Student Continuation in High School Chemistry.

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2006

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For the School of Education

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Chapter 1

The Need for Scientific Literacy

In the eighteenth, nineteenth and early twentieth centuries, economic competition was very different from how it looks today. One of the most obvious differences lies in the ability to transport goods between countries (let alone continents) and store them once they arrive. Because of this, the number of markets that were historically open to certain goods was limited to areas that were easily accessible to the producer. For example;

1) Perishable and semi-perishable goods remained close to the area of production prior to the ability to grow these items locally.
2) Design has always been an important element of the sales process. Designs need to change regularly and arrive promptly if they are to keep up with the ever changing trends that are common many industries. Until the recent arrival of rapid transport, ensuring the prompt arrival of products over long distances was hard. As a result, these items had to be fabricated locally.
3) Raw materials like iron and steel are items that are used in a variety of industries. Manufacturers have two choices when it comes to siting plants that use these raw materials. They could site their plants near the raw materials and transfer their goods to markets or site their plants at the market and ship the raw materials to their sites. Irrespective of what was selected, the need to ship items at regular intervals, in high volumes and at precise times is considerable. As a consequence, many locally based companies would not be able to compete internationally until the road, rail

and shipping infrastructure becomes sufficiently well-developed to allow for reliable trans-continental shipping to occur.

As the twentieth century progressed, transportation and storage became less of an issue. In response to this, governments introduced tariffs and other protectionist actions at ports and other receiving stations. These actions raised the price of imported goods, making them less competitive than their home-grown counterparts. This would seem counter-intuitive if the focus was on the consumer (the consumer is entitled to lower prices after all), but these measures were implemented for two main reasons. These were:

1) They protected home grown jobs and industries that struggled to compete on price; and
2) They ensured that the home nation remained active in politically sensitive fields like microelectronics.

Since World War II, protectionist strategies have slowly been removed by international agreements like the General Agreement on Tariffs and Trade (GATT) and organizations like the World Trade Organization (WTO). This resulted in cheaper goods for consumers, but also a reduction in the number of low paying 'blue collar' in First World countries that have tough labor laws and comparatively high minimum wages.

Up to the end of the 1970s, governments responded by arguing for local price freezes (or even price cuts) to help their countries to compete against foreign imports (Yergin & Stanislaw, 1997). Experience, however, tells us that this is hard to achieve. When asked to compete against countries like India, China and the Philippines on price, businesses respond by making staff redundant, cutting pay and insisting on productivity increases from those that remain. These are things that most governments cannot stand.

As a result of this thinking, it can be argued that if America is to compete, it needs to promote value rather than cost. A literate, technologically aware, scientifically and mathematically proficient population can make suggestions to local manufacturers, thereby adding value to local items, without adding cost. This will help American industry differentiate itself from its competitors, giving it a competitive edge (Borman, 2005). A scientifically literate population would make these suggestions more effectively and is therefore of the utmost importance. Without those literate employees to suggest changes to current designs, America's attempt to differentiate itself on the basis of value will be doomed to failure because they have failed to gain the skills to add local value.

Does America have a scientifically literate workforce?

Initial examination of the evidence suggests that America falls short when its workforce is assessed for scientific literacy. By 2001, there had been a 12% decline in graduate enrollment in physical, earth, atmospheric, and ocean sciences from the highs achieved in 1993. This figure was worse for mathematics, with a 17% decline over the same period (National Science Board, 2004). In addition, it is worth noting that the percentage of scientific papers written by Americans has fallen 10% since 1992 (Davidson, 2004). The decline is much worse in some areas, with the percentage of American papers submitted for publication in Physical Review (a well regarded physical science journal) halving since 1983 (Davidson, 2004).

The lack of academic growth in the physical sciences might seem to simply be a problem for the American academic community, but problems with scientific literacy are not just limited to academia. Between 1980 and 2003, Japan's share of world industrial patents rose from 12% to 21%. Taiwan's share rose from 0% to 3%. In contrast, the U.S.

share of patents fell from 60% to 52% over the same period (Davidson, 2004), implying a lack of growth in the physical sciences is a problem for American industry too.

While it is fair to say that much of the direct preparation that is needed to make America technologically literate society occurs at universities and community colleges, high schools play a significant role in preparing students for college and the workplace. Consequently, this work started by considering if high schools do enough to prepare students to be viewed as literate in science.

Do schools help students become literate in science?

There are 40 high school science courses that are readily available to high school students [National Center for Educational Statistics (NCES), 2004]. It is unrealistic to suggest that this work should focus on all 40 subjects (the scale would be too large). Consequently, this work should more realistically focus on one subject. If there is evidence that the foundations of a scientifically literate workforce fail to occur in that one area, then it would be fair to say that high schools need to improve (in that area at least).

Before a single science is examined in more detail, however, it is worthwhile to spend some time considering the general scope of the problem in high school science. Data issued in 2004 by the National Center for Educational Statistics suggest the number of students who elect to take science beyond the state-required minimum for graduation is small (NCES, 2004). As a result it can be argued that America is becoming a less scientifically literate (AAAS, 1993, Culliton, 1989, Shymansky & Kyle, 1988, Walberg, 1991), especially when compared to other countries (SciMath^{MN}, 1999).

In elementary grades, the performance of the typical American student is among the strongest in the world, with students ranked in the first two or three internationally

(SciMath^{MN}, 1999). By the end of high school, however, students were placed ahead of just Italy, Hungary, Lithuania, Cyprus and South Africa amongst the countries that took part (SciMath^{MN}, 1999). While it is fair to say that some of this drop in comparative position can be explained by the large fall in the number of students that attend high schools in third world countries (which means a small group of able students in Taiwan, for example, are being compared to a large group of American students); however, that fails to explain why American students did worse than their counterparts in the rest of the First World, all of whom could realistically expect a similar numbers of students to continue on to 18 years of age.

Anecdotal concerns about high school science are common. Evidence suggests that this concern has been regularly stated since the 1970s, and has been a thread in educational discussions ever since (Walberg, 1974, Southern Regional Educational Board (SREB), 1981, National Commission on Excellence in Education (NCEE), 1983, Crosswhite, Dossey, Swafford, McKnight, & Cooney, 1985, McKnight, Crosswhite, Dossey, Kifer, Swafford, Travers & Cooney, 1987, AAAS, 1990, Nelson, 1998, and Gaynor, 2005). Explanations for the problems that schools face are almost as easy to find as the problem statements themselves. Some of the reasons why there is such poor performance in science are examined in greater detail elsewhere, but everything from a "smorgasbord curriculum" (especially when it was combined with extensive student choice [NCEE, 1983]) to low teacher expectations of the students (Sadker & Sadker, 1983) have been blamed for this underachievement.

In addition to the qualitative concerns that are expressed about scientific literacy in high schools, there is some quantitative evidence that supports these concerns about the levels of scientific literacy. Examination of the 2004 National Evaluation of Academic Progress Report tells us that grades in science are significantly lower than overall high school grades and that science is the least frequently taken "Core Class" (NCES, 2004).

Table 1
Science GPA, as Compared to Overall Student GPA

Year	Science GPA (Overall GPA)	Relative Position
1990	2.39* (2.68)	Second Lowest**
1994	2.50* (2.79)	Second Lowest**
1998	2.62* (2.90)	Second Lowest**
2000	2.67* (2.94)	Second Lowest**

*The difference between the GPA that students achieve in science GPA they achieve throughout their schooling is statistically significant at the $p<0.05$ level.
**when compared to all other subjects, students only scored lower in Math.

Table 2
Carnegie Units Taken by Students in High School "Core Classes"

	Ave. # of Science Carnegie Units Taken	Ave. # of Math Carnegie Units Taken	Ave. # of Social Studies Carnegie Units Taken	Ave. # of English Carnegie Units Taken
1990	2.8*	3.2**	3.5**	4.1**
1994	3.1*	3.4**	3.6**	4.2**
1998	3.1	3.5**	3.8**	4.1**
2000	3.2	3.7**	3.9**	4.3**

*The difference between the # of Carnegie Units completed and the corresponding 2000 value is significant.
**The difference between the # of Carnegie Units completed and the corresponding # of "Science Carnegie Units" taken in that year is significant.

Taken in isolation, examination of the results for science could allow it to be argued that there is little cause for concern (they are improving after all). However, given that grades in science are still significantly lower than nearly every other subject, some concerns might be well founded. Students fail to take as much science as they could and when they take science, they struggle to do as well in it as they do in most other subjects (their grades are significantly lower).

The facts that have been outlined so far may speak to the problems that schools are having with science, but none have, as yet, spoken specifically to the position of individual science areas. Consequently, it is worth remembering that while 60% of high school graduates attempt chemistry courses, fewer than half (49.5%) leave with any high school chemistry qualifications and only 4.6% of students graduate with two or more chemistry courses (NCES, 2003).

These "continuation rates" are not only a problem for chemistry. The situation for high school physics is worse: 75.9% of students have no physics credits at all when they leave high school, and only 1% of students graduate with 2 or more physics courses (NCES, 2003). In fact, without the popularity of Biology and the mandated minimum curricula that many states currently employ, one has to wonder how much science most students would actively choose science at all.

These statistics tell us that there are problems with respect to high school science. Students struggle to be successful in science. They opt out of science as much as they can and many students that do select science drop out once they start (18% of students who start a chemistry course fail to complete it). This speaks to how students see science.

Do universities improve student literacy in science?

Student performance in high school science impacts how they perform in science courses at university. This is because the knowledge that students use as a foundation for their learning in university comes from their high schools. Given that concerns are expressed about high school science, it should come as no surprise that concern about American science literacy is not just limited to schools (Davidson, 2004).

Students arrive at university with a variety of expectations for the future. Some students might want to be dancers; others might want to be reporters or teachers or engineers and scientists. One of the most obvious issues facing university science departments is that less than half of all college freshmen who planned to major in science or engineering had managed to graduate in that area 5 years later (NCES, 2000b, Center of Institutional Data Exchange and Analysis, 2001). Couple this with the fact that 20% of academic year 2002 college freshmen who planned to major in science or engineering needed remediation in math and 10% needed remediation in science and concern has to be expressed over whether high schools are preparing students for the scientific life of universities (National Science Board, 2004).

These facts should be of concern because although they are comparable to the continuation rates of other subjects at American universities (around 40-45% of all freshmen change their major, compared to around 51% for science and engineering students), the question still remains as to whether American universities are doing enough to keep students involved in science. Europe produces more scientists and engineers than America (in both actual and per capita numbers [Busquin, 2003]), China produces almost five times as many scientists and engineers as America and Japan produces almost twice as many (Boylen, 2004). Additionally, a quarter of all American scientists and engineers are expected to retire by 2008 (U.S. Department of Commerce, 2002) and the United States ranks seventeenth among nations surveyed in the proportion of its 18- to 24-year-olds earning natural science and engineering degrees in 2000 (National Science Board, 2004). This is down from third in 1975.

What do people think the problem with science is?

Any number of reasons has been suggested for the low level of science literacy in US schools and universities. They range from the idea that current structure of science is inappropriate (Lederman, 2002a, 2002b, Wilt, 2005) to issues surrounding the ability and socioeconomic status of the students taught (Coleman, Campbell, Hobson, McPartland, Mood, Weinfield & York, 1966).

Is Structure the Problem?

High schools in the United States have been controversial since the time they were first introduced to the United States in a widespread way. Much of that initial discussion focused on who would use them and what courses students would take. In response to these concerns, the "Committee of Secondary School Studies" (which is better known as the "Committee of Ten" after the number of people who sat on it) was set up by the National Education Association in 1893 to investigate the condition of these nascent high schools, and recommend improvements.

The committee, which was composed of academics from a variety of reputable schools and universities, argued that high school students should receive an "academic education," that curricular standards must be high and, most importantly, they must be the same for all students irrespective of what the students planned to do with their education after they had received it (Kliebard, 1986).

As part of this general plan of collegial education mandate, science was structured so that "general science" was taught first, followed by biology, chemistry and physics (in that order). The thinking behind this includes the fact that society was more rural in the late nineteenth century, so knowledge of biology would prove to be of more use. Biology was felt to be a useful forum for the teaching of personal hygiene and health care and could be taught by rote memorization (which was felt to be easier on the students), while physics, and to a lesser extent chemistry, would need a greater understanding of math.

This thinking lasted long into the twentieth century, and probably contributes to a popular perception today that biology was easier than either chemistry or physics. This thinking is exemplified by the fact that 18% of students fail to complete the chemistry classes they start, making it unlikely that they will ever return to science.

Alternative Explanations

Examining the facts, as they have been presented here, suggests that a number of factors might be contributing to the problems that are being faced. They can be broken down into issues surrounding the teacher, issues surrounding the relationship between students and the teachers and issues surrounding the student. Because of their scale, however, these areas should be tackled individually.

1) **Issues surrounding the teacher**
   While poor teaching might contribute to lower grades and persistence rates in some schools, it is unlikely that this is such a widespread problem that it entirely explains the poor student continuation rates in science, so the quality of overall teaching can be tentatively ruled out.

   This does not mean that all teachers are equally effective, however, or that all approaches that teachers could take have the same impact. There is evidence to suggest that using the most appropriate instructional strategies can have a large impact on student achievement (Marzano, Pickering & Pollock, 2001). Marzano et al. demonstrated that effect sizes of up to 1.61 can be generated in 9 areas related to how lessons are structured.

If it is accepted that these “effective teaching methods” are patchily distributed, however, it could explain why some schools are more effective at retaining students in chemistry than others. Poorly conceived or presented ideas about what should be taught at what level will clearly impact how a student responds to a subject and their willingness to remain involved with that subject (Eccles, Adler, Futterman, Goff, Kaczala, Meece, & Midgely, 1983, Eccles, & Wigfield, 1995, Eccles, J., Wigfield, A. & Schiefele, 1998, Brophy, 1999).

2) Issues surrounding the relationship between students and the teachers

There are number of issues that are raised in this area. They vary from the idea that teachers have an inappropriate expectation of what students can achieve, to the fact that the curricula that is taught is poorly thought out with respect to what should be taught at each level, and the fact that text books that are inflexible and do not change with the times (and so do not relate to students current experiences).

It is possible that less effective teachers have unrealistic expectations of what students can achieve. As example of this, while Japanese eighth grade mathematics teachers practice the reforms recommended by national organizations (NCES, 1997), American teachers who reform their teaching methods seem to be reforming the aspects of their practice that have little demonstrated effect on students' thinking

(Hiebert and Stiegler, 2000). Whether or not this is so sufficiently strong or widespread that it impedes general persistence in chemistry is not clear, but individual teachers might consider this area when thinking about what might impact persistence in chemistry.

There is a stronger argument against US curricula. It has been argued that US science and math curricula make fewer intellectual demands on their students and that they delay topics that are covered much earlier in other countries (Schmidt, McKnight, and Raizen, 1997). This is an important idea because if students are presented, for the first time, with challenging ideas in high schools, it is easier for them to walk away and change classes.

Concerns about the curriculum become stronger if the content is compared to the content of other countries. Examination of the content of US science and math curricula suggests they cover topics that are no longer considered to be important nationally and internationally (Schmidt, McKnight, and Raizen, 1997, Stevenson, 1998, Schmidt, McKnight, Houang, Wang, Wiley, Cogan, and Wolfe, 2001). This means Americans expects students to compete internationally when they are not given the tools that would help them to compete. This is of concern to those who want American students to compete by adding value to the items that they make in industry once they leave school. Unless students are aware of what is important internationally, they cannot compete on the world stage.

Curriculum content, however, does not lie at the feet of most teachers. State curricula are not formally passed into law by teachers and as a consequence teachers use what they are given. The curriculum can be used by teachers in a myriad of different ways. The important thing to uncover is how the teacher uses the curriculum to stimulate persistence in chemistry and not the content in and of itself. Some teachers can mold the curriculum so that it engages students. Others do not. Identifying effective use of the curriculum is therefore important when looking to improve persistence in chemistry.

Turning now to problems with U.S. textbooks (Venesky, 1992), it should be pointed out that according to NCES, science textbooks cover more topics, with less coherence, than in other countries (NCES, 2000a) and that they are felt to convey less challenging expectations, are repetitive, and provide little new information in most grades (Flanders, 1987, Eyelon and Linn, 1988). Given that ensuring that the pitch is right is one of the key factors when it comes to motivating students (Brophy, 1999), this would seem to be a fundamental flaw in textbook design. This problem will only be heightened if, as has been suggested, science teachers tend to overly rely on textbooks (Stevenson and Stigler, 1992, Stigler and Hiebert, 1999). Clearly therefore, understanding how effective teachers use textbooks (and which textbooks they use) is important when considering what teachers do to encourage persistence in their classrooms.

In response to criticism of their textbooks, there is evidence that publishers have changed their books to some degree. The problem is that even after these changes have been fully implemented, analysis of the changes suggests that much of the old material and structure is retained (Schmidt, McKnight, and Raizen, 1997).

3) Issues that surround the student

A number of issues could be raised in this area. They vary from the fact that student socio-economic status impacts student success and persistence in school, the impact that intelligence has on student persistence, and how student motivation can impact student success and persistence in science.

Socio-economic status is one of the strongest indicators that impacts success. Children of more affluent parents can expect to do better in school. The poor can be helped by integrating the children of affluent parents into their schools, but even then, they are less successful than their counterparts in higher socio economic groups (Coleman, Campbell, Hobson, McPartland, Mood, Weinfield & York, 1966).

Within the confines of what teachers can control in the classroom, however, there is very little that they can do to address these socio-economic concerns. Teachers teach their students science. They cannot wave a magic wand that removes the socio-economic issues that students face. In addition, while this issue is important, it fails to explain why some schools in poor areas have higher persistence rates than others. As a result, while this issue is important, it shall be left to others to investigate.

Intelligence, which is commonly regarded as a fixed quantity in students, impacts success. There is some evidence, however, that, intelligence is composed of knowledge (which is also known as crystallized intelligence) and cognitive skills (which is also known as fluid intelligence) (Cattell, 1971, and Ackerman, 1996). Fluid intelligence is regarded as fixed, but crystallized is something that can be altered and as a consequence is something that can be impacted by teachers. Effective teachers could raise achievement by stimulating their intelligence. In fact, when this idea of intelligence is used to appropriately to impact achievement, effect sizes of up to 2.02 can be generated (Walberg, 1984).

Student motivation is something else that is clearly impacted by teachers, with effect sizes of 1.62 being generated when used effectively (Willingham, Pollack & Lewis, 2002). Boring, inaccessible, or inappropriate material reduces student motivation (Brophy, 1999). Consequently, how motivation to continue in chemistry is impacted by differing paths through the subject could be investigated here. Of more importance, however, is the fact that effective teachers use what they teach to implant motivation and persistence in their students. This suggests that the pathway through the curriculum (how ideas are sequenced and paced for students) might be of importance (Whitener, 1989), because, one assumes, teachers have to teach the same material.

It is often hard for teachers (even experienced teachers) to judge how to pitch ideas so that students find them accessible. Accessibility is important, because if a student finds it hard to access what is being taught and work at the subject, he is more likely to drop out of the course (Brophy, 1999). This idea of pitch ties into issues of curriculum and textbook content and reinforces concerns about how curriculum and resource materials are molded to maintain interest and motivation.

Conclusion

Given the data that were outlined in this chapter, it is fair to say that America (as a whole) is falling short when it comes to making students literate in science. This does not mean that all teachers and schools are unsuccessful, however. Some schools are bastions of teaching. They are beacons of light whose practices could be used to show other schools, in similar situations, how to encourage students to persist in science.

The question, therefore, becomes: where are the schools that encourage students to persist and, more importantly, what are they doing? This work aims to identify schools that encourage students to persist and identify what they do. As a consequence of identifying their practices, it should be possible to disseminate these ideas widely so that the overall standard of literacy and persistence in chemistry can be raised.

This work focuses on more than just the gifted and talented. For an industry to be competitive in today's global market, every employee has to spot cost savings and add value. Consequently, this work will look to describe schools that encourage the entirety of the student body to persist in chemistry and not just the gifted few.

Summary

In today's global economy, inhabitants of first world countries like America will struggle to compete against the inhabitants of third world countries on price, so must compete on quality. Science allows employees to add value to products and services, but American students achieve less in science than they do in other subjects they take. As a result, America produces fewer scientists and engineers than their major competitors, and if this continues, it will become increasingly difficult for the US to compete on quality.

