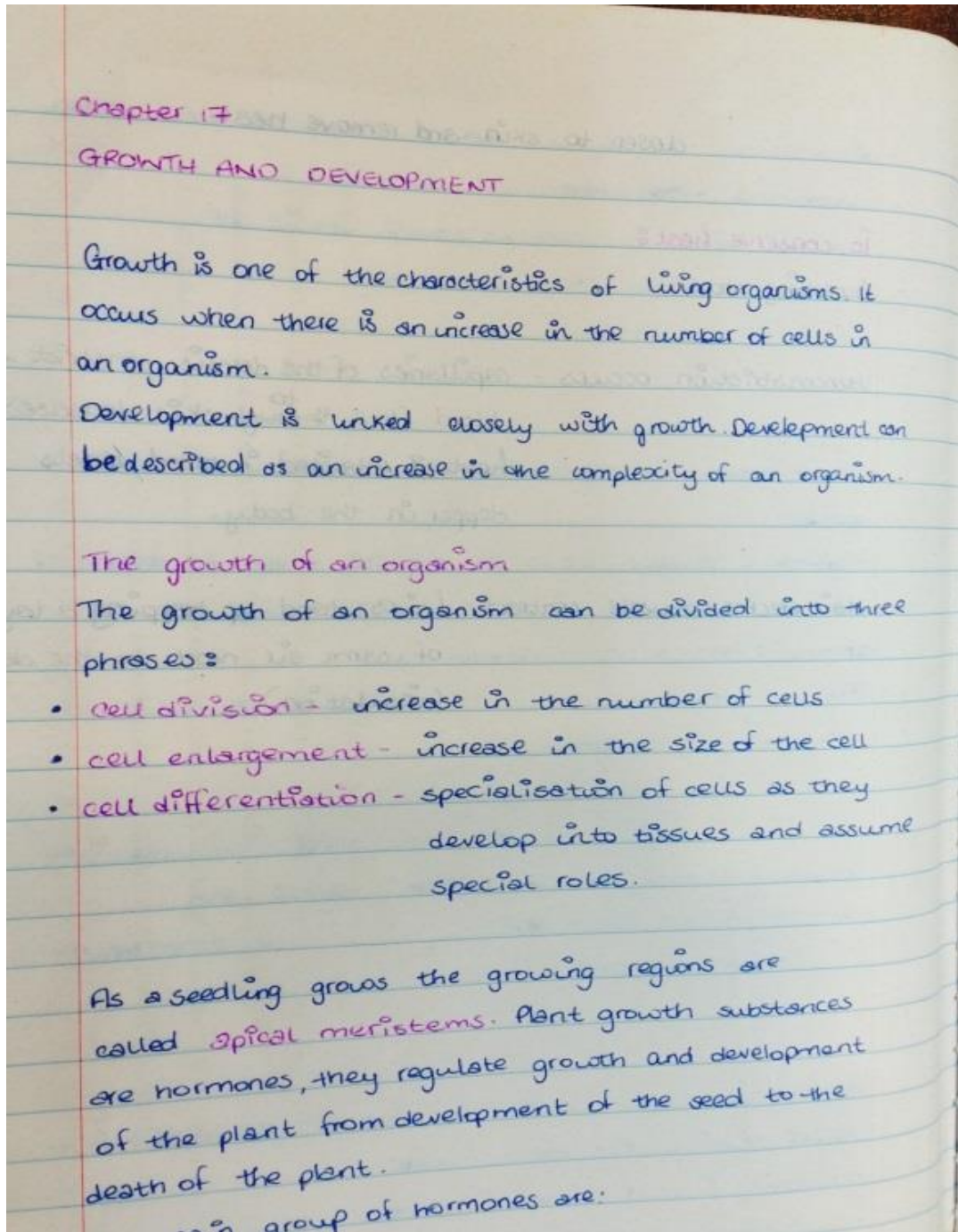
- c) State one feature of respiratory surfaces which helps with Gaseous Exchange.

The feature of respiratory surface is the blood capillaries. (1 mark)

EXAM TOTAL: - 30 MKS.

APPENDIX 13:

Examples of note taking



TOXIC METALS

Many metals can be poisonous and harmful to living organisms. These are usually released into the environment by industrial processes, burning fossil fuels & the use of pesticides and fertilizers.

Some of the common effects on humans are shown below:

METAL	SOURCES	SYMPTOMS
Mercury	fossil fuel burning, dental fillings, large fish, canned tuna, manufacture of chlorine & cement, water pipes, pesticides, fungicides, fabric softeners, adhesives, fertilisers	Nervousness, irritability, personality changes, muscle tremors, jerky gait, inflammation of the mouth & gums, excessive flow of saliva, loosening of teeth & kidney damage
Lead	lead pipes, lead headed nails, cigarettes, solder, vehicle exhaust, wrong leaded fuel, paints, crayons	mental confusion, visual disturbances, loss of cognitive abilities, anti-social behaviour, paralysis, anorexia, blue line on gum margins, nausea, vomiting, severe abdominal pain, anemia.
Aluminium	Deodorants, cooking utensils, baking powder, anti-caking agent in salt, soft drink cans, construction materials	mental changes, speech disturbances, tremors, abnormal heart rhythms, bone disorders, anemia, kills liver cells

APPENDIX 14:

Example of instructions and mark scheme for an SBA

SBA # 2007
EXAM YEAR:
EXPT. TO DETERMINE THE CONCENTRATION OF SODIUM CARBONATE SOLUTION.