Teachers are an important factor when it comes to encouraging students to continue in science. Few other individuals have the opportunity to communicate its importance over prolonged periods. It is unlikely that the effective teachers communicate the importance of science by saying "Science is important because of…" Yet there are some exceptional teachers who can communicate the importance of science all the same and as a result, they achieve larger amounts of persistence than might be expected; given the students they teach.

This research aims to identify a school that is positioning all students so that they are willing to persist in Chemistry. Once this school is identified, its practices will be described so that other schools in similar situations can use their ideas to grow their chemistry departments. It is only this identification and roll out that will enable students and countries in the First World to remain competitive in the twenty-first Century.

This idea will be applied to all students, not just the gifted and talented. This is important because it focuses on how to improve the quality of the entire employee base of a firm, all of whom could contribute to improving product quality. Consequently this research will look at what practices effective schools departments and teachers use to ensure that as large a number of students as possible (given their background) continue on in chemistry, should they so wish.

Chapter 2

Teacher Behaviors in the Classroom

Strict labor laws and a comparatively high minimum wages mean that workers in First World countries can no longer compete against the Third World on price. If they wish to compete in a 21st Century marketplace, they need to compete by adding value to otherwise comparable items at minimal cost so that customers chose the items they fabricate rather than the cheaper priced foreign alternative.

One of the ways that this can be achieved is by ensuring that all relevant employees in a particular firm have a thorough and ongoing understanding of science. When employees have this understanding, they can combine their knowledge with an understanding of their workplace to make recommendations to their employer. This is important because while the overarching issues that relate to implementation lie with management, day-to-day implementation is the bread and butter of employees who work on the production line. They have more nuts and bolts experience of what works in their area and so are likely to be able to recommend small improvements to the process.

To be considered truly knowledgeable in science, high school students need to be encouraged to take as much science as is reasonably possible. Given the timeline of this work and the fact that there are 40 high school science courses (NCES, 2003), it is unrealistic to assess schools to discover what caused students to persist in every subject. As a result, this work aims to discover how students can be encouraged to persist in one high school subject, chemistry.

Examination of a large number of schools that have a considerable number of students is also unrealistic. Gaining access to such a wide number of schools might prove to be so challenging that this project would fail, given its current timeline. Consequently, this project aims to examine what one high school does to encourage persistence in chemistry, so that at the very least, a framework is developed for others to use in future investigations.

Becoming proficient in chemistry is one way to compete in today's marketplace, because knowledge of chemistry is needed in a variety of areas, and not just the realms of pharmaceutical giants like GlaxoSmithKline. Chemistry enables companies to develop effective working procedures in everything from an iron foundry and automotive manufacturer to oil rigs and tire factory (Pople & Williams, 2002). It is those effective procedures, if understood by employees on the production line, which will allow value to be added to the products that are made (Goldratt & Cox, 2004).

Given this thinking, it is not surprising that the idea of understanding how the best high schools produce what could be described as "foundation chemists" was raised in the previous chapter. These "foundation chemists" are important because, irrespective of whether or not they go on the college or move straight into the world of work, a thorough understanding of chemistry can be used to improve quality at work.

What Factors Might Impact Continuation Rates?

In the real world of Texas education, Texas education law stipulates that there are 3 programs that the high school graduate could follow (Texas Education Agency (TEA), 2005a). The students could graduate through the 'Minimum Program' (which requires that students complete 22 credit hours), the 'Recommended Program' (which requires that students complete 24 credit hours) and the 'Distinguished Achievement Program' (which requires that students complete 24 credit hours, but with a more challenging mix of classes). To gain access to Texas public universities, students have to graduate through either the 'Recommended' or 'Distinguish Achievement' programs (TEA, 2005a).

As part of the recommended and distinguished achievement plan, students have to study at least three science courses during their high school experience. All students must do a biology course and two subjects which should include Chemistry (i.e. Chemistry I, AP Chemistry or IB Chemistry), Physics (i.e. Physics I, AP Physics or IB Physics) or Integrated Physics and Chemistry (TEA, 2005a). In theory, 34 other basic science subjects are available (NCES, 2003), but the quality and availability of these subjects is so inconsistent that the TEA requirement is usually translated to these three "base subjects" in the students' minds. Consequently, when trying to define how we would recognize a "foundational chemist" the answer tends to focus on how schools encourage students to meet the minimum standard that are set in Texas (by taking Chemistry: I) and then going on the complete Chemistry II.

The focus of this work is what schools do to encourage students to persist in chemistry. Before the actions that schools take to encourage students are examined however, it would be useful to consider the main inputs that could impact student perceptions of chemistry before they arrive in the classroom. These variables impact student achievement directly or mediate the impact of other variables. They include:

1) **Actions of School District**
   No two school districts have the same managers, priorities and management styles. Because different things are going to be important to different managers, the importance of both chemistry and AP chemistry might vary from district to district and school to school.

As an example of this, both Dallas and New York have started to invest in “themed high schools” that build their instruction around a certain driving principle that can include ideas as diverse as art, science, nursing and law enforcement (Janofsky, 2005). The argument is that students are more likely to be attracted by a theme that runs through their learning and so be more willing to participate in science. Because of the recentness of their introduction, however, there is little evidence that this is in fact the case (Janofsky, 2005) but is an indication of what different managers are willing to try to increase participation.

2) Per Student Spending of School District

Since the 1973 *San Antonio School District vs. Rodriguez* Supreme Court ruling, different school districts within the same state have been able to spend differing amounts on the students that attend their schools. As an example, Massachusetts school districts spend, on average, $9,049 but the actual spending ranges from $6,285 to $21,386 per student, depending on the district (Massachusetts Department of Education, 2006).

This variety in spending can usually be explained by a spending formula that taxes better off families more, and it can argued that any persistence that occurs in a school could be a result of middle class family values rather than any increase in spending (for example, analysis of AP Chemistry class sizes in Dallas Fort Worth suggests that even in urban districts there is an inverse relationship between the size of the low SES population and the number of students studying AP Chemistry).

This having been said, however, science is one of the most expensive subjects that a school has to teach (in addition to all the textbooks and disposable items that you might find in any classroom, the cost of lab time and materials has to be factored into the cost of the class). Schools that have limited funding to invest in lab time can use other alternatives instead, but whether these approaches are as effective as hands on experience has yet to be demonstrated.

3) Intelligence

There is a long history of research that demonstrates that intelligence is generally positively correlated to achievement (Marzano, 2003), with effect sizes of 2.02 being reported by some researchers, such as Walberg (1984) when intelligence is used appropriately to improve results.

Using intelligence appropriately is doubly important because it results in not only the pleasure of immediate success for the students, but also an expectation of success in the future. Eccles (1983) tells us that it is this expectation of future success that often results in students persisting in a subject that they would otherwise have stopped taking.

This does not mean that intelligence and an expectation of success are always going to be enough to get the students to continue in chemistry (Eccles et. al., 1983). Clearly how the work is pitched is important too. Instructional differentiation allows the most able students to be stretched, while encouraging the weaker students. This differentiation comes from the teacher (Brophy, 1999). Therefore, understanding how students use differentiation is important in this case.

4) Gender

Irrespective of the current position of female students within school, each society has a set of unspoken expectations that it assigns to both men and women. These expectations will be internalized, to a greater of lesser extent, by members of those groups (Sadker & Sadker, 1994).

Not all of these unspoken expectations are going to be gender specific. There is evidence that both males and females perceive physics to be the hardest subject, for example (Walberg, 1974), but other expectations are going to be gender specific (girls are better at biology, boys at physics for example), and will be applied to chemistry and might impact continuation rates within it. Consequently, how this issue is addressed by teachers needs to be assessed in this investigation.

5) Gender Balance in Class

It is argued that students behave differently in different surroundings. What might be considered to be appropriate behavior in one classroom setting might be inappropriate behavior in a classroom elsewhere in the school (Sadker & Sadker, 1994).

It is also argued that a factor that impacts academic achievement of both boys and girls is the presence of the opposite sex in the classroom (Sadker & Sadker, 1994, Larson, 1996). Evidence suggests that students (especially girls) are more likely to act in a way that suggests that they *are not* able students when there are certain types of student in the classroom. This behavior needs to be addressed by teachers if students are to be encouraged to persist in science.

6) **Ethnic Origin**

The argument here works in much the same way as the argument that was previously outlined for female students. American ethnic minorities have made a great deal of progress in the field of civil rights over the past 40 years, but irrespective of their current official position in school, there are expectations that are assigned to all ethic groups within the school system, and these expectations will be internalized, to a greater of lesser extent, by members of those group (Eccles et. al., 1983).

Not all of the expectations that people have of students are specific to certain groups (the idea that students are "more trouble" these days is fairly common, for example), but other expectations might be ethnically specific, and might be subconsciously applied in chemistry lessons in a way that impacts student motivation. This behavior needs to be addressed by teachers who are interested in persistence.

7) **Socio-Economic Status**

It is a common perception that chemistry is educationally challenging (Walberg, 1974) and that students whose parents attended college are more likely to attend college themselves (and so take courses like Chemistry II that are a pre-requisite for some college courses).

Students from lower SES backgrounds (which can be assessed by examining parental income and using that figure to decide whether their child is entitled to receive free school lunches), attend college less frequently and have fewer expectations about going to college. This will make it harder to motivate them to take classes they perceive as challenging. This behavior needs to be addressed by teachers and is a factor that could be considered by this investigation.

8) **Age**

Students typically take Chemistry I in either their sophomore or junior year at public high school. This does not mean that all students in a typical chemistry class are going to be between 15 and 17 years of age. Students are regularly forbidden from proceeding in American schools, which means that the median age in a chemistry class is unlikely to be near the 16 median that one might expect half way though the year.

Older students are likely to have differing requirements and expectations of chemistry than those who take chemistry at the expected time in their development. In addition, they potentially bring a variety of different experiences to the classroom. Consequently, these students will have different motivational, expectational and academic characteristics (Tinto, 1973, 1993). This will impact how they behave in class, their interactions with other students and their approach to the subject once they start. This behavior needs to be addressed by teachers and could be considered by this investigation.

9) **Student Interactions with the Teacher**

An expectation of future educational success is important to students (Eccles et. al., 1983). It is argued here that this is influenced in part by the informal relationships that the students have with teachers (Pascarella, 1980). Teachers are often the face of a subject when it is presented to students, so clearly having a good working relationship with students should encourage students to persist (Pascarella, 1980).

It is also worth pointing out that when a student enters the classroom, he entered with characteristics that interact with the environment. In this environment, several psychological processes take place. These processes carry on continuously and they depend on the feedback the student receives. If the student is successful, persistence, loyalty and commitment to the subject occur (Bean & Metzner, 2000).

10) Parental Support & Expectation

Parents have a large impact in a student's life. Parents mould student expectations and so need to be described during the investigation. This is important because the family is the one community outside of school in which the student is bound to interact. Clearly, therefore, the family will play a part in student persistence in school, in general because the family contributes to the fabric of beliefs that make up the student (Tinto, 1993).

11) Peer Pressure

Students are influenced by more than their parents and teachers. The expectations of friends and classmates can impact student behavior and motivation and so needs to be assessed and controlled for as much as possible during the investigation.

The argument is that a student enters the classroom with a history (including peer group expectations) and an initial set of goals for the class. The student's experiences in the classroom then combine with these initial experiences and goals. This results either a willingness to persist, or a failure to integrate into the environment, both of which will affect the student's intentions with regard to AP Chemistry in the future (Tinto, 1973, 1993).

Were this a quantitative investigation, all these would have to be statistically similar in both the control and experimental groups that were set up. Because this work is more qualitative in nature these areas will simply be described in reasonable detail so that readers of this work can assess whether the school described in this work is so similar to theirs that the practices of the described school can be transfer and sit comfortably in the new school.

An Overview of Teachers' Best Practices

Teachers have two responsibilities in the classroom. They have to proactively set an agenda in the classroom that facilitates learning and yet still be sufficiently reactive to the unexpected challenges that they face once they arise (Marzano, 2003, Marzano, Pickering & Pollock, 2001). The reactive elements of teacher behavior might be interesting, but are harder to generalize beyond the classroom in which they occur (the mix of students will be very different within different classrooms of the same school, let alone between schools, regions and countries). Consequently, the proactive actions of teachers, and how effective they are at impacting student persistence in chemistry, are studied here.

There are about 3 million teachers in the US (NCES, 2005), and it is reasonable to argue that the majority of these teachers are, by and large, moderately effective, with a small number of teachers who are particularly effective and a small number of teachers who are considerably less effective (Marzano, 2003). Taken on their own, the most effective teachers have been shown to improve student performance by up to 53% over one academic year and 83% over three, while, for the least effective teachers, these figures are believed to be 14% and 29% respectively (Sanders & Horn, 1994, Wright, Horn & Sander, 1997).

If the standard of the school is taken into account, the impact of teachers is even more dramatic. Over a two year period, the least effective teachers will only improve a student by 3% in a poorly performing school, while in the best performing schools, the most effective teachers can improve performance by 96% (Marzano et. al., 2001, Marzano, 2003). Clearly therefore, effective teaching is an important factor when attempting to ensure that students achieve a reasonable level of success in a subject.

Employing effective teachers is doubly important for this project. Students who are taught by effective teachers are more likely to meet the minimum standards set by the TEA, which gives students a base level of literacy in chemistry. In addition to this however, students who expect to do well in a subject are more willing to persist in it (Atkinson, 1964, Covington & Omlich, 1979, Eccles et. al., 1983, Krapp, Hidi, & Renninger, 1992, Schiefele, Krapp, & Winteler, 1992, Wigfield & Eccles, 2001), and it is a major argument of this work that to be viewed as truly literate in chemistry, students have to choose to study Chemistry II. Effective teachers create an atmosphere where students can expect to do well. Thus employing effective teachers should create an atmosphere in which more students persist in chemistry. Consequently, identifying practices that enable this to happen in chemistry is going to be important.

Best Practices in Teaching

When classroom activities and behaviors are examined, it is possible (at least in theory) to break those activities down in a number of ways. It would be illogical, however, to give the investigative phase of this work no structure, in the hope that the lack of structure would allow something revolutionary to be observed during the investigative phase of this work that would otherwise be missed.

It makes sense to give this work some scaffolding on which the investigation can rest during the observation phase. This scaffolding need not be so prohibitively focused that it excludes other behaviors that fall beyond its boundaries from being raised, but it should give observers an initial focus for the investigation.

It can, in fact, be argued that classroom behaviors can be broken down into four distinct areas (Marzano, 2003, Brophy, 1996, Cotton 1995 & Creemers, 1994). To these four areas, it is argued here that a fifth could be added, that shows the teacher is keeping up to date with current thinking with regard to the teaching profession. The five standards are:

1) Instructional Strategies (or lesson structures or lesson design).
2) Discipline (or behavioral control)
3) Relationships (with children)
4) Curriculum Strategies.
5) Awareness of up to date thinking about the teaching profession.

It might not be possible to disentangle these ideas to find the impact of these factors individually (the effective teacher presumably has all these characteristics), but clearly they are all important factors when it comes to ensuring that teachers are effective (Brooks & Hawke, 1985).

Additionally it is important to point out that just because there are five categories listed here, does not mean other categories are not available, but most of what occurs can be placed in one or more of these groups. Consequently, while the investigation will primarily focus on these areas, the investigator will remain sufficiently conscious of what occurs around him to define factors that sit in more than one of these areas.

1) **Lesson Design**
   Put simply, this can be viewed as what strategies teachers use in the classroom. It can be viewed as occupying two levels, a pattern of teaching that the defines the course as a whole (for example, problem based learning [Albanese & Mitchell, 1994], learning styles inventories [Dunn, 1990], multiple intelligence [Gardner, 1999], practical intelligence [Sternberg, 2002] or the standard "chalk and talk" approach that most people recognize) and some of the practices that occur in class (for example, practicals, homework, instructional media and differentiation) once a teacher has decided on an approach for a class.

   Most schools use some form of "chalk and talk," either on its own, or in combination with some other approach to classroom teaching (most commonly either constructivism or brain based education, which are discussed later); so it is expected that this investigation will probably result in a description of effective practices in this area rather than a description of the variety of overarching teaching approaches that exist (some of which are hard to define [Newman, 2003, 2004], while some of the remainder are of doubtful worth [Kavale & Forness, 1987, 1990]).

   Given that this is a scientific subject, hands on practical experience is expected to be an element of an effective chemistry class. The notion that practical work aids understanding is believed by many science teachers in the UK and the USA. The sentiment behind the Chinese proverb “I hear and I forget, I see and I remember, I do and I understand” is often quoted as embodying the arguments in support of practical work (Harlan, 1999). While it will later be shown there is some evidence that practical work might not be as effective as has been claimed (Reynolds, 1991, Hodson, 1993), it is still expected to be part of the typical science classroom.

One of the biggest problems when it comes to assessing the effectiveness of teachers is the variety of measures that can be used to assess effectiveness. Bennett (1986), for example, developed 40 measures of teacher effectiveness. Unsurprisingly, Bennett’s list is neither the only nor most extensive list. Creemers (1994) and Battistini (1997) developed 9 criteria, for example, while Wise and Okey (1983) have developed 12, Walberg et al. (1980), Fraser (1987), Hattie (1992) and Marzano (2003) all developed 8, Kemp and Hall (1992) developed 7, Fashola and Slavin (1997) developed 4 academic criteria, Litteral (1998) developed 3, and Cotton (1995), has developed 150.

There are very few common actions that appear on all the previously mentioned lists. The setting of homework, for example, is the most widely recognized action that appears on the lists, but even this action does not appear on all lists mentioned.

A reason for this lack of internal agreement among lists might be that the elements described on these lists are so broadly defined as to include elements of other lists. However, the fact that there is no generally agreed upon definition to describe effective instructional practices suggests that entering a classroom with a "checklist" would be counter-productive and result in observers missing teacher driven practices that were excluded from the list when it was developed.

2) Discipline

Work has been done at elementary, middle and upper schools to assess the impact of behavior modification approaches on different age groups (Stern, Fowler & Kohler, 1988, Salend & Lamb, 1986, & Sugai & Rowe, 1984). A wide variety of these possible approaches have been tested. They vary from the use of tokens as a form of reinforcement (O'Leary, Becker, Evans, & Saudargas, 1969) to full blown individual therapy (Cowen, Orgel, Gesten & Wilson, 1979).

Sage and Quiroz (1997) argue that the wide variety of interventions that a teacher could take can be captured in one of four intervention categories. Students can be:

1) Punished for poor behavior.
2) Praised for good behavior.
3) Undergo immediate consequences.
4) Receive a combination of punishment and reinforcement.

These intervention approaches provided a variety of effect sizes, with no immediate consequences providing the smallest effect size (at 0.64), while, perhaps unsurprisingly, a combination of both punishment and reinforcement gave the largest effect size, at 0.97 (an equivalent of 33% improvement in behavior by those people tested).

While not all possible interventions have been tested in high schools, those that have been tested give an average effect size 0.86 (Sage & Quiroz, 1997). Considering the number of possible interventions, it is unrealistic to define all the interventions that teachers could use in high school. Given this, it would be more useful to observe what practices an effective teacher uses and describe those practices could be used elsewhere in other classroom.

3) Relationships and Behaviors

Maintaining the right mental attitude is part of being an effective teacher. A strong element of this is an awareness of what is going on around you (Kounin, 1983, Brophy, 1996), which is also called "with-it-ness."

Broadly speaking, this "with-it-ness" can be defined as an awareness of what is occurring around you. By being aware of what's going on in the classroom, teachers can peremptorily act to prevent behaviors that are inappropriate, while encouraging behaviors which are considered to be more appropriate (Brophy, 1996). Many commentators consider this awareness to be important.

Being aware of what is going on in the classroom is only half the problem. Making the correct emotional response to student behaviors is equally important. While there can be no doubt that there are times when decisive action is needed, reactions need to be emotionally neutral and consistent (Soar & Soar, 1979, Nelson, Martella & Galand, 1998).

4) **Curriculum**

This could most accurately be described as the ideas that are taught during lessons. As has already been stated, there is evidence that teachers tend to over rely excessively on the content of textbooks for lesson content and pathways through the curriculum (Stevenson & Stigler, 1992, Stigler & Hiebert, 1999). This might be a good thing if the textbooks were written with learning principals in mind, but there is evidence that little thought goes into this area of textbook design (Venesky, 1992).

It could be argued, therefore, that effective teachers should demonstrate that they are not overly reliant on textbooks. But what should they do? There are two strands of research that are currently receiving a considerable amount of coverage in this area. They are "constructivism" (where learning is viewed as an active process in which students resolve problems that arise in the classroom, [Anderson, 1995]) and "brain-based learning" (where an understanding of brain functions is felt to help teaching and learning [Berman, 2001]).

5) **Awareness of effective practices in the teaching profession.**

Enacting processes that others found effective in these four areas is no guarantee of success. Effective teachers will select activities that are appropriate for their students' abilities and effectively introduce them in class. Less effective teachers will struggle to implement the same ideas as effectively.

The question therefore becomes: "How are effective teachers identified?" Different countries use different criteria. For example, Cypriot high schools might want to use one set of criteria (Kyriakides, Demetriou & Charalambous, 2006), while the UK might want to use another (OFSTED, 2005).

In the US, it would only make sense to use these foreign criteria if none existed in the US and those foreign criteria were proven to work (there is evidence to suggest that the Cypriot criteria, for example, do not work, Kyriakides, Demetriou & Charalambous, 2006). These "effective teacher standards," however, do exist in the US and so it would make sense to select these standards for American teachers that are rooted in the culture that is under consideration (if for no other reason than there is no need to modify them to be effective in the US).

A number of states have readily available documents that articulate education standards. The California State Board of Education (1998), New York State Department of Education (1996), Kansas Department of Education (2005), and Pennsylvania Department of Education (2002) all have their own criteria for assessing teaching. Given this fact, two alternatives are possible. The most obvious course of action is to use Texas State Board of Education's standards (Texas State Board of Education, 2002). These standards have the advantage of being easily applied to Texas schools. The most readily available standards, however, apply to minimum requirements for newly certified teachers (which might not necessarily be the standard you want to use).

In comparison, the alternative, "National Standards" (National Research Council, 2004) are standards that cover all aspects of teaching. They were designed by a group that was specifically set up to create "Effective Teacher Standards," but are less likely to be specific to Texas. In addition they are based on research done in the 1990s, which might make them out of date.

Given that the modern teacher is becoming increasingly mobile, having criteria that are specific to their current position makes little, if any, sense. Add the fact that a variety of teaching groups recommend the use of "National Standards" (American Association of Physics Teacher, 2006), and it would make sense to use the national standards as a way to assess performance in the school under observation.

The standards developed by the National Research Council cover a number of different areas related to teaching:

1) **The Process of Teaching.**
   These standards cover the classroom environment. In the most effective environments, students and teachers work together in active environments.

2) **Assessment in Science Education.**
   These standards speak to how teachers can most effectively assess student understanding in science and how to use assessment to improve the student experience.

3) **Course Content.**
   These standards speak to the things that are taught at each grade level. They specifically talk about the importance of

investigations and hands on activities and how these activities can be assessed.

4) **Course Structures.**
These standards recognize importance of both "stand alone" courses and the inter-relationships among courses (both within and across years). They argue that the transitions between courses and years need to be monitored and the standards focus on those transitions.

5) **The Professional Development of Teachers.**
These standards speak to how teachers are trained once they enter the profession. For this to happen there has to be a clear relationship among the department, the school and the school district.

6) **State Education Structures.**
These standards focus on how the state (the largest organization that is typically involved in the education of high school age children) can best implement the teaching of science.

Of these six areas, the first three appear to be the most applicable to this investigation. Consequently, they will be discussed in more detail when recommendations are made for the future. However, had discussion of the remaining sections been needed, they too would have be covered in detail.

Is Practical Work Important?

As was indicated in the previous section, many teachers and scholars believe that hands on practical activity is an important part of any science, because as the Chinese proverb states, "I hear and I forget, I see and I remember, I do and I understand" (Harlan, 1999).

This belief can be traced back to the influence of H E Armstrong at the beginning of the 20th century and the expansion of science education, which created science projects like the Nuffield project in the UK and the PSSC, BSCS and CHEM study in the US (Solomon, 1980).

More recently, it is argued that practical activities improve motivation, the development of different skills, the conceptual thinking of students and attitudes toward science (Harlan, 1999). Turning first to motivation, there is no evidence that increasing the amount of practical work increases pupils' interest and motivation in relation to science (Gardner & Gauld, 1990). In addition, it has been found that while 57% of 13 to 16-year-olds like practicals, 40% indicated they were less motivated when they struggled to understand what they were doing or why things went wrong (Hodson, 1990).

Turning now to the development of different skills in the student, it is argued that this effort occurs in two areas: the acquisition of generalizable skills which may be of value outside the laboratory, and the acquisition of skills required by future scientists (Hodson, 1993, Harlan, 1999). It is argued, however, that these hopes are often unrealistic or "hopelessly over-ambitious," when it comes to the training of scientists (Hodson, 1993).

Similar criticisms are leveled at the idea that practicals help with conceptual learning (Harlan, 1999). A study of the effects of an experiment-based physical science program on students in grades 4 to 8, for example, found no effect on cognitive outcomes and a small effect on scientific processing skills, but only for the students of motivated teachers (Reynolds, 1991).

Turning finally the argument that practicals improve attitudes towards science and scientific thinking, and help students become more open-minded and willing to consider evidence, there is evidence of some success in this area (Gauld & Hukins, 1980), but this success is often swamped by the need of both students and teachers to get the right answer (Harlan, 1999).

These criticisms do not mean that practical activities should not occur, however, because practical work provides students with first-hand experience of what is being learned (as long as it is presented clearly), encourages students to approach problems logically, and broadens the students' experiences with school, all of which are felt to be important if the student is to become a rounded adult (Harlan, 1999).

Constructivism and Brain-Based Learning

Perhaps two of the most significant developments in education over the last few years are constructivism and brain-based learning. It could be said that these ideas occupy two sides of the same coin because one (constructivism) tends to focus of the psychology and evolutionary necessity of learning, while the other (brain-based learning) tends to focus more on the mechanics of how learning impacts (and works with) the brain. They are both important, however, because both strands of thinking impact school (and college) curriculum and the way lessons are structured in the classroom.

Before these ideas are discussed in more detail, however, it is worthwhile to spend some time trying to understand some of the other ways that students were thought to learn in the past, and explain (where appropriate) why they are not used as much now.

Behaviorism

Behaviorism pre-supposes that learning (and other psychological activities like hunting for food or the flight-or-flight response) occur as a result of a response to external stimuli. Behaviorists are people who insist on confirming hypotheses about psychological events in terms of behavioral criteria. There are three types of behaviorism. These are:

1) **Methodological Behaviorism** is a theory about the scientific conduct of psychology. It claims that psychology should concern itself with the behavior of organisms, not mental states (like an animal's desires). Methodological behaviorists take this view of mental states because they feel it does not add much to a psychologist's understanding of the sources of behavior. Mental states are private entities and so do not form proper objects of empirical study (Watson 1913, 1930).
2) **Psychological Behaviorism** is a research program within psychology. It purports to explain human and animal behavior in terms of external physical stimuli, responses, learning histories, and reinforcement (Skinner, 1953). It is this theory that teachers most typically focus on. Teachers that use this approach are going to teach into different "skills" and then sequence these parts from the simplest to the most complex (Twomey-Fosnot & Perry, 2005).

3) **Analytical Behaviorism** is a theory within philosophy that examines the meaning of mental terms or concepts. When someone is said to believe something, we are not saying that he has a mental condition. Instead, we are characterizing the person in terms of what he or she might do in particular situations (Place, 2000). Recent advocates of this point of view have suggested that one section of analytical behaviorism be restricted to intentional states of mind, which it was felt constituted one type, although not the only type, of mentality (Place, 2000).

Learners who are taught under this approach are seen to be passive, in need of external motivation, and affected by external reinforcement (Skinner, 1953). In addition, they are expected to learn in a linear way. They start at point A and can only get to point D by passing through points B and C. Teachers respond by designing activities that work to this set of factors. An example of this approach includes an approach based on Bloom's taxonomy of needs (Bloom, 1976), where ideas and skills are broken down into sub-sets and the initial skills learned are used to learn future skills.

The biggest drawback to behaviorism is that it fails to address how to change cognition (the processes that you use to work things out, [Cattell, 1971, and Ackerman, 1996]), which it assumes is fixed. It has been argued recently, however, that cognition is something that can be taught (Twomey-Fosnot & Perry, 2005), and so, while behaviorism continues to play a significant part in education, it has slipped from the central position it once held.

Maturationism

Maturation assumes that there is a genetic component to learning and that people develop a capability to access different levels of knowledge over time (Freeman & Hatch, 1989). This means that students' ability to access knowledge is based on the developmental stage of the learner and that student will struggle to access subject matter till it is developmentally appropriate for them to do so (Twomey-Fosnot & Perry, 2005). This does not mean that genetics are the only factor involved in learning (the genetics of learning can be impacted by the environment in with a human lives, for example), but genetics is still an important factor when it comes to learning (Kohlberg, 1968).

So how does this fit in with ideas about teaching? Put simply, it could be argued that if this idea were accepted, it should be possible to establish when the introduction of an idea is appropriate, given a particular child's developmental level. As a result it should make teaching and learning easier for everyone because the work is taught at an age that is developmentally appropriate for the students and in a way that makes the idea accessible to them. This having been said, there are a number of things that would a teacher need to bear in mind if they were to use maturationism (Kohlberg, 1968). These are:

1) Personality is developed in response to stimuli and students are stimulated throughout the day and not just in school.
2) Learning occurs in two distinct ways: there is the discreet gathering of new knowledge and the understanding of how it fits into a larger framework.

3) The child is born with very little patterning of personality. Initially it should be possible to teach any pattern of personality, but as they develop, this becomes more of a challenge.
4) Only appropriate early learning processes help later learning.

On its face, this might seem to be an intellectually accurate statement of the situation, but there are critics of the current situation. As the National Association for the Education of Young People (1988) point out:

1) Just because a student is capable of performing certain activities does not mean that the content should never covered again (under the assumption that the student comprehends the idea already).
2) Just because a student has demonstrated the capability to use an idea in one area does not mean that the student can apply the idea in every area.

As a consequence, it would seem logical to look for alternatives to this idea. This is where the ideas of brain-based learning and constructivism come in.

Constructivism

As was indicated earlier, constructivism is an attempt by evolutionary biologists and Piagetian psychologists to explain how students learn and why learning is not a linear process. Constructivists argue that instead of learning a long sequence of facts, students should be taught how to develop in two new areas (Twomey-Fosnot & Perry, 2005). These areas are:

1) The ability to work out the "whys" of a situation for themselves.
2) The ability to develop their cognitive skills.

By doing this, students can learn how to apply the knowledge that they have and uncover facts about themselves, their relationships, and their places in the world as they develop (Brooks & Brooks, 1999a, 1999b).

The argument is that as a result of this way of learning, students are able to apply their "new approach to thinking" to new ideas that they are presented with in non-academic settings, like clubs, sports, the arts, and life in general. This is appealing to evolutionary scientists and Piagetians, because it speaks to how living organisms learn in nature (Twomey-Fosnot & Perry, 2005). It is argued that this is the case because living organisms learn by:

1) **Interacting with their Surroundings**
   Here it is argued that organisms learn through experience. They perform actions and find that it either is in some way beneficial to them (or at least did them no harm) or is harmful to them. Those actions that were beneficial to them are repeated and those that were not as beneficial are avoided.

2) **Adapting to their Environment**
   One of the main tenets of both behavioral science and evolution is that organisms either develop or perform actions that are best suited to their environment. While some of these actions are genetic and cannot be changed, others are learned behaviors.

3) **Using their Skills**
   Different people have different strengths and weaknesses. Some are strong in music or math, while others are stronger at English or sport. Organisms have learned to work with their strengths and avoid their weaknesses.

It was this logic that was used when ideas like multiple intelligences (Gardner, 1983), practical intelligence (Sternberg, 2002), and learning styles inventory (Dunn, 1990) were developed and promoted.

4) **Evolving in New Situations**
When organisms move to new environments, the inputs they receive, assess and act upon change. The skills students learn in a previous situation are not necessarily as effective in the new environment. The skills that they possess need to change, and that is a typical response of living organisms.

5) **Watching the Systems they Inhabit**
Young organisms often learn by attempting actions and discovering that, for whatever reason, they do not produce the expected results. This is not always the most appropriate form of action and soon they learn that if they listen to the advice of others and watch what they do, problems can be avoided. This is a learned behavior.

6) **Moving to Environments Better Suited to their Skills**
Simply put, it makes no sense for an organism to work in an environment that fails to utilize their skills. Organisms often respond by moving to an environment that is better suited to their set of skills. This is a learned behavior.

When constructivism was introduced, it was stated that it allows the student to develop cognitively (in addition to learning how to apply knowledge). This idea can be broken down into the following areas if people are going to develop cognitive skills:

1) **Cognitive Equilibration**

When confronted with a new situation, organisms often fall back on previous experience to help them. They then rush in and build a new experience based in that new area based on those old skills.

Sometimes, however, those previous experiences and skills are wrong (an example might be an attempt to calculate the speed of a passenger walking on a moving plane). As an organism's cognitive equilibration skills develop, it becomes more effective at framing the problem and seeing the nuances in situations.

2) **Contradiction**

This can be described as how an organism responds to an action not producing the results that were expected. Does the organism continue doing the things that it knows may not work or does the organism try something new that it cannot be sure will work either? Understanding this contradiction can help an organism develop its cognitive skills.

3) **Possibilities, Correspondences and Transformations**

As an organism's cognitive skills develop, it learns to see a variety of possibilities in the situations that are presented to them. They respond to this array by looking for something that corresponds to something that they have seen before. They then transform (or modify) this similar action or create a new set of actions (if this new experience is too dissimilar to anything that they have experienced before) and perform it in this new environment.

After the action is complete, the organism adds this experience to the "library of experiences" so that when the organism is presented with a new set of circumstances similar to this experience, this prior experience will be brought out, dusted off and introduced to the new problem.

4) **Structures**

Organisms do not see the society that they live in as an amorphous, uncontrolled mass that is beyond their understanding and description. From the time they are born, they try to bring structure and meaning to what they see, hear and experience.

When organisms are young, these structures seem more amorphous and an organisms' understanding of them is less well defined. As they develop, the kaleidoscope through which organisms see their society becomes clearer and better developed. For example, teachers have the power to guide students in a way that ensures they see the importance of chemistry and its relevance to society.

5) **Mind, Consciousness and Language**

Because organisms have a framework for their understanding of the world around, they try to fit new experiences into that framework. When this fails and they still need to incorporate new ideas, they develop a greater understanding of self and sufficient language skills to be able to frame new ideas.

Organisms typically respond by developing "spontaneous" and "scientific" concepts about the world around them (Kozulin, 1986). Spontaneous concepts typically present themselves in every day life in an unstructured way, without any formal thought about their being developed. Scientific concepts, in comparison, are more formally structured and presented to the organism (it could be a new process learned while at work or at school, for example) and their ability to grasp an idea that often confused "great thinkers" for centuries is remarkable. Ask any 5 or 6 year old what happens to the water level in a bath and nearly all will be able to answer. Tell any 10 year old that this can tell them how big they are and most would have no problem understanding why and yet it took many years for Greek philosophers and scientists to develop those exact same ideas. That is the power of the mind, consciousness and language. Any adult that comes in contact with students has the power to structure these scientific concepts so that they are accessible to students and allow those students to grow.

6) Zone of Proximal Development

No challenging idea ever comes prepackaged in a form that is readily accessible to everyone (Brophy, 1999). No teacher would realistically consider presenting the mathematics of the Theory of General Relativity to 5 year olds. Those students simply would have neither the language nor the intellectual skills to fully comprehend what was told to them.

Teachers have to understand that there is a time for all students when they are ready to take that next step in their education. For those that are gifted at math and physics, the Theory of General Relativity may be accessible at 16, 14 or even 12. For some of the population, it may never be readily accessible. This readiness to take the next step in their learning is called the zone of proximal development and teachers have the potential to play an important part in assessing whether (and when) students are ready to take that next step.

7) **Inner Speech**

This chapter has discussed, at length, the internal frameworks that people have and the fact that people use these internal frameworks when dealing with new ideas.

Organisms, however, do not frame their thinking in the form of amorphous ideas that are inaccessible to them once the ideas have been put in place. They use language, math and picture as ways of recalling the ideas that make up the patchwork quilt that is their framework. This mixture of language and pictures is the organism's internal voice.

New ideas are presented to organisms all the time. If the idea is to be incorporated into the organism's framework, however, it needs to be translated by the organism into that organism's internal voice. To do this, any new idea that is presented to the organism has to be in a language that the organism can readily translate. As a result, teachers need to be conversant in languages that students will find accessible.

<u>What has this got to do with Classroom Teachers?</u>

So far, the ideas that have been outlined about constructivism do not necessarily apply to just teaching, but more generally to how organisms survive in their environments. In teaching, however, it is worth remembering that only areas that are academic and easily measurable get assessed, and only those assessed areas are subject to rewards and punishments. Consequently, when teachers consider the constructivist framework, it could be argued that they are looking at it through that lens.

As a result of this need to combine the recognition of how people really learn with the need for results that keep employers, parents and students happy, it is claimed that teachers:

1) Have moved away from the didactic approaches used in the past to a more collaborative approach to learning, because that is how people learn in life (Marzano, 2003).
2) Have made lesson more active, because constructivism suggests that this is in reality how organisms learn (Andersen, 1995).
3) Structure lessons around big ideas, so that new ideas can speak to a variety of internal frameworks. That way lessons become accessible to a wider variety of students
4) Use relevance to challenge their students because relevance encourages students to make connections between what they are learning and their lives at the moment (Brooks & Brooks, 1999a, 1999b, 2001, Sylwester, 2000, Barrell, 2001).

It would be interesting, therefore, to find out how schools that are effective at encouraging students to persist in chemistry use constructivism, what their teachers' perceptions and understandings of it are, and how much it drives teachers' thinking in the classroom.

Brain-Based Learning

Brain-based learning is another strand in current thinking about teaching and learning. While constructivism attempts to focus on the evolutionary necessity and psychological underpinning of learning, proponents of brain-based learning focus more on using the mechanics of the brain to aid learning. Brain-based teachers argue for the importance of understanding how the brain works when it is learning. They argue that teaching without an awareness of how the brain learns is like designing a glove with no sense of what a hand looks like, its shape, how it moves, and what the different parts of what the hand do (Hart, 1983). There is some suspicion about this concept because it is felt that teachers do not fully or accurately understand how the brain learns (Caine & Caine, 1994), but that does not prevent certain researchers from attempting to develop teaching approaches based on their understanding of this area.

The nervous system in any living organism is a collection of cells (called neurons) that transmit information to and from the brain. Some nerves in the nervous system collect information from the body (from the five senses or the digestive tract, for example) and pass it up to the different areas of the brain. The brain then interprets the data that it receives and passes instructions down other neurons, telling the body how to respond (Connell, 2005). Sometimes the input, interpretation and response are consciously controlled by the individual (when to speak and what to say in a conversation, for example), but other times it is not (respiration, for example). Learning is supposed to take place when individual neurons in the neural network of an organism make connections to other neurons. Brain-based learning tells us, in theory at least, that the brain has an inexhaustible capacity to learn, so long as neurons can continue to make these connections to one another (Caine & Caine, 1994).

This might sound somewhat confusing, but it can probably be understood if we examine the learning of language in a newly deaf individual as an example. MRI technology indicates that there are different areas of the brain that are associated with hearing, seeing and speaking of language and the formation of words (National Research Council, 2000). If a part of the nervous system (as it relates to the language center of the brain) is damaged, evidence suggests that the part of the brain associated with that damage (for example the auditory cortex in newly deaf organisms) is used less (NRC, 2000). As time progresses and hearing does not return for a newly deaf individual, he or she starts to learn sign language. Logic might suggest that it is the visual cortex that is stimulated during this learning process. Examination of MRI scans, however, suggests that it is the auditory areas of the brain that are most stimulated during periods while a deaf individual learns how to interpret sign language. It is hypothesized from this that new connections are being created in the brain as this new language is learned (NRC, 2000).

This leads people to ask: what practices best encourage these neural links to be created? When answering this question, it is important to remember what education tries to do. Effective teaching focuses on two broad skills, memorization (how words are spelled or that 7x5= 35, for example) and developing transferability (where a student learns how to recognize when an old skill is important and how to apply it to a new set of circumstances [Byrnes, 1996]). In the lower grades, teachers tend to focus more on memorization than application. As students rise up through different grades, transferability plays a more significant part of the process.