CRITERIA ASSESSED: M/M, A/I

Instructions to students:

1. Rinse a clean burette with dilute hydrochloric acid solution, then fill it with the hydrochloric acid solution to a convenient mark. Record the burette reading.
2. Rinse a clean pipette then transfer 25 cm³ of sodium carbonate solution to a clean conical flask. Add 1 to 2 drops of screened methyl orange.
3. Titrate the sodium carbonate against the hydrochloric acid until the end-point is reached.
4. Repeat the titration until two consistent readings are reached.

Treatment of results: MARKING SCHEME FOR A/I

1. Write a balanced chemical equation for the reaction. [2]
2. Find the number of moles of HCl in the average volume of HCl used, given that its concentration is 0.1M. [2]
3. Hence find the number of moles of Na₂CO₃ in the 25 cm³ of solution used. [2]
4. Find the number of moles of Na₂CO₃ in 1 dm³ of solution. [2]
5. Find the number of grams of Na₂CO₃ in 1 dm³ of solution. [2]

TOTAL = 10 MARKS

MARKING SCHEME FOR M/M:

Measurement : Examiner's titre = 26.50, cm³
+/- 0.2 cm³ difference [10 marks]
Every other +/- 0.2 cm³ difference : subtract 1 mark.

Manipulation: [10 MARKS]

Correct use of burette

- use of funnel when filling [1]
- removing funnel immediately after filling [1]
- ensuring tip is full of liquid [1]
- ensuring that there are no air bubbles [1]
- removing hanging drops [1]
- ensuring burette is straight when reading [1]
- reading at eye level [1]
- reading bottom of meniscus [1]
- accurate interpretation of scale [1]
- correct positioning of fingers and thumb around the tap [1]

TOTAL = 20 MARKS

A/I = 10
M/M = 10 } 20
Mani = 10 }

APPENDIX 15:

Example of a marked SBA

Materials/Apparatus: 500 ml beaker, potassium permanganate crystals, straw, spatula.

Method: A beaker was filled with water and left for several ^{minutes} potassium permanganate was placed into the water. A labelled drawing of the beaker was drawn to show how the colour was distributed at the start of the experiment. The beaker was left completely undisturbed for hours. A second drawing was made to show how the colour was distributed.

Results: See drawings on the following page.

Discussion: Diffusion is the movement of particles from a place of high concentration to one of lower concentration ^{until evenly mixed}. The potassium permanganate crystal began to disperse in the water and by ^{not clear} with one molecule the colour of the water was a lighter purple than if more crystals were added. This is because of the rate of diffusion depends on the difference of concentration / diffusion gradient. The importance of the diffusion / concentration gradient is that it allows living organisms to get rid of waste and obtain nutrients. The only problem

✓ Title: Osmosis

E1 Aim: To observe some effects of osmosis.

Materials/Apparatus: Distilled water, salt solution, pair of forceps, G10 absorbent paper, potato tissue, ruler, 2-100ml beakers. ~~which~~

H1 Method: Two potato strips were cut roughly 1cm² and 8cm long. The length of each was measured as accurately as possible using a ruler. The potato ~~stripped~~ ~~was~~ ~~rubbed~~ strips were rubbed between the fingers to assess the texture. Each potato ^{strip} was placed into a beaker. One was distilled water and the other was a strong solution of sodium chloride (salt). They were then left for 15 minutes. The potato cylinders were removed, measured accurately and the texture and flexibility were then checked.

Results: TABLE SHOWING THE EFFECTS OF WATER AND SALT WATER ON POTATO STRIPS

	First Texture	Final Texture	First length (cm)	Final length (cm)	Change in length (cm)	%	
water	Turgid	Turgid	4.0cm	4.1cm	0.1cm	2.5%	+
salt	Turgid	Flaccid	4.0cm	3.9cm	0.1cm	2.5%	-

I1 J1 Description: Osmosis is the process by which water moves across a partially permeable membrane from a solution of high concentration to a solution of low concentration of water molecules. This is found in the plant cell's membrane and the inner membrane around the plant cell's vacuole. When the potato strip is put into a distilled ^{water} solution the water molecules move into the potato strip through the partially permeable membrane since the

lab #

4

YY	MM	DD

Discussion (cont'd): the distilled water solution. This made the potato ~~strip~~ strip have a turgid texture as well as making the potato ^{strip} increase in length from 4.0 cm to 4.1 cm. However, with the potato strip that was in the salt solution, the concentration ^{of water} was lower outside of the cell making the water molecules from inside the cell move outward through the partially permeable membrane. This resulted in the potato strip having a flaccid texture and a decrease in length from 4 cm to 3.9 cm.

Conclusion: The length of the strip placed in distilled water increased by 0.1 cm, but the length of the strip in the salt solution increased by 0.1 cm. ^{due to osmosis.}

A 1

B 1

C 1

D 1

E 1

ORR 9/10