There are a number of brain-based factors that could impact transferability. They include:

1) **Context**
   The context in which a problem is presented is important to the application of knowledge. Students often perform better in one area than others. As an

example, mothers find it easier to make “best buy” calculations in a supermarket than on a written test (Lave, 1988). Repeated use of the same ideas in different contexts enables students to become more proficient at using concepts out of context (NRC, 2000).

2) **Problem Representation**
Students have to recognize that while the descriptive part of a question might have changed (the students might be asked to calculate the speed of a train up a hill rather than a runner at the Olympics), the process of calculating the answer has not changed (NRC, 2000). By gradually moving the problem from concrete examples to abstract ideas, students should be able to answer questions when they are presented in new frameworks.

3) **Relationship between Learning and Transfer Conditions**
Students are not asked one type of question in one area, never to see it ever again in other contexts. Ideas that are raised in math are also raised in physics or chemistry and writing styles that are taught in English are also used in geography, history or civics classes.

If students are to use ideas learned in one domain in other domains, a clear link must be drawn between the two. If the link is not demonstrated, students will struggle to make links between the two on their own (Singley & Anderson, 1989, NRC, 2000).

4) **Active Participation in Learning**
While passive learning assumes that students sit quietly and accept instruction from others quietly, active learning involves greater involvement in their own education (Singley & Anderson, 1989). There is

evidence to suggest that active involvement in learning is important if students are to retain knowledge and apply it effectively in different areas (Singley & Anderson, 1989, NRC, 2000).

5) **Building on Existing Knowledge**
Students already have some knowledge of the subjects that are taught when they enter the classroom, even in elementary school. By understanding what these students know before any new knowledge is presented, the teacher can work with that knowledge to create links in the students' minds (NRC, 2000).

As an example of this, Nunley's layered curriculum (2001) argues that teachers should present students with layers of learning. Each layer would represent a different level of understanding in a topic and is geared toward a different level of learning. Students then use this leveling to choose how deeply they wish to examine a topic and which level best fits their learning style and ability, thereby choosing the grade they earn.

6) **Understanding Conceptual Change**
Moving from topic to topic is a challenge for students. Therefore, teachers need to be explicit about the patterns that exist within the subject, why things are relevant, and how to intellectually move from one idea to another if students are to keep pace with the ideas that are presented to them (NRC, 2000).

7) **Relevance to Culture**
Explaining new ideas to students is a challenge because they are often very different from ideas that they have seen before. These concerns can be allayed, however, if the ideas can be demonstrated as being in some

way relevant to student lives and the culture which they inhabit (NRC, 2000).

What has this go to do with Classroom Teachers?

Brain-Based teaching and learning tells us that neurons in the brain are stimulated when we learn and that different areas of the brain can be stimulated when new ideas are learned in different areas (NRC, 2000, Connell, 2005). This concept has been tied to theories as diverse as Gardner's Theory of Multiple Intelligences (Gardner, 1999), Sternberg's Theory of Practical Intelligence, and Learning Styles Inventories (Dunn, 1990) to explain why they work (even if there is some evidence to suggest that Learning Style Inventories does not work [Kavale & Forness, 1987, 1990]).

Taking Gardner's theory as an example of how the argument for brain-based learning might work (1999), the theory argues that different areas of the brain are strong in different people. Some people might be particularly strong in math (because that area has a large number of neurons presumably), while others might be strong at music or sport (because that area of their brain is neuron rich). The theory then encourages teachers to present ideas in a variety of different ways to make the work accessible to students (because different brains access information in different ways).

Are there Problems with Brain Based Learning?

The arguments around brain-based learning are not wholly positive. Bruer (1997, 1998 and 1999) has been one of brain-based learning's most consistent critics. He argues that while the physical behavior of the brain (firing neurons for example), and some of its psychological components might be understood, it is too early to try to attempt to tie specific brain activities to educational outcomes. This having been said, however, it is possible that brain-based learning is regularly discussed in the staff room and so it is important to assess the impact it might have had on what an effective teacher does. Any examination of effective teaching needs to consider the level to which either brain-based education is involved in lesson planning.

Why do these Processes Work?

These ideas might be effective at raising continuation rates in high school, but why do they work? Why are they effective? There are two strands that could address these questions. One speaks to student intelligence; the other speaks to the psychological structure of students.

Turning first to intelligence, there can be little doubt that intelligence impacts success. Effect sizes of up to 2.02 have been generated when intelligence is used appropriately (Walberg, 1984). Intelligence is usually regarded as a fixed quantity within students, irrespective of which class the student is in. There is evidence, however, that this is not the case, that in fact intelligence is composed of knowledge (the information you know, also known as crystallized intelligence) and cognitive skills (the processes that you use to work things out, which is also known as fluid intelligence [Cattell, 1971, Ackerman, 1996]). Crystallized intelligence is clearly something that can be readily altered, and as a consequence, is something that teachers can impact. Cognitive skills are more of a challenge, but these can be changed by effective teachers too, with time.

Turning now to students' psychological make up, Snow argues that there are three component parts to people and their behavior: the cognitive, the affective and the conative (Snow, Corno & Jackson, 1996). The cognitive domain is defined by functions like analysis and interpretation and includes processes like reasoning, remembering and symbol manipulation. The affective domain refers to temperament and emotions. The conative domain encompasses areas like motivation and volition (Kupermintz, 2002).

The argument is that the conative and affective elements of someone's personality impact his (or her) cognitive functions and eventual achievement (Kupermintz, 2002, Roeser, Shavelson, Kupermintz, Lau, Ayala, Haydel, Schultz, Gallagher & Quihuis, 2002) and so, by positively stimulating conative and affective functions, should achieve more (Lau & Roeser, 2002).

It is argued here that the actions that were outlined in the previous section are effective because the process of teaching in and of itself should improve a student's cognitive functions, while the interpersonal aspects should impact the affective and conative domains a student possesses. Given that the affective and conative feed into the cognitive, it is little wonder that this area is potentially important, especially when ideas like a student's "Expectancy of Success" (where a student does well and remains involved in an area because he expects to do well in that area, Atkinson, 1964; Covington & Omlich, 1979) is introduced. Work that is done to improve a student's cognitive skills is likely to improve willingness to work at that field, so long as the improved cognitive skills are associated with success in that field.

Summary

Students are struggling to achieve all that they could in science education. While this work is not arguing that it is possible to create a nation of Nobel Prize winning scientists, knowledge of science will help employees to improve production in everything from iron production to tire manufacturing.

Schools and teachers are important factors when it comes to producing an effective understanding of science, but the impact of teachers is greater than that of the school as a whole, because they are the driving force behind the learning of new knowledge in the classroom and consequently are bound to have a greater impact in gains in their subject than general school behaviors.

Effective teaching is a key driver to generating academic success in a subject. Five factors, lesson design, discipline, interpersonal relationships, the curriculum, and the meeting of certain professional standards, have been identified as factors that contribute to effective teaching. It would not necessarily be possible or a productive use of time to measure the impact of each of these factors individually.

These four factors in and of themselves will not create the most effective strategy for improving the teaching and understanding of science. Poor teaching is poor teaching, no matter how well the lesson is designed. They need to be combined with a set of standards that all teachers, schools and school districts should work towards. To this end, it is recommended that the National Science Education Standards be used to assess the quality of teaching that is being observed.

If the processes that effective chemistry teachers use can be identified and their behaviors described holistically and set against some framework of standards, further research can be performed into why they are successful. This is what occurs in the remainder of this work.

Chapter 3

Investigating Persistence in High School Chemistry

Concern has been expressed about the state of science understanding and education for some time (Walberg, 1974; Southern Regional Educational Board (SREB), 1981; National Commission on Excellence in Education (NCEE), 1983; Crosswhite, Dossey, Swafford, McKnight, & Cooney, 1985; McKnight, Crosswhite, Dossey, Kifer, Swafford, Travers & Cooney, 1987; AAAS, 1990; Nelson, 1998; and Gaynor, 2005). Efforts have been made to force students to take more science by raising the minimum amount of science a student requires before they can graduate (TEA, 2004). While this increases the amount of science being taken, it does nothing to ensure that students are sufficiently engaged in the subject to return to a subject such as chemistry, once their minimum graduation requirement has been met.

An Approach to Examining Effective Teaching

The aim of this investigation was to find out why students at one particular high school take a large number of high school chemistry classes, when compared to what you might expect from a school of that type. When investigating this area, it was assumed that those who take a higher number of chemistry classes have been taught by effective teachers and departments, and if those effective practices were taken to similar schools, then those schools should see an increase in AP Chemistry numbers.

For ease of access, 49 high schools in 3 large school districts in a metropolitan area of Texas were identified. These schools were typical 4 year public high schools. They were not private schools, where the expectations set for the students by parents and teachers might be markedly different from what you might expect in public school. The schools do not exclusively teach individuals with language difficulties or students from other countries. They were not set up to specifically teach students with learning difficulties or behavior problems that were considered too severe for mainstream schooling. In addition, they do teach students who want to accelerate their learning and graduate before the age of 18. In fact, they target the mainstream, publicly educated students that would be found in most urban communities. This resulted in schools which, despite their varying sizes and locations, are what most people recognize in urban and semi-urban environments in Texas.

Data were collected about these schools, through the Texas Public Education Information Management System (or PEIMS, TEA, 2005a, 2005b) and the Just for the Kids website (Just for the Kids, 2005). These sources contained demographic information (how many students were enrolled, ethnic backgrounds etc.) and educational data (the percentage that passed the science TAKS test and the number of students enrolled in A.P. Chemistry) about the schools.

Of the 49 schools that were initially identified, 9 were immediately ruled out because these schools were deemed to be academically unacceptable by TEA standards (TEA 2005b). One of these schools came from the western-most district under observation, while the remaining eight schools came from the eastern-most district. These schools were rejected for two reasons. Firstly, it is hard to argue that a school that has been deemed unacceptable has anything to teach acceptable, recognized or exemplary schools with the same sorts of students. Secondly, there is less chance of finding a teacher who is so gifted at meeting the “National Standards,” the curriculum, lesson planning, discipline and interpersonal relations requirements that he is truly stretching his students. These teachers exist, but it would be considerably more challenging when it comes to identifying them.

Of the schools that remained, 12 were identified as magnet schools or contain sections that could be described as “Magnet Schools-Within-Schools.” These schools were not geographically assembled schools and they do not have a typical distribution of students. These schools, which can be regarded as “choice programs,” were removed from the list because it is not clear how students who attend these schools interact at school, how they are motivated, and how this initial motivation impacts the school. A motivated student is going to be easier to teach in some ways, but more of a challenge in others because he or she will expect to be stretched. Consequently, teacher behaviors in these schools might be very different from regular, non-magnet schools. Couple this with the fact that the students who attend these schools might not be representative of students in general in the area, and it seemed logical to remove them.

This left 28 “academically acceptable” schools (according to the TEA definition) from the original list. Data were then collected from each of the high schools about the size of the AP Chemistry class at each of the schools. For Central Independent School District (CISD) and Western Independent School District (WISD), this simply required contacting the school district directly to obtain the numbers enrolled in AP Chemistry.

In the Eastern Independent School District (EISD), however, it was necessary to contact individual schools directly, either through the school counselor or the data administration officer. In one case, the Dean of Instruction at one Eastern ISD high school was not prepared to release this data and so this school was excluded. With three other schools, repeated requests for data, requests to the school counselor, data management officer, Dean of Instruction and the science department were ignored. Consequently these schools were removed from the list of schools that were to be considered in this investigation. It is also worth noting at this stage that one school does not offer AP Chemistry (as opposed to offering it but having insufficient students select it). As a result, it was removed from the list of schools that were to be assessed.

This resulted in 23 schools being identified for further investigation. Eight are based in the Western ISD catchment area. Nine are based in the Eastern ISD catchment area. Six are in the Central ISD catchment area. Of these schools, one Eastern ISD school was rejected because there were insufficient data points available in certain areas (no white students were entered for the Science TAKS exam for example) and it was felt that this might impact the overall pattern of results that might be obtained.

The schools that remained are not normally distributed, so using basic statistics is not possible. They did, however, give rise to a number of correlations that are significant at the 0.05 level. The correlations are listed in Figure 1. They tell us, however, that increasing the Science TAKS test pass rate in every demographic group should impact the number of students taking AP Chemistry. It can also be said that increasing the number of gifted and talented students that attend the school and reducing the number of low income students who attend the school will impact AP Chemistry enrollment.

It was suggested, during this investigation, that increasing the size of the Asian population that attend the school might enlarge the size of the AP Chemistry class. It is therefore worth pointing that the level of Asian enrollment (with a significant p value of 0.11), while not significant at the 0.05 level, does contribute marginally to AP Chemistry enrollment (with a correlation coefficient of 0.359).

Figure 1: Significant correlations in the Eastern, Central and Western school data,

Significant Variable	Correlation to Enrollment in AP Chem/1000	Significant P Value
White Pass Rate in Science TAKS Test	0.587	0.005
Overall Pass Rate in TAKS Test	0.543	0.011
%age Low Income Passes Science TAKS test	0.525	0.025
Gifted & Talented Enrollment	0.487	0.017
%age of Enrollment that is Caucasian	0.445	0.043
%age of African American Students Pass Science TAKS test	0.441	0.045
%age of Hispanic Students that Pass Science TAKS test	0.427	0.051
%age of students who are Low Income	-0.478	0.029

Examination of School-Based Data

Examination of the results that were generated for each of the schools suggests that they fall into four categories. One group of two schools has about 2.3% of their enrollment engaged in AP Chemistry. The second group of five schools has between 1 and 1.5% of their enrollment engaged in AP Chemistry. A third group of eight schools has between 0.5 and 0.75% of their enrollment engaged in AP Chemistry. The remaining schools have no AP Chemistry program.

Energy was focused on those schools that have an AP program. Logic suggests that the two most numerous groups be examined first to see if there were any members of these groups that were over-performing, when the correlations that were previously identified are taken into account.

Examination of the demographic and results data from the most successful school suggested that a number of non-teaching factors might contribute to their success. One in three of their students are defined as gifted or talented. In addition income level and socio-economic status are identified as indicators of persistence in school (Cooper, 1966), and this school has many fewer lower income students than other schools (1 in 14 of their students have been identified as low income, compared to 1 in 6 for the group as a whole). Couple this with the fact that the science TAKS test pass rate for the Caucasian population is much larger than for every other group and it would seem logical to suspect that the school is performing only as would be expected given these factors. As a result, this school was not felt to merit further investigation.

The second most successful school is more of a challenge to explain. The number of gifted and talented, low income and Caucasian students were more similar to the general population under examination. This having been said, their success seems to be focused within the Caucasian community (these students do about twice as well as Hispanic, African-American and low income students in the science TAKS test). Couple this with comments from staff at this university, suggesting that the school might be a school of two halves, and concerns start to grow. According to this staff member, one half is Caucasian, affluent and well motivated, while the other is the mirror image of this. Before this school was identified as being worthy of further interest, concerns about the importance of this school's Caucasian population and their impact on the AP Chemistry needed to be explained or another school needed to be identified.

Examination of demographic and pass rate data for the second group of schools shows that nearly all were broadly similar across the areas that were identified in the initial investigation. The most obvious exception was Martin Van Buren High School in Central ISD. They had fewer than average numbers of gifted and talented students. Three out of every five students came from low income homes and 86% of the student population was from an ethnic minority. At the same time, despite having a large AP class, the school has considerably fewer students are passing the Science TAKS test than their competitors in this second group. Logically, Martin Van Buren should not be as successful as it was, and so merited further investigation.

Examination of the success at Martin Van Buren has the added advantage of not being obviously dependant on the success of any one ethic group, which would address concerns that were raised at the other school of interest. Caucasian students do better in the Science TAKS tests than their ethnic minority counterparts, but not by as much as they do at the other interesting school. Consequently, Martin Van Buren was approached first to see if they would be amenable to a study on how chemistry was taught there.

Describing the Investigation

This investigation is best described as mixture of a case study and an ethnography, because the effective behaviors that teachers and departments exhibit are studied here. Case studies describe the behaviors of a single individual (like a teacher for example) and the responses that those behaviors generate. Ethnographies, in comparison, describe the behaviors of a group (like a high school chemistry department and the students that they teach) and the responses that those behaviors generate. Both types of behavior are being examined here, so it is fair to say that this is a mixed method case study and ethnography (Gay & Airasian, 2003).

The sampling that was used was a mixture of quota and convenience sampling. While this is not an unbiased sample, it has the advantage of being readily accessible, while still generating a sample that is representative of urban and semi-urban schooling (Gay & Airasian, 2003).

Some thought was given to observing both a strong and weak school, so that a comparison could be made between the two schools. Doubt, however, was expressed as to the ease of access to the weaker schools (would a weak school really want to be observed?). This was reinforced by one Eastern ISD high school's response to data requests. The Dean of Instruction's angry response to a request for the size of the AP Chemistry class suggested that some lower performing schools would not be amenable to being compared to others. As a consequence, this idea was ruled out as a viable option.

Once the school was identified, the role of the investigator became important. Should the investigator be a participant or disinterested observer? The argument against participation is that it might alter the behaviors of the observed teacher and students. That having been said, schools might be unwilling to accept someone into the classroom who was not prepared to become involved. In addition, students might be more willing to "act up" in front of someone who was so obviously an observer and the observer might find it challenging not to become involved in a school or classroom should he remain there for a prolonged period. In this investigation, however, the observer was "detached" from the class, making it easier to watch the behavior of the class as a whole.

Details of the Investigation

As was indicated in the previous chapter, this investigation focused on five areas: an assessment of whether or not the teaching staff are meeting nationally agreed upon "effective teaching" standards, discipline, relationships with students, curriculum and teaching styles in the science classroom. When attempting to address these areas, a four stage approach was taken. These stages are:

1) An understanding of how the school functions.
2) An understanding of how teachers the department functions.
3) Classroom observation to see the policies put into practice.

4) Closeout interviews to get the participant's final analysis.

Understand School Structures

Starting with an attempt to understand the school and its relationship with the chemistry department was important because it placed what goes on in the science department in a larger context and allowed the investigator to understand the relationship between the school and the department. In addition, some of the criteria from the "National Science Standards" that are used in this investigation look at how the Chemistry Department interacts with the school as a whole, which made understanding how the school operates doubly important. This meant that a thorough examination of both the school and the department had to occur and so required the use of an assessment tool that is similar the one used in Arizona for school improvement (Horne, 2005).

Selecting the correct assessment tool was important. The Arizona school assessment tool, for example, might well meet the needs of the Arizona Department of Education, but there was little independent evidence that it measures what it claims to measure and no evidence that its quality has been exposed to outside assessment.

A variety of different systems exist as an alternative to the Arizona system. These alternatives include the Comprehensive Assessment of the School Environment (or CASE, which is reviewed in the 11th Mental Measurements Yearbook or MMY (Kramer & Conoley, 1992)), the School Assessment Survey (or SAS), the School Effectiveness Questionnaire (or SEQ, both of which are reviewed in the 12th MMY (Conoley & Impara 1995a, 1995b)) and the Classroom Environment Scale (or CES which is in the 10th MMY (Conoley & Kramer, 1989)).

Of the 4 alternatives to the Arizona study, CASE was the most promising. It examines a variety of areas that included Teacher-Student Relationships, Security and Maintenance, Administration, Parental Involvement, the Curriculum, Student Discipline, Job Tasks and Communication. It has a comparatively high internal consistency and test-retest reliability (between 0.63 and 0.92, depending on the area being examined) and has evidence of validity for the instruments being measured. This having been said, it fails to assess the organizational climate of the school and, as of yet, there is no evidence that it helps the observer differentiate between good and bad schools.

In comparison, SAS has the advantage of being quicker and simpler to complete, though this might be merely because it assesses fewer areas (including Goal consensus, Leadership, Instruction, Curriculum and Resources, Conflict Discipline and Teacher Behavior). The final results seem to be highly reliable (with a range of 0.76-0.96, depending on the sub-scale in question), but there is little evidence of any correlation between the areas that are examined and no evidence of inter-rater reliability (Conoley & Impara, 1995a). This would prove to be a problem for many investigators, especially those that wished to repeat this investigation, because there was some concern that they would not get the same results when they observed the same events.

The School Effectiveness Questionnaire was criticized by both reviewers for the Mental Measurement Yearbook (Conoley & Impara, 1995b) and thus was immediately eliminated from consideration for this section. The Classroom Environment Scale, the remaining alternative that assesses schools, has some evidence of validity and reliability (the internal consistency instruments range from 0.67 to 0.86 for example), but tends to focus on relationships rather than the variety of other areas that describe schools (Conoley & Kramer, 1989).

This section wanted to focus on the general climate in which the chemistry department performs its functions. The actions the department takes are not taken in a vacuum, but in response to the societal expectations of what they are expected to do. As a consequence, the eventual decision as to whether the Arizona, CASE, SAS or CES templates be used was based on which would give us the most satisfactory results in this wide variety of areas. In response to this need, CASE was used.

Understanding Department Structures

Once an overarching view of school policies and practices was obtained, the investigation moved to the department and the behaviors of teachers and students there. Additionally, it examined their perceptions of the department as it relates to the five areas outlined in Chapter 2.

An interesting approach to this area comes from the Scale for Effective Teaching-Teachers (SET-T), which can be used to interview teachers (Conoley & Impara, 1995b). The plan was to couple it with either an Our Class and its Works Questionnaire (Mitchell, 1985), a Classroom Environment Scale (Conoley & Kramer, 1989), a MSALT classroom descriptor (Michigan Study of Adolescent and Adult Transitions, 2000) or a modified Kloosterman interview with students about student attitudes to science (Kloosterman, 1997) for the students.

The SET-T questionnaire (Conoley & Impara, 1995b) measures a variety of items in 15 areas that largely mirror the CASE areas, when applied to the classroom. The areas that it examines include Instructional Techniques, Academic Learning, "Time on Task," Discipline and the Monitoring of Student Progress. It is, however, described as being too open to subjectivity and lacking in some areas that relate to validity and inter-rater reliability. The instrument's subjectivity, however, is not necessarily a bad thing. While it would be nice to find objective reasons why a teacher thinks an approach is good, objectivity need not be the only reason why something works. If a subjective reason for the success of a teaching style works and that subjective reasoning resonates with other teachers, then that approach can be used by teachers with whom that approach resonates.

This thinking about SET-T made it an attractive option that was seriously considered for inclusion in this study, but when the publishers were contacted with regard to purchasing this instrument, the investigator was told that the instrument was no longer available. This was not a problem, however, because the main focus of this work was why students selected AP Chemistry and not what the teacher thought of the class. Were the students not forthcoming with reasons why they select AP-Chemistry, the lack of an effective tool here might be a problem, but, fortunately, that was not the case.

Turning now to the potential student questionnaires, the major flaw of the Our Class and its Works questionnaire might be more of a challenge to overcome (Mitchell, 1985). The questionnaire fails to tell us why a particular subject is good or bad. It only tells the user the state of the class. When approaching research like this, unexplained knowledge, which is presented in overly broad terms, will fail to be sufficient for this investigation. As a result, this questionnaire was rejected.

Turning now to the alternatives for working with students, the advantages and disadvantages of the CES assessment were outlined earlier (it has some evidence of validity and reliability but fails to necessarily focus on all the areas that could be said to describe a school and focuses on relationships too heavily). As this is an important part of the investigation, it could be used both here and in the classroom to assess those areas of the investigation.

As for the MSALT classroom descriptor (Michigan Study of Adolescent and Adult Transitions, 2000), the tool has reliability and validity scores assigned to it, but finding these figures proved to be somewhat problematic and so it could only be used as a last resort. This problem can also be applied to the Kloosterman interview about student attitudes to mathematics. No evidence of validity or reliability seems to be assigned to it, which draws the protocol into doubt.

Using the correct tool could have enabled the investigator to compare aspects of the chemistry program with previous years, other departments in the school or the school as a whole. Examples of this might include student perceptions of discipline across departments and student grades over the last 5 years, where available. As will later be seen, however, gaining access to data from previous years, and other departments was impossible, making the thought of tracking changes with time unworkable.

As was indicated earlier, it was initially decided the investigation move forward with the Scale for Effective Teaching- Teachers (SET-T) for use with teachers, but when this was unavailable, the investigator elected drop discussions with teachers about their specific classrooms because this work started to focus more on student thinking with respect to Pre-AP and AP Chemistry. In response to this requirement, the Classroom Environment Scale instrument was selected for use with students.

Classroom Observation

Once the chemistry program at the school was fully understood and documented, the process of understanding the behavior of teachers in the classroom began. How a teacher behaves in the classroom can be viewed as stemming from a set of beliefs which guide the teacher. They are based on the personal experiences of the teacher and are derived from what a teacher does both in and out of the classroom (Cornett, 1990, Cornett, Yeotis, & Terwilliger, 1990). It is these beliefs that shape how a teacher behaves with respect to the "National Standards," curriculum, instructional practices, discipline and interpersonal skills. These beliefs, and the teacher's resulting actions, can best be observed in the classroom. Once observed, these beliefs were categorized by the observer, because it is only with categorization that the development and dissemination of models of excellence can occur.

It is worth noting that much of evidence needed to support whether the teaching meets the "National Standards" occurs within the classroom. Without the visual confirmation that teachers at Martin Van Buren meet a particular standard, any suggestions that are made will not be accepted at other schools that consider implementing them. This makes getting evidence from the classroom about the quality of teaching there, doubly important.

There are a number of approaches that could be used when it comes to investigating how teachers behave in class (Cornett, 1990, Sweeney, Bula & Cornett, 2001). These include:

1) Teachers' journals may be used to see how a teacher thinks when it comes to managing a class. In these journals a teacher can record observations,

analyze their experiences, and reflect on their practices over time. From personal experience, it is known that first year teachers are encouraged to do this in some English schools. The argument for doing so is that it encourages teachers to take an intentional pause for thought in their efforts (Fitzgerald & Weidner, 1995) and helps them see things in a different light once some distance has been placed between them and the events under consideration (Patterson, 1995), which would be helpful in their development.

In this investigation, convincing teachers who have no investment in this investigation to regularly keep a journal was considered to be unworkable, however, because the Head of Department publicly stated he opposed its implementation. In response to this, other teachers stated that they were unwilling to give up the time that journal writing requires. The investigator, however, used this approach to think about what was seen in class.

2) Essays allow teachers to reflect on their experiences and to construct an argument about their behaviors in the classroom (Gomez, Grau & Block, 1991, Guillaume & Yopp, 1995, Takona, 2002). Classroom observations can provide the data that teachers can use to write their essays. These data can be used to convince others about the merits of particular instructional approaches.

The problem with this idea was the same as the problem faced by the first approach to collecting data. The Head of Department was unwilling to entertain the idea and in this light, convincing teachers to write pieces that force them to reflect on their practices was felt to be impossible. External coercion could have been used, but this would have brought the reliability of the results that into question.

3) Oral inquiry processes are procedures in which groups of teachers' research or record their experiences in different areas (Lyttle & Cochran-Smith, 1990: Yonemura, 1982). This is both collaborative and oral in nature. Because this requires openness and honesty amongst the teachers, however, the Head of Department felt it was unworkable.
4) A study of what a teacher does in the classroom is the most conventional research endeavor (Lyttle & Cochran-Smith, 1990; Rorschach & Whitney, 1986; Sweeney, Bula & Cornett, 2001). Here, researchers seek to answer questions like:
   a. What instructional approach work best with the students?
   b. What is the most appropriate form of assessment for these particular students?
   c. How might a particular aspect of the classroom learning environment be explained and improved?

   This type of analysis of a teacher's classroom can provide insights into personal practical theories, if implemented appropriately.

Politics was an important part of gaining access to the school and as a consequence, only classroom observations played a significant role in this section. The observations only occurred once the school was fully understood, however, because the investigator wanted to understand what to expect in the classroom before the observations started.

As in the previous sections, an appropriate tool needed to be selected. Through a thorough examination of Buros, a number of possible observation tools were identified. They included the Teacher Performance Assessment (Plake, Impara & Spies, 2003), the Teacher Evaluation Scale (Conoley & Impara, 1995a), the Classroom Environment Scale (Conoley & Kramer, 1989), the Scale for Effective Teaching- Teachers (SET-T) (which could be used as an observational tool in addition to being an instrument that can be used to interview teachers (Conoley & Impara, 1995b)), and an MSALT classroom descriptor (Michigan Study of Adolescent and Adult Transitions, 2000).

Of these alternatives, the most obviously criticized was the Teacher Performance Assessment (Plake, Impara & Spies, 2003). Comments like “insufficiently authentic,” “the assessor is often left to rely on a single instrument to assess teachers,” and “fails to meet the professional standards necessary for the use as a tool in teacher assessment” suggest that it should not be used. In response to these criticisms, it was ruled out.

Of the alternatives, the concerns expressed about the MSALT classroom descriptor were the same as the concerns expressed about its questionnaire. While it looks sufficient and has clearly been used by other teaching institutions to assess the classroom environment, outside evaluation of the tool is not widely disseminated, making it hard to assess its reliability and validity. Consequently, it would only be used if the alternatives are deemed inappropriate for the investigation.

Of the remaining alternatives, the CES assessment tool could have be used at this time to monitor the relationships between students and both teachers and their peers.

While this measure is far from perfect, it could have given an indication of student-student and student-teacher interactions. Because it fails to examine the entire scope of what a teacher does in a class, however, it was ruled out as a method of teacher observation.

Turning finally to the SET-T tool, it was indicated in the previous section that this tool was unavailable. This alone ensured it was eliminated it as a tool for classroom observation in this section.

Because there were no really appropriate classroom observation tools, it was decided to use the MSALT classroom descriptor and make additional notes about the class, as and when it was felt to be necessary, to support the instrument.

These additional observations saw student and teacher behaviors being noted, along with how the teacher presented the subject, its apparent relevance to the students and its appropriateness to the age group. At the same time, students were asked at appropriate moments what they are doing, learning and understanding during the lessons. In addition classes were monitored for student involvement. This helped the investigator to understand what was being taken from the lesson by the students once the lesson was complete. Additionally, homework and test data were collected to track student achievement to see if it could be correlated to subsequent persistence in chemistry.

While time might well be very important in this investigation, it does not negate the importance of thoroughly understanding what teachers do in the classroom. It made sense to observe all teachers within the department. This allowed the investigator to understand whether observed behaviors were common across the department or was specific to certain teachers.

The investigation as to whether behaviors are broadly or narrowly based within a department is important for two reasons. Firstly, if an effective practice is limited to a small number of teachers and those teachers leave, it is possible that the department might fall back on less effective practices that reduce persistence in chemistry. Secondly, if an idea does not become widely-disseminated within a group of teachers, a question has to be raised about the overall transferability of the idea. Ideas are only as effective as those that implement them and so, assessing the spread of ideas within a department will give additional information about the idea itself.

The classroom observations were probably the most important part of the investigation because without them no generalizable conclusions could have be drawn. It does raise the question, however, of how many observations are "enough." It is hard to set the number of classroom observations in advance of meeting with the school and gaining some initial data. Up to 100 observations per department per site have been talked about by some researchers (Boaler, 1991), but it was not possible to get this many observations in this investigation. This having been said, the investigation allowed for fifty four observations to occur. While this is not as many as some might hope, it would be enough to draw some meaningful conclusions about the Martin Van Buren Chemistry Department.

Final Interviews

Towards the end of the school year, students were interviewed. This interview reviewed the year with the students and established whether they plan to continue with chemistry the future. The Kloosterman interview template (Kloosterman, 1997) was modified and used for the investigation. While there is little evidence of reliability and validity for this tool, it was tested on university freshmen prior to its use in the school and these students responded in the way that Kloosterman predicted. Consequently, it was felt to be suitable for upper age group high school students.

Summary

This is an ethnographic case study investigation. A school was examined and those variables that are realistically measurable were measured and described. Once the school was described, students, teachers and administrators were initially interviewed to obtain some basic information about the school. Later in the investigation, these same groups will be re-interviewed to uncover their thoughts and views on what had been learned during the heart of the investigation.

The heart of the investigation focused on classroom observations. Five areas were identified in a previous chapter. Chemistry and other science classrooms will be observed and compared to these areas. The differences that are observed between the classes will be used to develop actions that other science departments could be used to improve student persistence in Chemistry.

Chapter 4

The City, the School and the Science Department

Richmond

Richmond, Texas is a city that covers approximately 100.0 mi² of Sears County, a county located in North-East Texas whose county seat is Camp Walton. Richmond, which has a population of approximately 360,000, is the 7th biggest city in Texas and the 55th biggest city in America. It is located 12 miles east of Camp Walton (population approximately 603,000 in 2004) and 20 miles west of Tacoma (population approximately 1.25 million in 2004) and borders the cities of Great Plains (population 141,427), Bronte (population 34,735), Kennedy (population 5,850), Plantation (population 2,318) and Darlington Gardens (population 2,186).

The city was founded in 1875 and was named after Richmond, Virginia. After the arrival of the railroad in 1876, it grew as a cotton-ginning and farming center, and was incorporated in 1884. Large-scale industrialization began in 1954 with the arrival of a General Motors assembly plant. Automotive and aerospace development gave the city one of the nation's greatest population growth rates between 1950 and 1990.

The city, however, is probably most famous today as home to the Richmond Rangers professional baseball team, the future home to the Tacoma Cowboys professional American Football team and the theme park "Six Flags over Texas." It became such a strong sporting and cultural center through its physical proximity to Tacoma, Camp Walton, Great Plains, the Tacoma-Sears International and Tacoma Fields Airports, and a number of Interstate highways. I-30 and I-20 connect West Texas and the Southern Texas Panhandle to Shreveport, Louisiana, Little Rock, Arkansas and Jackson, Mississippi, while I-35 connects San Antonio and the US-Mexican boarder to Oklahoma, Kansas, Missouri, Iowa and Minnesota. Despite the strength of Richmond's road system and the proximity of a number of important highways, however, the citizens are sufficiently concerned about the impact of a public transport system on their tax base to make it the largest city in the US without a public transportation system.

As of the 2000 census, the city had a total population of approximately 333,000 (who live in 125,000 households, 85,000 of which are families), a figure that had grown to 360,000 (spread almost evenly between both sexes) by 2004. Richmond's population (which is 67.69% Caucasian, 18.27% Hispanic, 13.73% African-American, and 6.01% Asian), is spread across a number of different age groups:

Age Range*	Number of Inhabitants (%age of total)
Under 18	101,880 (28.3%)
18-24	39,600 (11%)
23-44	130,662 (35.7%)
45-64	68,040 (18.9%)
65 and Older	21,960 (6.1%)

*The Richmond population has a median age of 29.6 years.

Despite the fact that 10% of the population lives in poverty, men have a median income of $38,612, compared to a median income of $29,339 for women. This gives rise to a median household income for the city is $47,622, a figure that rises to $56,080 for families (a discrepancy which can be explained by how the Census Bureau defines a household). In Richmond, only 51.6% of households have couples that are married or are living together. Of the remainder, 21.8% are non-family units and 24.7% are individual adults.

Schooling and the School District

Richmond is home to two major public university/colleges, the University of Texas at Richmond (UTR), which is part of the University of Texas system, and the Southeast Campus of Sears County Community College (the remainder of which can be found in Camp Walton). The University of North Texas and Texas Woman's University are other local public universities, and can be found some 34 miles north of Richmond in nearby Denby, while the University of Texas, Tacoma (another University of Texas satellite school), Tacoma County Community College and the University of Tacoma are Tacoma based public schools.

In addition to these 7 public universities, there are a number of private universities and seminaries that students could attend. Richmond Baptist College is a privately funded college based in Richmond. Texas University (TU) and John Wesley University (JWU) are private universities based in nearby Camp Walton. Southern Baptist University (SBU) and Tacoma Baptist University (TBU) are based in Tacoma.

For those that do not wish to continue on to university, there are a number of large employers based in the Tacoma-Camp Walton metropolitan area (which is commonly shortened to the Metroplex). Texas Instruments, TXU, Southwest Airlines and Blockbuster Video, for example, are headquartered in Tacoma, while AMR Corporation (American Airline's parent company), Radio Shack, D.R. Horton and Burlington Northern Santa Fe (amongst others) are headquartered in Camp Walton. No major corporations are directly headquartered in Richmond, but the Great Southwest Industrial District (which borders Richmond and Great Plains), does host a number of manufacturing concerns, including General Motors (who has an SUV assembly plant located there), Johnson & Johnson, Bell Helicopters and National Semiconductors. These companies, along with UT Richmond, the City Council, the School District, and Six Flags over Texas are among the largest direct and indirect employers in Richmond.

Richmond has four school districts that serve its students. Central ISD (CISD) runs most of the city's public schools. CIDS's six high schools are Richmond, Warren Harding, Martin Van Buren, Chester Arthur, James Buchanan, and Cesar Chavez, all of which are rated at the 5A level by the University Interscholastic League. The three other school districts that serve the Richmond student population are Bronte ISD (which has 3 standard high schools of its own), Kennedy ISD (1 high school) and Hearst ISD (2 high schools). These three smaller school districts only teach those members of Richmond's student population who live in certain areas of suburban Richmond.

In addition to these public schools, there are a number of private schools in Richmond. A majority of these target niche markets. Some private schools have a religious ethos. Others specifically aim to teach students with specific learning difficulties. Three private high schools in Richmond do not target niche markets, Leafy Grotto Day School, The Ridgeline School and The Richmond Classics Academy.

Martin Van Buren High School

There are 210.2 full time equivalent teachers employed at Martin Van Buren High School (which will be called Martin Van Buren from now on). They teach the 2999 students who are started the academic year enrolled at Martin Van Buren. 1129 of the students at Martin Van Buren are freshmen. 716 are sophomores, 568 are juniors and 586 are seniors. This approximate student break down has been consistent over the last few years. Martin Van Buren typically has more freshmen who drop out in their first year (when compared to other Richmond high schools), but once this "thinning" has occurred, the school is more successful at retaining students into their senior year, (TEA, 2005c).

Examination of the student population shows that 66.7% of the students at Martin Van Buren are from low income homes and 14.2% of students are English language learners. 49% of the students are Hispanic, 29.7% are African America, 14% are Caucasian, 6.8% are Asian 0.6% are Native American. These figures make Martin Van Buren an atypical Richmond high school. To consider the degree to which Martin Van Buren is different, consider the following areas:

Area of Difference	Degree of Difference
English Language Learners	290% more*
Hispanic Students	161% more*
Low Income Families	150% more*
Caucasian Students	75% fewer*
African-American Students	30% more*
Special Needs Students	22% more*

*when compared to other Richmond high schools.

The schools that operate under Central ISD's direction have notional geographic catchment areas, but the school district offers its students an "open-enrollment" policy for its schools. This means that at fixed times during the year, students can opt to transfer to another school, even if the school that the child opts to leave is described as average - or better - by the Texas Education Agency.

Even though the school district operates an open enrollment policy, some teachers feel that Martin Van Buren was "picked on" when the latest catchment areas were drawn. Martin Van Buren had a representative on the catchment area committee, but this teacher was diagnosed with cancer early on in its deliberations and the school was not allowed to replace this teacher with another. It was this action that was felt to contribute to the strange shape of Martin Van Buren's current catchment area.

In addition to this, there is some concern that the "open-enrollment" policy has racial undertones. As an example, an expensive apartment complex sits comfortably within Martin Van Buren's catchment area, but there is some amusement at the fact that many of the bumper stickers read "Proud parent of honor student at (insert name of other high school here)." One teacher went so far to say "I'm surprised the ACLU or LULAC hasn't taken out a law suit given how different this school is [to other schools in the district]."

The school itself underwent a renovation and expansion in 2003. Prior to the expansion, some teaching was done in portable classrooms. The school district was unhappy with this arrangement, and the school was expanded so that all students could be taught in regular construction buildings. This renovation saw the science department move to new teaching quarters, which irritated some members of the department, but had the benefit of allowing the handicapped unit to be located in one area.

Gaining access to the school after the official start of the school day is problematic. The majority of doors are locked from the inside when school starts and while students can exit the school easily, entering the school is impossible if you do not meet someone exiting the school at the same time. This lack of access compares starkly with England. Schools in many areas of the UK (especially suburban and rural areas) often stay open for community use till typically 6:30 in the evening, for evening classes or, more typically, sport and recreational activities.

The concern for safety at Martin Van Buren is continued in the building. Keys are required if doors are to be opened from the outside. As a result, teachers govern access to their classroom when they are teaching. They can set the locks so students can come and go as they wish, but this does not often happen. Teachers who want to give students access to the corridor do so this by propping the door open.

Examination of the classes that are offered at the school suggests, unsurprisingly, that the students are offered a variety of possible classes and are taught the Texas curriculum. Spanish and French are offered as second languages at the school. There are 10 fully equipped computer rooms (that are in constant use) at the school. These computer labs have facilities that allow teachers to project directly onto special screens. The chemistry labs have at least 6 computers in each room. The Pre-AP and AP Chemistry lab has 10 internet ready computers available to students. In addition, the school has a custom made baseball diamond and stadium (which can double up for softball games) and a football stadium with its own temporary seating. The football stadium has parking for both visiting and home supporters.

Turning now to the classes themselves, the school operates a two week timetable (the weeks are called Week A and Week B), with a different timetable operating during each week. The advantage of having a two week timetable is that it allows for greater flexibility. Within Chemistry, for example, students see their teacher 5 times a fortnight. Half the classes have 3 lessons during Week A and 2 during Week B, while the remaining classes have 2 lessons during Week A and 3 in Week B. The class length is 90 minutes, with 4 classes taught each school day (though some departments stay after school for up to an hour, on top of their official “contact hours”).

Lessons start at 7:35 in the morning and finish at 2:55 in the afternoon. The school is a large single story structure and the students are allowed 10 minutes of “down time” to cross the campus between lessons. During this transition, most teachers stand in the doors to their classroom, waiting for their classes to arrive. Some members of the senior staff take position in the corridors to ensure that problems do not start.

In addition to the senior staff presence in the halls, the school has uniformed "corridor walkers" whose job it is to remind the students that they should not be loitering in corridors, but making their way to class. These corridor walkers have both a whistle and pepper spray available to aid them, should they need it. The whistles were only sparingly used during the period under observation. The pepper spray was not used at all during the observation, but the students openly talked about one occasion when a fight broke out between two African-American girls. According to the students, so much pepper spray was used that they had to evacuate the cafeteria (a fact that was later confirmed by the staff).

The corridor walkers do not just operate within school buildings. These employees also observe the perimeters and run checks on cars that are parked in the parking lots. There are three parking lots. One of the lots at the school is used by the staff, another is used by the students and a third is used by visitors who watch sporting events. This third lot is, however, used by students when events occur in the student lot. If someone parks in the wrong lot, their license plates are initially reported to the central office. Repeated violators are towed. In addition, it is worth noting that the corridor walkers do not like "in-and-out" traffic in the student lot. They were observed stopping a number of people who were leaving the school during the school day.

Because of the size of the school, feeding the students is a challenge. In response to this, 3 lunches operate during the school day. The students are assigned to one of the lunches, depending on their class schedule. Lunches are 40 minutes. They start at

10:48am and finish at 12:20. Consequently, the first, second and final lesson are fixed time-wise, while the third lessons "floats" and is not common to more than approximately 1,000 students at a time.

A variety of male and female sports are offered at Martin Van Buren (whose teams are nicknamed the Texans and have a cowboy mascot). Male students have the opportunity to play football, basketball, baseball, volleyball, swimming, athletics, wrestling and tennis. Female students (whose teams are called The Lady Texans) have the opportunity to play soccer, softball, basketball, volleyball, swimming, athletics, tennis and cheerleading (the Tex-Annes) competitively. At home games, the football team is supported by a marching band that is composed of both male and female students.

While they may try, many of the teams are not very successful. There are two jokes that are told about school teams by teachers, students and ancillary staff. The first is that you only need to know how many weeks you are into the season to know how many games the football, basketball, baseball and soccer teams have lost. The second is that if you are Martin Van Buren supporter going to home football games, you had better enjoy the marching band because you are not going to enjoy the football.

Individual sports are more successful. Tennis is a particularly popular sport at Martin Van Buren, with a variety of ethnicities playing (and enjoying) the sport. Two Hispanic students have qualified for inter-district competition, which was played near the end of the spring 2006 semester and Asian students identify it as a sport that they believe that they can excel at, with a number of them calling "our sport."

The Academic Decathlon team (which is run by Mr. Thomas, the Head of Science at the school) is typically more successful than the sports teams. During the 2004/05 academic year, the team won the district tournament and progressed to the regional competition, where they were placed 5th. The 2005/06 team was less successful, but their last place in the district tournament can be explained by last minute withdrawals of two members of the team.

The staff and senior management are very strong on the enforcement of minor rules. The thinking behind this is that while the enforcement of minor rules can seem petty, it is easier to do this than have the students pick and chose which rules they will follow. As an example, staff and students are expected to wear identity badges and keep them visible at all times. Assistant principals walk the corridors during the first period to ensure that all students have their identity badges. If they do not they are subject to an ever increasing number of punishments. The punishment starts with the signing of a contract that says that the problem will not occur again (after the first incident) and rises to up to 5 days in isolation for a repeat offender. If an identity card is lost, students pay for a replacement.

Clothing is also monitored closely at Martin Van Buren. Martin Van Buren does not have a school uniform, so students can wear what they want, within reason. Clothing and colors that are not explicitly related to gang activity are not banned, but do-rags, overly baggy or tight clothing, and trousers that do not "sit properly" on the wearer are banned. Belts are provided to students who cannot wear their clothes properly and teachers are expected to be on their guard for infringements of the rules. A standard infringement/consequence procedure is used for this area. Like the identity badge issue, one infringement sees the student sign a contract (not to repeat the infraction). Multiple infringements see the offender spend time in isolation or on suspension.

Finally, it is worth pointing out that like many American schools it is felt to be necessary to have a police presence on site. Unlike the schools that are talked about in newspapers and seen on television and in films, however, this amounts to one policeman (and his associated squad car) most of time, though this rises to two policemen and squad cars when school "lets out." Their duties, however, seemed to focus on directing traffic and reminding people to move on promptly when they have picked up their child.

Science Department

Students in Texas have a variety of choices when it comes to studying science. This variety in their potential high school science experience is written into the Texas Education Agency (or TEA) curriculum guidelines. The guidance indicates that the amount of science that students take depends on the path the graduation selected by the student. If the students are to graduate through the "Minimum Graduation" plan, they have to take a minimum of 2 "Science Carnegie Units" (drawn from Integrated Physics and Chemistry, Biology, Chemistry or Physics). If the students graduate with the "Recommended High School Program" or the "Distinguished Achievement Program," they have to take a minimum of 3 "Science Carnegie Units" (which, too, are drawn from Integrated Physics and Chemistry (IPC), Biology, Chemistry and Physics).

In addition to these content requirements, it should be pointed out that students in Richmond do not have to pass an entire year of a particular science in one academic year. Students can do one semester of a science subject in 1 year and another semester of the same science in another year (as long as they do not repeat the same semester). In reality, however, this is only used when a student fails a semester of a course and does not want to study that course over summer school.

Martin Van Buren responds to the TEA curriculum requirements by automatically enrolling all freshmen in Integrated Physics and Chemistry (unless they can demonstrate that the class was taken in junior high). To ensure that the students receive the education they deserve, Martin Van Buren employs 10 IPC teachers. These teachers are viewed as an independent department within the school in the same way that French is viewed as an independent member of the languages department. IPC is not, however, viewed as subject that feeds directly into Chemistry or Physics. They have their own laboratories (9 in total) and independently plan their own curriculum.

During their freshman year, students, in theory, meet with the school counselor at least twice. During these meetings, options for sophomore classes are discussed. Students who are identified as being “Honors Students” (those students with a high grade point average) are strongly advised to take Pre-AP Biology (and other Pre-AP and AP sciences in subsequent years). Those students who are viewed as being less able are encouraged to take “Regular Biology.”

In total there are 9 Biology teachers in the school. Of these teachers, 6.5 full time equivalent teachers predominantly teach Regular Biology. One teacher teaches the AP Biology class and half the Pre-AP students. Another teacher teaches the remaining Pre-AP students, but also teaches Anatomy and Physiology. One teacher spends half her time teaching a unit called “Geology, Oceanography and Meteorology.”

Students progress from Biology to Chemistry at Martin Van Buren, with what could be called “Chemistry I” (i.e., Regular Chemistry or Pre-AP Chemistry) being taught, most commonly, in their junior year. There are 5 teachers within a chemistry department that offers 4 subjects: AP Chemistry, Pre-AP Chemistry, “Regular

Chemistry" and Chemistry in the Community (which is commonly called ChemComm by the science staff). One teacher (the head of the department) teaches all AP and Pre-AP chemistry. Chemistry in the Community is taught by 1.5 full time equivalent teachers and the remaining 2.5 teachers spend most of their time teaching "Regular Chemistry" (one "Regular Chemistry" teacher teaches "Regular Biology" to one group of students).

The perceived validity and importance of Chemistry in the Community is not consistent within the student body. Some students believe it is appropriate to use Chemistry in the Community to meet the chemistry requirement of going to college, others do not. All students view Chemistry in the Community as an easy subject that they should have no problem passing. Whatever the status of Chemistry in the Community, however, the school needs to clarify whether it can be used by students to get into college.

Students typically study Physics in their junior or senior year, with "Regular Physics" and "Pre-AP Physics" containing both junior and senior grade level students. AP Physics contains only seniors this academic year. Physics is seen as a "math subject" at the school and is taught to predominantly boys (more than 66% of the students in all physics classes are male). Physics is the least popular science. One teacher is sufficient to meet the schools physics teaching needs.

It should not go unstated that the size of the different science departments at Martin Van Buren speaks to how confident the school is at keeping students in school. If student perceptions of school were positive, they would remain in school. As a result, the school would need more chemistry and physics teachers (and labs to teach them in). This, however, is not the case. The school relies on students either dropping out or not opting for chemistry and physics. If there were a sudden change in student persistence, there simply would not be the teachers or facilities to teach them effectively.

Chemistry Department

The chemistry department at Martin Van Buren is composed of five male science teachers (four of whom are Caucasian, one of whom is of Indian descent) with a variety of teaching experience. The Caucasian head of department (who also oversees the entirety of science education at Martin Van Buren) was initially a biology teacher, but gradually moved into chemistry, via math, over the 15 years that he has taught. He teaches the Pre-AP and AP Chemistry classes and informs anyone who asks that he moved out of biology because it “wasn’t scientific enough,” “was too imprecise” and “didn’t have enough math to make it feel like a proper science.”

Two other members of the department have recently entered the profession. One of these teachers specifically trained as a science teacher, while the other trained as a geologist, but moved into teaching when, after completing his masters, he found work in geology hard to find. These teachers mostly teach “Regular Chemistry” (one of the teachers teaches biology to one class). The remaining members of the department are Caucasian. They have taught for a minimum of five years and have been based in the department for at least that long. One of these teachers teaches Chemistry in the Community full time. The other teacher divides his time equally between Chemistry in the Community and “Regular Chemistry.”

The teachers teach in 4 classrooms. The two most experienced teachers (the head of department and the full time Chemistry in the Community teacher) have their own classrooms, while the three less experienced teachers share the two remaining classrooms and use one of the biology classrooms.

The chemistry classrooms, which come equipped with their own fume hood and a minimum of 6 computers (the Pre-AP and AP classroom has 10), are divided into two areas. In three of the classrooms, the front of each classroom is composed of desks and stools that face a chalkboard. At the rear of these classrooms there are two parallel lab benches, both sides of which can be used for practical activity. In the remaining classroom, the lab benches are at right angles to the right hand wall. The lab areas of the classroom are equipped with their own power points, gas taps and sinks, which are positioned centrally to the work benches. The benches have computers situated either on them or nearby.

The classrooms themselves are very rule driven. In most of the classrooms, the only work on the walls is a Periodic Table and posters that display the rules which the students have to live by (in Chemistry) and the reasons that they must work at Martin Van Buren. In the Pre-AP-cum-AP classroom, these rules and expectations posters are joined by five "off topic" posters (one promotes the Red Hot Chili Peppers, another promotes the Abbey Road album by The Beatles, while the remaining posters are pictures of Texas Instruments calculators that the students could use in Chemistry), seven posters about various aspects of science (including absorption spectroscopy and electronegativity) and a number of musically-based bumper stickers (that promote a number of smaller bands). Mr. Thomas, the AP and Pre-AP chemistry teacher, is a music fan, having gone to the South by Southwest festival, in Austin, Texas, during spring break. He sometimes talks to the students about music. Unlike the biology classrooms across the corridor (which are replete with a large amount of student work), no student work is on display in any of the chemistry classrooms.

While it is not mentioned in the "National Standards" (National Research Council, 2004), classroom presentation can demonstrate to people how teachers and students see science. The Pre-AP and AP classroom is very "math heavy." Anything that is even vaguely academic speaks to the importance of math in chemistry. In addition, nothing academic in the classroom speaks to student involvement in the classes taught there. Mr. Thomas might not be aware that he is sending these messages to the students who enter his classroom, but it is possible that the students receive this message all the same. The idea that students are not expected to become "active participants" in their own learning is in contravention of the "National Science Standards" (National Research Council, 2004).

When it comes to students selecting the course they plan to take in Chemistry, the process occurs twice a year. The first "major selection process" occurs at the end of the spring semester previous academic year. As that semester comes to a close, sophomores decide which Chemistry course they will take. This decision is implemented at the start of the next academic year. Towards the end of the first semester, students have a choice as to whether or not to continue with the course as they continue into the Spring Semester. Few students drop the class or move into another chemistry subject, however, unless they are "failing horribly."

This does not mean that every student will be admitted to the course. There are number of minor pre-requisites for all the Chemistry courses that the school offers. When it comes to Chemistry I (at either the "Regular Chemistry" or the "Pre-AP Chemistry" level), the students have to take Algebra (or have already taken it, though this is rare). For Chemistry II (which is viewed by the district as another name for AP Chemistry), the students have to have successfully completed Chemistry I. This means that, in theory, “Regular Chemistry” can be used as a jumping off point for AP Chemistry, but in practice, this does not occur that often. One student attempted to make the transfer this year, but the student rapidly dropped out of the class.

During the time of this investigation, 54 classes (taught by 4 of the 5 members of the department) were observed, between mid-February and mid-May. The classes observed included 3 Chemistry in the Community lessons, 10 “Regular Chemistry” lessons, 28 “Pre-AP Chemistry” lessons and 13 AP Chemistry lessons.

This investigation predominantly focused on the Pre-AP classroom because it is important to try and understand why students elect to study AP Chemistry and that decision is undertaken in the Pre-AP Chemistry classroom. Consequently, knowing what occurs in the “Pre-AP Chemistry” classroom is important and is why more that half the time spent observing classes was spent in the Pre-AP classroom.

It was initially felt that the observation of “Regular Chemistry” lessons might help explain why some students transfer to “Pre-AP Chemistry.” In reality, however, this upward transfer of students to Pre-AP Chemistry is rare. The Pre-AP teacher could not remember it ever happening, though transfers from “Pre-AP Chemistry” to “Regular Chemistry” and from “Regular Chemistry” to Chemistry in the Community occur more often. When the students were asked why they transferred, they explain it was because they either were less interested in chemistry once they started the class, or that they found it too hard (especially when it came to the math aspect of the class).

As soon as Pre-AP Chemistry lessons were observed, it was possible to suspect that the structure of the lessons was not going to be a factor when examining why students are involved in Chemistry, beyond Chemistry: I. There are a number of reasons for this suspicion:

1) The piles of paper that cover the lab space in the AP-Chemistry classroom suggest that it would be impossible to use it for practical work. Discussions with students at both the school and TU would later confirm this. Students at both the Pre-AP and the AP level stated that their classes had not done a practical all year, while students at TU stated that they had not done any practical in chemistry at Martin Van Buren either, but that Mr. Thomas "had done some demonstrations." However, this usually meant he had shown them how to use their calculator.

   This is in violation of Texas education law, which states that 40% of a student's time in a science classroom should be spent "doing lab work." Rumors that schools tend to ignore this part of the law are widely promulgated through the education community, however, and should not be viewed as a problem that only affects this school.

   The unwillingness of teachers to do practical work is not just limited to the AP and Pre-AP classes. Of the 54 classes that were formally observed, one "Regular Chemistry" class saw the whole class engaged in a practical at the same time; while one "Chemistry in the Community" class saw the students do a practical one student at a time, while the rest of the students in the class copied from an overhead.

In addition to these formal observations, it was possible to walk the halls sometimes to see what was going on in classrooms when the doors were propped open. No other practical activities were observed, in any science lesson, during the time the observations took place.

In Chapter 2 it was explained that oftentimes practical work was used in an inappropriate way, and that this form of practical activity should be avoided. This having been said, however, the "National Standards" state that if students are to develop their scientific thinking, they must "actively participate in investigations and use the cognitive and manipulative skills associated with the formulation of scientific explanations" (National Research Council, 2004). When no practical activities are occurring in the classroom, however, it is impossible for this "National Standard" to be met.

The "National Standards" add that by high school, students should "understand that experiments are guided by concepts and are performed to test ideas." They add that students "often have trouble dealing with data that seem anomalous and in proposing explanations based on evidence and logic rather than on their prior beliefs about the natural world" (National Research Council, 2004). While this can be done without the direct use of practical activities, it is hard to believe that the didactic teaching that occurs at Martin Van Buren would do it better than practical activities.

2) The AP and Pre-AP classes are very didactic. The classes almost always start with the students being given a test. Once this is complete, they are

given handouts and the teacher spends the remainder of the lesson reading them to the students. During this, the students are told to highlight important passages in the work, but are not asked to read it themselves. In addition they rarely ask questions. At intervals throughout the lesson, the work is interspersed with questions that the students answer. The teacher answers 75-80% of those questions for the students, drilling into the students exactly how to answer the questions as he works them. In theory, the students answer the remaining 20-25% of the questions, but most students have learned that if they wait long enough, Mr. Thomas will answer those questions too.

The “Regular Chemistry” classes that were observed were less didactic, with more interaction occurring between the students and the teachers. This having been said, the lessons of only one of the teachers looked like they contained ideas resulting from recent research into education. This teacher started with a clearly stated “Goal” for the lesson. The lesson was broken down into manageable chunks for the students (they never spent more than 15 minutes on one activity). In addition the teacher actively asked questions of a variety of students (and not just those that always answered them). This resulted in more students actively listening to the teacher (if only to avoid not being caught not listening). Even this teacher, however, was never observed doing practical work.

The “National Standards” state that teachers have many teaching and learning models that are relevant to science teaching and that they should "integrate a sound model of teaching and learning, including a practical structure for the sequence of activities, into their classroom" (National Research Council, 2004). When this standard is applied to Mr. Thomas's classroom, it is hard to argue that Mr. Thomas's didactic reading of work really meets the "National Standards" for students.

3) When the students in the class are observed, up to one third of the students are engaged in work that has nothing to do with the subject (this ranges from writing essays for English, History or Spanish and doing math problems to reading books, drawing pictures, to looking at photos and texting other students on their cell phones). Another third of the student body are not engaged in other work, but are not doing anything. Typically this involves sitting in a way that looks like activity to the casual observer, but ensures the student will not cause a fuss. On one occasion, however, it included the student falling asleep in class and drooling on his homework – Mr. Thomas's only comment about this was that he would put this work in a separate area. The final third to 40% of the class are positively engaged in the class.

When one of these "inactive" students was asked what she thought of chemistry, she muttered after class something about "being able to get away with stuff." When pushed, she burst into tears, informing the investigation that "I mean shit. I know I backed off a little this semester but I thought I could cos I got all As last [semester]. And now it looks like I'll fail this semester if I don't get a 76% in the final." She continued with

“I mean he doesn’t care. If you work he likes you and he usually likes the Asians because we work, we’re his favorites cos of that, but if you don’t, he doesn’t care. He doesn’t tell us off or anything if we don’t do stuff. I mean I know you sit behind me, but you look more irritated with me if I’m not working than he does and he’s our teacher. It’s just hard to get started when you don’t work.” Two of her friends agreed with this statement, before comforting her and continuing on to their next lesson.

When this situation is compared to the “National Standards,” it is found that these national standards state that effective teachers “involve students in the design and management of their learning environment” (National Research Council, 2004). If students can independently access what they need, they can take responsibility for their own learning. It is hard to argue, however, that this is occurring in Mr. Thomas’s classroom.

In addition, the “National Standards” state that skilled teachers “recognize the diversity in their classes and organize the classroom so that all students fully participate.” As an example, effective teachers “monitor the participation of all students and determine if all members of a class are involved with what is being learned” (National Research Council, 2004). This monitoring can be particularly important in classes of diverse schools like Martin Van Buren, where social issues of status and authority can be a factor. Given the lack of involvement by large numbers of the class at different times, it is hard to argue that this particular standard is truly being met.

4) The marking was generally kept up to date, with work 3 or 4 handouts being handed in by the students once a week. There is some evidence that historically, homeworks in the past were not returned promptly (there is work dating back to 2002 on the practical benches), but this unreturned work dated back to previous years.

   The "National Standards," however, suggest that "teachers collect information about student understanding almost continuously and make adjustments to their teaching on the basis of their interpretation of that information" (National Research Council, 2004). In addition the standards add that teachers "use assessments to plan curricula, with data being used to select content, activities, and examples that will be incorporated into a course of study, a module, a unit, or a lesson" (National Research Council, 2004). Sadly however, there is no widespread evidence that Mr. Thomas adapts what he is teaching in response to the assessments that are performed by the students.

   After homeworks are returned, Mr. Thomas talks to the students about the problems that the students had with the homework. This having been done, he does not seem to modify how content is presented at all. Content is presented in the exact same way across all 4 Pre-AP classes, with no evidence that it has been changed in any way to meet the needs of the students. In addition, it is worth pointing out that while the content for the AP Chemistry classes is different, it is presented in a similar fashion.

The concerns raised here that the teacher is not very responsive to the changing behaviors of the students are reinforced by the comments that the student made in the previous section. If the student is to be believed, an 'A Grade' student is presenting the teacher with poorer grades and yet the teacher fails to respond to these changes. While this lack of response might not be surprising, it indicates that there is little of merit in the conduct of the teacher when it comes to encouraging the students to return to working hard the class.

5) When it comes to the "Content Area" of the "National Standards," there is little doubt that much of what could be called "mainstream chemistry" (areas like atomic structure, reaction rates and thermodynamics) are thoroughly covered. When these areas are taught, however, they are covered in detail, but are typically only tied into success in the final exam.

   Other chemical areas that are talked about in the "National Standards" are not covered in anything like as much detail (National Research Council, 2004). As an example, "Geochemical Changes" are covered in great detail in the "National Standards and are not taught by Mr. Thomas. Interestingly, "Geochemical Changes" is a common thread of chemistry subject matter internationally, with it comprising approximately 25% of the English "Chemistry Curriculum."

   When Mr. Thomas was asked as to the teaching of the "Geochemical Changes" of the national standard, he suggested that they were, in fact, covered in "Integrated Physics and Chemistry" (or IPC).

While this might well be the case, one of the students in the AP Chemistry class complained that his failure in the Texas Science TAKS test could be traced to him not being able to recall the stuff covered as a freshman all that well. If Mr. Thomas had prepared the students for that TAKS test by revising what had been covered in IPC, the student might have had a better chance of passing the TAKS test and graduating on time.

In reality, the student was not the hardest worker and struggled to follow even the most basic of instructions, so revision might not have helped him pass the TAKS test, but discussions with other students suggested that links were not always drawn to what was taught in previous years.

Surveying and Interviewing

Given that the structure of the lesson is does not seem to encourage the students to persist in Chemistry, what is encouraging them to persist? The answer to that question might be based in the questionnaires that were administered to members of staff and the students who are currently enrolled in Chemistry.

At the start of the 2005-06 academic year, there were 699 students enrolled in classes associated with the Chemistry Department. By the second week of the Spring Semester, 625 students were still enrolled. The enrollment can be broken down as follows:

Class	Winter Enrollment	Spring Enrollment	Net Change
AP Chemistry	24	22	-2
Pre-AP Chemistry	58	55	-3
Regular Chemistry	421	365	-56
Chemistry in the Community	196	183	-13

It was at this stage that the investigator discovered he had been mislead during the early stages of this investigation. The investigator had been told that Martin Van Buren had 77 students enrolled in AP Chemistry. This resulted in an examination of the e-mails that were received from both Central ISD and Western ISD. Both sets of e-mails show that the School Districts were asked to disclose how many students were enrolled in both the Pre-AP program and the AP program *as separate figures*. Western ISD responded by releasing these figures separately. Central ISD responded by releasing the figure for those students "enrolled in AP Chemistry." When they were subsequently contacted, by phone, about the figure for Pre-AP Chemistry, it was made clear that this figure was not available (it was assumed by the officers at Central ISD that the Pre-AP Chemistry and Regular Chemistry were merged by the schools, when, in fact, the Pre-AP and AP Chemistry figures were merged).

Given the confusion over how the enrollment in AP Chemistry was calculated in Richmond, it is not surprising that the initial error was made in this investigation. It did, however, ensure the investigator would double check third party data sources for accuracy in future.

This confusion does not, however, affect the overall thrust of the enquiry. The size of the AP class might be smaller, but students at Martin Van Buren still elected to choose AP Chemistry ahead of other subjects. Understanding the reasons why some of these students made their decision while others (who, by doing Pre-AP Chemistry were acclimatized to what to expect in AP class) did not will still allow teachers gain insights into how to encourage those students (who are currently not enrolled in AP Chemistry) to choose chemistry in the future.

When it comes to the ethnicity and gender break down of the current AP and Pre-AP Chemistry enrollment, some interest facts can be observed:

Ethnicity	**Martin Van Buren Student Population**	**Pre- AP Chemistry***	**AP Chemistry***
African-American	29.7%	17.24% (10)	4.55%*** (1)
Asian	7.8%	15.51% (9)	40.90% (9)
Caucasian	14.0%	15.51% (9)	22.73% (5)
Hispanic	49.0%	44.8% (26)	31.82% (7)
Other	0.6%	10.35%** (6)	0% (0)

*The figure in brackets indicates the number of students in each class.
**The "other students" in the Pre-AP class are all of Indian origin.
***The student is a black African whose parents live in America.

Gender	**Martin Van Buren Student Population**	**Pre- AP Chemistry***	**AP Chemistry***
Male	49.5%	47.27% (26)	40.91% (9)
Female	50.5%	52.73% (29)	59.09% (13)

*The figure in brackets indicates the number of students in each class.

These figures suggest that the school is effective at encouraging Asian students to take all the more challenging forms of Chemistry, Caucasian students to persist with Chemistry beyond Pre-AP Chemistry, and Indian students to take Pre-AP Chemistry. The figures also suggest that the school is less effective at encouraging African-American students to take any form of upper level chemistry and Hispanic students to persist past Pre-AP Chemistry.

When this investigation was planned, the intention was to use the Comprehensive Assessment of School Environment Project (or CASE, which was designed by the National Association of Secondary School Principals) and the Classroom Environment Scale (or CES, which was designed by Trickett and Moos) to assess the school that was being observed. It was hoped that these questionnaires might indicate that the students who take Pre-AP and AP Chemistry, teachers or parents (of students who take Pre-AP and AP Chemistry) are significantly different to their counterparts in regular high school population in some regard and that this difference could be used to explain their persistence in Chemistry.

The management at Martin Van Buren proved unwilling to help in this investigation (despite it being made clear that little or no work would be required on their part) and made it clear that they were unwilling to allow any teacher outside the science department to be surveyed about their views on school. This lack of access was extended to the parents of students at the school. Despite repeated attempts to explain the importance of the surveys, the school's management was unwilling to allow the surveys to go out. It is not believed that this would be a problem, however, because even if it accepted that Asians are innately more likely to take Science classes because of parental expectations (Wong, 1990), it should be pointed out that:

1) Asians students come from a background of greater academic success. Their parents are more likely to have persisted in school and this makes students more likely to persist themselves (Wong, 1990). It is not clear, yet, whether student persistence is because of the Asian-ness or the academic success of the parents (academically successful parents are more likely to send their children to college).
2) The Asian AP students at Martin Van Buren are of all of Vietnamese ancestry and the Vietnamese are, historically, amongst the least likely of the Asian students to persist in school (Wong, 1990).

3) Even if we accept that the only reason why Asian students who select AP Chemistry at Martin Van Buren is parental pressure, it beggars the question, why do the 91.45% of Asian students who take other forms of Chemistry at Martin Van Buren do not respond to parental expectations to take these tougher Chemistry classes. This suggests that there is another reason why these students are selecting AP Chemistry.
4) It does not explain why students of other backgrounds fail to pick higher level chemistry classes.

Consequently, surveys were issued only to the students and the science department teachers, despite the obvious limitations that this would impose on this project.

Teacher Perceptions

The Comprehensive Assessment of the School Environment (or CASE) was designed to assess student, parent and teacher perceptions of the school they are attached to. The teacher surveys, like the surveys for all other groups have two sections. One section examines teacher perceptions of Martin Van Buren's climate. The other section assesses how satisfied teachers are with the school. The survey results that are generated are in the form of a percentile rank that ranks the school in comparison to how teachers at other schools rank their school. The higher the percentile rank, the more positively the school is viewed. A score in the seventy-fifth percentile, for example, indicates that a school's teachers view their school more favorably than 74% of teachers view their school.

As was indicated earlier, the teachers in the science department and students in the school were surveyed as part of this investigation. Turning first to the teachers, the response rate to the 2 forms was 84% (21 of the 25 pairs of forms were returned). This gives rise to a confidence interval of ±8.73%.

The following results were obtained from teachers when they were asked about the school's climate:

	Percentile Rank
Teacher Student Relations	42.0%
Security	47.8%
Administration	49.2%
Academic Orientation	38.1%
Behavior Values	43.5%
Guidance	40.6%
Student Relationships	37.6%

The following results were obtained from teachers when they were asked about how satisfied they were with the school:

	Percentile Rank
Administration	55.5%
Compensation	52%
Opportunities for Advancement	78%
Student Responsibility and Discipline	37%
Curriculum and Job Tasks	52%
Co-Workers	67%
Parents & Community	43%
Buildings	55%
Communication	51%
Community	35.5%
Instructional Management	44%
Student Activities	42%

Perhaps the most interest results here fall into two categories. Teachers would appear to be satisfied with their co-workers and their chances of promotion and dissatisfied with the community and students who attend the school.

Student Perceptions

The student CASE surveys work in the same way for students as they do for the teachers. They measure student perceptions of the school climate and how satisfied these students are with differing aspect of the school. They allow Martin Van Buren to be ranked in comparison to other schools, using a percentile ranking system. As before, a score in the seventy-fifth percentile indicates that a school's students view that area more favorably than 74% of the student population nationally.

For this survey, all Pre-AP and AP students were surveyed. These students were selected because it was felt that the results that these students generated were of the most use when it came to understanding why students select Pre-AP and AP Chemistry. These students made a conscious decision to do challenging chemistry and persist with it once they have experienced it, so understanding their view of school is important.

The following results were obtained from students when they were asked about the school's climate:

	AP Chemistry (Percentile Rank)	**Pre-AP Chemistry** (Percentile Rank)
Teacher Student Relations	51%	51%
Security	44%	41%
Administration	50%	46%
Academic Orientation	51%	42%
Behavior Values	49%	46%
Guidance	44%	46%
Relationships	44.5%	44.5%
Community	45.5%	38%
Instruction	45%	44%
Student Activities	50%	50%

The following results were obtained from students when they were asked about how satisfied they were with the school:

	AP Chemistry (Percentile Rank)	**Pre-AP Chemistry** (Percentile Rank)
Teachers	53%	55%
Students	48.5%	48%
Schoolwork	55.5%	52%
Activities	51%	49%
Discipline	44%	44%
Decision Making Opportunities	54%	52%
Buildings	47.5%	48%
Communications	53%	50%

These results would suggest that the students do not feel any more positively (or negatively) towards school than students at other high schools. It was possible, however that the students in non-AP classes at Martin Van Buren had different views to those students who attended AP classes. To see if this was the case, 4 "Regular Chemistry" classes were sampled at random and exposed to the CASE surveys so that their results could be compared to the results provided by Pre-AP and AP students. Any significant difference between the two sets of result could then be reported here.

The following results were obtained from "Regular Chemistry" students when they were asked about the school's climate:

	"Regular Student" Climate (Percentile Rank)
Teacher Student Relations	54%
Security	42.5%
Administration	50%
Academic Orientation	45%
Behavior Values	49%
Guidance	48.5%
Relationships	45.5%
Community	44%
Instruction	45%
Student Activities	52%

The following results were obtained from "Regular Chemistry" students when they were asked about how satisfied they were with the school:

	"Regular Student" Satisfaction (Percentile Rank)
Teachers	53.5%
Students	48%
Schoolwork	51%
Activities	59.5%
Discipline	42.5%
Decision Making Opportunities	53%
Buildings	47%
Communications	50%

There seems to be very little difference in attitudes to school between those students that attend higher level and those that attend "Regular Chemistry" classes. It could be argued that the more able students were more positively inclined to schoolwork, while the standard students were more positively inclined to the other activities that school had to offer, but these differences are neither significant nor surprising.

Before the results from the Pre-AP and AP classrooms are examined, however, it is worth pointing out that further examination of the raw data provided in the CASE returns given by Pre-AP and AP students shows that there are a number of statistically significant correlations (at the 5% level) that are occurring within this group of students. These significant correlations are:

1) Female students feel a strong sense of relationship and community at the school, but are less inclined to think positively about school activities and teacher-student relationships.
2) Caucasian students feel they have a strong sense of their own academic orientation.
3) African-American students are less inclined to think positively about discipline at the school.
4) Teacher-student relationships improve as students move up the school.
5) Indian students feel they exhibit good behavior at school.

Student Classroom Perceptions

The Classroom Environment Survey (or CES) examines student perceptions of certain areas of a particular class. It was administered here to all AP and Pre-AP classes to examine if there were any patterns of behavior or perception in the Chemistry that made these classes particularly different from other classes that students might attend.

The survey groups the answers into eight groups of ten answers. Students can score up to a maximum of ten points in each of the eight areas, depending on how similar each of their answers is to a standardized answer. Once the result for each group of answers has been obtained for each student, average scores can be obtained for a class or groups of classes. These results can be broken down in one of two ways. Firstly, the class scores can be converted to a percentile rank that shows how the class is doing compared to all the other classes that exist (French, English, etc). If a class scores in the fiftieth percentile in a section, for example, it is doing better than 49% of classes, but worse than the other 50% of classes. This can be useful if the goal is to find the relative position of a class compared to other classes.

Alternatively, the scores from the eight individual sections generated can be compared to the average score a particular subject area got in a section. This allows investigators to calculate the number of standard deviations different from the mean that a particular class scored in a particular section. The larger the number of standard deviations, the more significant the section is in the classroom under observation. This allows investigators to find if one area or another is contributing significantly to the success (or otherwise) or a class.

Turning first to the results of both classes combined, these results were obtained:

	Classrooms In General (Percentile Rank)	**Science Classrooms** Raw Score (std. dev. from exptd)
Involvement in Class	53%	6.54 (0.42)
Affiliation with Students	68%	8.67 (1.59)
Teacher Support	49%	6.51 (-0.06)
Task Completion	59%	7.83 (1.30)
Competition in Class	64%	6.94 (1.13)
Order and Organization	49%	5.65 (-0.16)
Rule Clarity	51%	6.15 (-0.51)
Teacher Control	50%	3.90 (-0.37)
Innovation	45%	4.13 (-0.53)

Disaggregating these results allow the results for the different classes to be examined individually. Turning first to the AP class, the following results were obtained:

	Classrooms In General (Percentile Rank)	**Science Classrooms** Score (std. dev. from exptd)
Involvement in Class	58%	6.68 (0.50)
Affiliation with Students	67%	8.64 (1.56)
Teacher Support	53%	7.09 (0.28)
Task Completion	62%	8.23 (1.62)
Competition in Class	59%	6.41 (0.57)
Order and Organization	50%	5.86 (-0.03)
Rule Clarity	50%	5.91 (-0.71)
Teacher Control	51%	3.95 (-0.33)
Innovation	49%	4.86 (-0.06)

Turning now to the Pre-AP classes, the following results were obtained:

	Classrooms In General (Percentile Rank)	**Science Classrooms** Score (std. dev. from exptd)
Involvement in Class	57%	6.48 (0.38)
Affiliation with Students	68%	8.68 (1.60)
Teacher Support	47%	6.26 (-0.21)
Task Completion	58%	7.66 (1.16)
Competition in Class	65%	7.18 (1.38)
Order and Organization	48%	5.56 (-0.21)
Rule Clarity	52%	6.26 (-0.43)
Teacher Control	50%	3.88 (-0.39)
Innovation	42%	3.80 (-0.73)

The most significant results generated in this section would appear to be the high degree of affiliation shown in the classes (especially when compared to other science classrooms), the level of perceived competition in the Pre-AP class, and the marked difference in student perceptions of innovation between the Pre-AP and the AP groups.

Student Interviews

The entire AP Chemistry group completed a questionnaire to examine some of the reasons why they wanted to study AP Chemistry. The questions focused on different areas, in the hope that these responses might shed some light onto the reasons behind their selection of AP Chemistry as a course option.

The initial questions in the interview surveys indicate that almost all the students had started with Integrated Physics and Chemistry as high school freshman, before moving on to Pre-AP Biology and Pre-AP Chemistry as the remainder of the 3 sciences that they are required to take by Central ISD and the Texas Education Agency if they want to progress on to college (which all these students wish to do). AP-Chemistry was selected as an optional subject that students can elect to take while they are at Martin Van Buren. Only half of the students were either taking or planning to take any form of physics. Those that did take Physics were taking it under the same "optional extra" guidelines that enabled them to take AP-Chemistry.

Examination of the grades that the students claimed that they got in school suggests that these students are generally quite able. They have obtained mostly A and B grades in the previous science classes they have attempted and expected this to continue in AP Chemistry, when they started the class. The grades that the students achieved in science were not significantly different from the grades that they were achieving in other subjects. With some of the students, the grades they got in science were higher. With other students the grades that they got in science were lower. In neither case, however, did this amount to more than a marginal difference. Those students that did better in science were only getting a slightly larger number of A grades in science (as a fraction of their overall GPA in the area), while those students that did worse in science were only getting a slightly fewer number of A grades in science (as a fraction of their overall GPA). It is also worth noting that only two of the students felt that they were better at chemistry than they are at the other subjects they take. Seven students believe they are worse.

The questions then moved to homework and what students did in their spare time. All of the students claimed that they completed their homework assignments (which was broadly confirmed by the Chemistry teacher who said that about 5 of the 22 students "had the odd assignment missing, but nothing more serious than that"), though the amount of time they claimed they spent on their homework varied from 90 minutes to almost 4 hours a night. For the benefit of balance, however, it should be noted that some "sharing" of homework was observed, even amongst these able students.

The students indicated that the homeworks were returned promptly by Mr. Thomas and they were able to discuss their homeworks with him both before and after they returned. In many ways, this is a good thing and meets many of the standards outlined in the "National Science Standards," but due to a lack of flexibility on the teacher's part (when it comes to designing the lesson), the results of assessments were not always used in the more appropriate manner. As an example one Caucasian female student informed the interviewer that she was averaging over 90% in her other classes but 72% (a score that can only be described as a borderline pass) in AP Chemistry. When this student was asked about the disparity in the scores, she said the teacher does things "in a boring way."

When their homework was complete, students indicated that they tended to watch television, use computers, or "hang out with friends" when they were at home. At school, most students tended to go to the computer rooms during breaks in their timetable. Seven of the students (four Asian, three Hispanic) were involved in the student council. Another group of seven students (five Hispanic, two Caucasian) were either in band or the orchestra or both. The most commonly played sport was tennis. Twelve students claimed they played it regularly, including at school. Of the 12 students, eight (out of the nine in the class) were Asian, four were Hispanic. These groups (council attendees, band members and tennis players) indicated that they were in many of the same classes.

When asked to describe Martin Van Buren, the students often talked about the necessity of school, coupled with its size, scale, diversity, dirtiness and either the friendliness or general unfriendliness of the place (depending on their point of view at the time). When asked to describe the chemistry classes they attend, descriptions tended to focus more on the challenge the students faced in the class, the friendliness of other members of the class and (where appropriate, some of the class were divided on this) the approachability of the teacher.

Asked about the teaching of Chemistry at the school, the students responded that they felt that there was a certain way of doing things in science in general and chemistry in particular. This might be a response to the content that is taught in AP science classes. AP Chemistry, as it is presented at Martin Van Buren, is a "math heavy" class and many students feel that "there's only one way to do math."

This point of view reinforces concerns about the teaching of AP Chemistry at Martin Van Buren, when it is compared to the "National Science Standards." The "National Standards" suggest that "science is a way of seeing the world, and should be taught as its own interactive, individual subject" (and not just an extension of math) and, listening to the students, there is some suggestion that this fails to occur at Martin Van Buren. It is not clear whether this is because of the teacher's urge to teach to the test or whether he really believes that chemistry is a math subject (as he essentially said).

Whatever the reason, however, the current, “math heavy” content of the subject is at odds with some elements of the “National Science Standards.”

When questioned about how their parents impacted how they felt towards school, most students admitted that their parents expected them to do well and work hard (the remaining parents did not have negative expectations, it was just school to them). Most of the students felt that this was a general expectation, rather than an expectation to do work in a particular area, though two Asian females indicated that their parents expected them to work particularly hard in math and science.

When asked what support their parents were giving them when it came to their homework and class work, students agreed that their parents could not help them with the answers to questions. This was explained in terms of the fact that the students “know more stuff about chemistry” than their parents. Their parents support came from their willingness to verify that their children were on top of their homework and ready for school. When asked to explain this, one student informed the investigation that “they don’t treat us like kids; they just expect us to be ready.”

Students agree that they get on with people in their class and some feel that they like their teacher and that he is approachable. Though the students said that having friends in the class and an approachable teacher were important, none of the students explicitly said that these factors were the deciding factors when they elected to study AP-Chemistry at Martin Van Buren.

When the students were asked, directly, why they studied AP-Chemistry, most were quite mercenary. One reported that it would look good on her transcript, while more than half of the remainder said that they needed it to either get college credit or because they thought it would help them with the courses that they wished to study at college. Of the remaining students, most claimed that they chose AP-Chemistry because it seemed to be the logical next step, having done Pre-AP Chemistry.

Summary

Martin Van Buren High School is in many ways an unremarkable high school in an unremarkable city. The student body is considerably poorer and more ethnically diverse than Richmond generally, but the students seem generally healthy, happy and well cared for. The buildings, which tend to be somewhat windowless, are clean, cared for and well looked after. Gaining access to the site once the day begins could be viewed as the most problematic area for those who are presented with the school for the first time.

The science department is large, with 25 teachers spread across 4 departments. The largest of the departments is “Integrated Physics and Chemistry,” with 10 teachers. The smallest is Physics, with 1 teacher. The chemistry department has 5 male teachers, 4 of whom are white, 1 of whom is Indian. Two chemistry teachers have less than 2 years experience each. Another two have up to ten years of experience. The Head of Department has 15 years experience. Teachers across the department are generally happy at the school. They relate with other teachers well and feel that they have a chance to be promoted, should they remain at the school. Their perceptions of the students and the community in which they teach are less positive, but not significantly so.

The chemistry department offers 4 subjects, Chemistry in the Community (which is taught by 1.5 teachers), “Regular Chemistry” (taught by 2.5 teachers), Pre-AP Chemistry and AP Chemistry (taught by 1 teacher). Lessons in these classes are generally very didactic and math heavy, with little lab time occurring in the department (this, despite the fact that there are laws that mandate large amount of lab time should occur).

Given, the lack of mandated lab time, it might lead some to wonder about the effectiveness of chemistry teaching at Martin Van Buren. It is, therefore, worth pointing out that while the Pre-AP and AP teacher does not seem to have any discipline problems at the school (unlike at least one of the biology teachers who seems to regularly remove members of her class from the classroom), the teacher is not necessarily the most responsive teacher when it comes to applying the entirety of the "National Science Standards" in his classroom.

The students who attend the school have attitudes that are common to many of their counterparts in other schools. The students rank the community poorly, on the whole (it is in the 38th percentile), but across a variety of other measures, the school ranks between the 42nd and 54th percentile.

In the Pre-AP and AP chemistry classes, the students feel a strong sense of affiliation with other students. In addition, they feel that the teacher has fully stressed the importance of completing their work, and competing against other students (especially when compared to other science classes, though competition is felt to be less visible in the AP class). The Pre-AP class did, however, have a much less favorable view of innovation in science, when compared to the AP group.

It is also worth noting that while the students that take AP Chemistry do well in school, they do not necessarily do as well in chemistry as they do in other subjects (though no student did all that much worse in science than they did overall). In addition, while the student came from generally supportive homes, they had a mercenary view of why they are taking AP-Chemistry. All the students plan to continue on to a 4 year college and over half the students felt that having AP Chemistry on their transcript would boost their chance of being accepted. In addition, many of the remaining students took AP Chemistry because they felt that it would help them once they were at school.

This attitude does not necessarily explain, however, why the students opted for AP Chemistry as opposed to AP Spanish or AP History (all three of the subjects would presumably help with college and look good on a transcript). This fact is combined with ideas about affinity and social groupings to explain why students opt for AP Chemistry in the next chapter.

Chapter 5

Results, Analysis and Recommendations for the Future

At the start of this investigation, the goal was to try to identify and define some aspects of the classroom experience in a typical 4 year high school that encouraged those students who had taken one chemistry class to return and take another. This is important because, in my estimation, if a student is to be defined as truly knowledgeable about certain areas of world, he (or she) ought to know as much chemistry as possible. This additional knowledge would also benefit industry because it would enable their more expensive American employees to add value, on the production line, to the products that their employer make, allowing the employer to compete against their cheaper, foreign made competition.

It was hoped at the start of this investigation that there would either be something that the teacher did or something about the nature of the lesson that could be easily identified and transferred from the observed lessons to other lessons, in similar schools. The hoped for discovery of a break through in how chemistry is presented in high school did not happen. In fact, quite the opposite occurred. As soon as the Pre-AP and AP Chemistry lessons were observed, it became apparent that the structure of the lessons was not a factor when examining why these students are involved in Chemistry.

Evidence against Lesson Structure being Important

When it comes to organizing the evidence against lesson structure being important for students at Martin Van Buren High School (hereafter called Martin Van Buren), they can be organized into two areas:

1) Direct observation of what teachers did in the classroom (and, where appropriate, how the students responded).
2) Comparisons between what is actually occurring in the classroom and what is recommended by national standards.

Direct Observation

Perhaps the most obvious initial issue that was noted about the Pre-AP and AP classroom related to the piles of paper that covered the back half of the class. The chaos in that area was, in fact, so bad that it would be impossible to use that area for any form of work at all. Practical work was not the only work that would be out of the question. The computers that were strategically positioned in that area could not be used unless the students were prepared to work round junk 5.25" floppy discs, zip drives that contained curricula that dated back 4 or 5 years, pile after pile of junk paper and unreturned homeworks that dated back (on the most superficial inspection) to November of 2002.

In the UK, this chaos simply would not be accepted (Reynolds, Hopkins, Potter, Chapman, 2001, Reynolds, Potter, Chapman, 2002, General Teaching Council, England, 2004, OFSTED, 2005, Department for Education and Skills, 2005, Teaching in England, 2006). Teachers in the UK have been criticized for untidy front desks, the argument being that it shows disrespect to the students (how are you going to be able to find the work the students turned in – all they need say is that they put it on your desk) and it teaches the students (and new teachers) bad habits. Even senior members of staff have been criticized (by their superiors) for this in the UK.

In this instance, however, the teacher positively enjoyed the chaos, having wall mounted bumper stickers (one of which said "Those people with tidy work spaces leave the real work to the rest of us," another saying "A tidy mind is a crazed mind") that made light of the situation.

The second problem with AP and Pre-AP classes is that they are didactic. The classes did not amount to much more than the giving out and reading of handouts. The teacher would spend nearly the entire lesson reading to the students. The students are told to highlight important passages in the work, but are not asked to read the handouts themselves. In addition to this, students rarely ask questions in class. There were voluntary "after school classes" with a structure that fostered more give and take between the students and the teacher, but this only raises the question: Why does that not occur in school time, when everyone can attend?

This lesson structure is not one that is seen with any degree or regularity among the lesson plans of competent teachers in the UK (Reynolds, Hopkins, Potter, Chapman, 2001, Reynolds, Potter, Chapman, 2002, Teaching in England, 2006). If a class were particularly unruly, it might be used for a lesson or two to allow the teacher to reestablish control, but teachers who use this more often than this are usually assumed to be weak and in need of support from the rest of the department.

The third obvious issue that grew out of the first few observations was the fact that there was very little active engagement (by students) in the lesson. As was indicated in the previous chapter, examination of what the students did in class (when they were supposed to be following along with the teacher) showed that at any one time, up to one third of the students are engaged in work from other subjects. Another third of the student body are not engaged in other work, but are not doing chemistry either. The final third were doing something that was at least partly related to what was going on in the class.

If this lack of involvement were regularly observed in a single UK classroom, there would be some talk of support being given to the teacher, or even talk of the teacher being brought up on competency proceedings (Reynolds, Potter, Chapman, 2002, General Teaching Council, England, 2004, OFSTED, 2005). There may be cultural differences between the USA and the UK that mean it is acceptable for this lack of active engagement to occur in the US, but even if it is acceptable, it is unlikely that a lack of involvement would encourage students to positively select a class.

The last issue of concern to an outside observer would be a lack of context. Ideas like PV=nRT, K_{sp}, K_{eq}, K_a, K_b and K_w were introduced to the students, but their relevance (other than being able to answer questions about PV=nRT, K_{sp}, K_{eq}, K_a, K_b and K_w) was rarely touched on. In short, the work could not be readily applied to the real world. This is not meant as a criticism of Martin Van Buren individually (the teacher would argue that the students were simply being taught what was in the test), but this pattern of teaching behavior was the sole driver of what was thought to be "successful teaching" in that classroom all the same. This is a shame because it did not have to be that way. Students did ask "but why…?" questions, but they were either ignored or given the most simplistic answers.

Comparing Lessons and Teacher Behavior to National Standards

As was indicated in Chapter 2, the "National Standards for the Teaching of Science" cover a number of areas; the teaching that goes on in the classroom, assessment, the content that is taught, district and statewide standards and the professional development of teachers (National Research Council [henceforth NRC], 2004). They were designed to raise standards and the quality of teaching in American science classrooms and to assess the practices teachers in those classrooms (NRC, 2004).

Among the list of criteria that were mentioned in the previous paragraph, it is likely that the classroom teaching, assessment and the content that is taught are going to be of greatest consequence to those students who select science. Consequently, the criteria the NRC generated in these areas will be applied to Mr. Thomas's classroom to assess how effectively he is meeting those standards.

Classroom Teaching Standards

In this section, the National Standards that the NRC generated in a number of areas will be applied to Mr. Thomas' classroom management (NRC, 2004). In each area, the "National Standard" is either quoted verbatim, or is simplified to make presentation clearer. Irrespective of whether the standard is quoted verbatim or simplified, however, the meaning of the standard is usually clear. Where they are not clear, they are explained before they are applied to the classroom

Turning first to the "Classroom Standards," the standards, which are in bold, cover the following areas:

1) **Teachers of science plan inquiry-based science programs for their students.**
   If teachers are to achieve this, the teachers have to demonstrate that they:

   a) **Develop a framework of year-long and short-term goals.**
      It could be argued that the year-long goal of the class was to prepare for the AP Chemistry exam and the short-term goals were to complete their work or the particular unit that the class was presently working on. No other goals were

explicitly stated by the teacher. It could be argued that this is a weak and narrow set of goals.

b) **Adapt curricula to the needs of the students.**
There is very little evidence that this occurred within these classes with the same subject matter being taught in the same way across multiple Pre-AP classes.

c) **Select strategies that support student understanding.**
With the same subject matter being taught in the same way across multiple Pre-AP classes, with no real variation in each individual lesson, it is hard to argue that this is occurring. In addition, because there was no teaching of how to use the concepts taught (other than in how to answer exam questions), the students will struggle because they will be unable to apply what they are learning to their lives (which, it could be argued, reinforces learning).

d) **Work with colleagues across disciplines and grades.**
When a student changes class (either because they have been promoted to another year or because they change classes within the year), the teacher who gains the student is given data about how the student performed and what was covered by the teacher who taught the student previously. They have little idea, however, about what is specifically taught in middle schools or other non-science areas of the high school.

2) **Teachers of science guide and facilitate learning.**
If teachers are to achieve this, the teachers have to demonstrate that they:

a) **Focus and support inquiries.**
There is very little evidence that this occurs (especially within the AP group). Few students asked questions, but those that did were narrowly answered with respect to the areas under discussion (sometimes ignoring sidelines that the students might find interesting or relevant). On a few occasions when the question could not be answered without straying, however narrowly, off topic, Mr. Thomas answered "I don't know; now let's move on."

b) **Orchestrate discourse among students.**
This simply did not happen. Before Mr. Thomas arrived, the students would have discussions that boiled down to "Quick tell me the answer to Question 10." But no discussions that moved beyond that were ever observed.

c) **Challenge students to accept responsibility.**
For some students this does occur. Most students cared how well they did in the subjects they study. At the same time, however, there were large numbers who were observed doing little or nothing during class, suggesting that they were switched off. This would suggest they do not accept responsibility.

d) **Encourage students to participate fully in science.**
Fewer than half the students were observed participating regularly in class, which is a worry if they are expected to

participate fully in learning. It is worth pointing out, however, that they do complete their homework (with a little help from co-workers).

e) **Encourage and model the skills of scientific inquiry.**
In reality, this does not happen. It has already been pointed out that few students were actively engaged in the lesson. Couple this with the fact that students who asked "off topic questions" were directed back to focusing on the exam, pretty promptly, and the fact that the idea of testing hypotheses through investigation and practical work is core to science but fails to occur here, and it can be argued that this area is not particularly strong.

This having been said, the questions that the students were asked to answer were similar to those asked in national exams, so they are being encouraged to think in the way national exams expect.

3) **Engage in ongoing assessment of their teaching and of student learning.**
If teachers are to achieve this, the teachers have to demonstrate that they:

a) **Use multiple methods to assess students.**
Mr. Thomas uses regular testing (on Monday mornings and at the end of each unit) and homeworks to assess the students' progress. The Monday tests, however, did not have much to do with what the students had studied immediately prior to the test, and there is some evidence that the homeworks are not returned regularly.

b) **Analyze assessment data to guide teaching.**
As has been indicated earlier, the same lesson plan was used with all classes, with little evidence that the teacher returned to work after it was returned to the students. He did ask the students if they had a problem with a question and if a number of students had a problem with a question, he showed them how to answer it.

c) **Guide students in self-assessment.**
This did not happen in any explicit way in class. He showed the students what they had to do to gain a passing grade in the class, but after this it was largely left to the students to be self motivating.

d) **Use student data to improve teaching practice.**
There was little evidence that this occurred, with Mr. Thomas freely admitting that he used the same handouts and homeworks over a period of years. The handouts were mildly edited year-on-year, however, to make them accessible to new students.

4) **Design the learning environments to meet the students' needs.**
If teachers are to achieve this, the teachers have to demonstrate that they:

a) **Ensure students engage in extended investigations.**
Throughout the period under observation, no investigations were observed. The lessons were very didactic and focused on what the teacher was covering.

b) Create a setting that is flexible and supportive.
The structure of the lessons did not change all that much from day to day and week to week. Had Mr. Thomas elected to change the environment, he could, but he felt his current working environment was successful.

c) Ensure a safe working environment.
Mr. Thomas is an experienced teacher. As a matter of course, the classroom was safe, but "a safe working environment" is easier to achieve when there is no movement about the class and no practical work.

d) Make materials accessible to students.
With the classroom being so didactic, there was no need for much material support. Handouts were usually ready for the students, however, and the students seemed able to access them.

On some Mondays, however, Mr. Thomas would spend up to 40 minutes printing and photocopying materials for the class. During this time, students would sometimes read their books or do homework.

e) Identify and use resources outside the school.
Because of the structure of the class and the way it is taught at Martin Van Buren, there is no need for outside resources in the subject. No trips to outside facilities were organized or referred to during the time the class was observed.

f) **Engage students in designing the learning environment.**
No student work was displayed in the Pre-AP/AP classroom, but some posters (usually of irrelevant side issues, like bands) that might be of interest to students were displayed.

5) **Teachers of science develop communities of science learners.**
If teachers are to achieve this, the teachers have to demonstrate that they:

a) **Display respect for the experiences of all students.**
Despite the fact that Mr. Thomas sometimes joked with the students in a belittling way, most students found Mr. Thomas approachable. This having been said, a number of students felt that Mr. Thomas expected you to be a certain way and if you were not, he was less interested in you. This does not mean he was not interested in the students, just that some felt he was not interested in them.

b) **Enable students to have a voice in course content.**
The content is felt to be prescribed by the "AP-Exams Board" and how it is implemented is felt to be best organized by the teacher (with help from other AP teachers in the district). Students were allowed to raise issues they were having problems at the start of the class, but other than that they had no input into the class.

c) **Nurture collaboration among students.**
This occurred when students had work to hand in, with students trading homework answers, but it does not seem to have been instituted by staff. During class, the students

only rarely leave their seats and when they do, it is only to hand work in. The didactic nature of the class means that there is little collaboration in class.

d) **Structure ongoing formal and informal discussion.**
The didactic nature of the class means that there is little collaboration in class. Mr. Thomas is focused on completing the course requirements. He is open to having students asking questions that are related very specifically to what is being taught, but there is very little "color" or background introduced. Informal discussions between students are rare, with students only talking about how to answer questions. These discussions rarely covered *why* the approach to answering a question worked or relevant side issues.

e) **Model the values of scientific inquiry.**
When the students were being shown how to answer questions, they were taught how to think in the way the examining board wanted them to answer questions. As was indicated in the previous section, there was very little "color" or relevant side issue discussion. If Mr. Thomas did not feel that a question was relevant, he gradually guided the students back to areas he felt were more important.

6) **Teachers of science actively participate in the ongoing planning.**
If teachers are to achieve this, the teachers have to demonstrate that they:

a) **Plan and develop the school science program.**
Mr. Thomas works with AP and Pre-AP teachers in the district to develop the AP and Pre-AP Chemistry program.

b) **Participate in decisions concerning resource allocation.**
Mr. Thomas is the head of department, and as such he has final say over the allocation of resources within the science department. He does, however, receive submissions from other department heads for money.

Assessment

The standards discussed here are either quoted verbatim, or simplified for presentational purposes. Irrespective of how the standard is presented, however, the meaning of the standard is usually clear. Where a standard is not clear, they are explained before they are applied to the classroom.

Turning now to the "Assessment Standards," the standards, which are in bold, cover the following areas:

1) **Assessments and decision making must be consistent.**
If teachers are to achieve this, the teacher has to demonstrate that:

a) **Assessments are deliberately designed.**
Homework sheets have been developed over a number of years and have been demonstrated to work to Mr. Thomas's satisfaction. The structure is simply a variety of questions with space left for answers. There is no real explanation on the question sheets, with Mr. Thomas assuming students know where to look for the answers. The questions are typically previous exam questions and a variety of relevant

textbook questions. The questions relate to what is being studied in class.

The students are tested at the start of each week. These tests seem to be more likely to be written at the last minute and sometimes do not clearly tie into either homework questions or what was studied in class. This is somewhat confusing, but Mr. Thomas argues that they need to keep on top of everything that has been studied so far.

With regard to the structure that Mr. Thomas uses for his homeworks, this structure is different from the structure that teachers are expected to use in England. In England, students are reminded of the relevant information, but Mr. Thomas' behavior is not unreasonable given that these are able students.

b) Assessments have explicitly stated purposes.

Mr. Thomas states that the purpose of his assessments he is to verify if students have understood what is being taught, and to prepare the students for AP exams. Both these purposes, while limited in their scope, are realistic purposes for these classes.

c) The relationship between decisions and data is clear.

It is not clear how Mr. Thomas uses the data. He talks to the students if they raise issues related to questions in the homework, but his sense of forward momentum ensures he only spends a minimal amount of time on issues related to the data in class. He does, however, expect students to come back to see him after school if they have issues related to a homework.

Mr. Thomas chooses not to use the data to remove students from the class. Mr. Thomas keeps students in the class, irrespective of how well they do in the subject, and admits that students who elect not to continue in the subject are self motivated when it comes to leaving.

d) Assessment procedures are internally consistent.

Mr. Thomas uses the same assessment procedures for all his assessments, with the aim of finding out how much the students understand about a certain area. This has no research basis, however, and is just an assumption that if you can answer exam questions in an area, you will do well in the terminal exam.

2) Achievement and opportunity to learn must be assessed.

If teachers are to achieve this, the teacher has to demonstrate that:

a) Data must focus on the content that students need.

Because he uses exam questions, the content of homework and class questions are set are clearly related to both what the students need to learn, and how to answer questions for the terminal exam. Mr. Thomas argues that this is the main focus for the classes he teaches.

b) **Data collected focus on the most powerful indicators.**
The data that Mr. Thomas explicitly focuses on, in his mind, whether the students can answer similar exam questions at the end of the course. In his mind, this narrow indicator is the most powerful indicator his of success as a teacher. While there is an argument for this point of view, it fails to create rounded individuals at the end of the course.

c) **Attention must turn to opportunity to learn.**
In many ways, this is questionable. Mr. Thomas sets homework questions regularly, but does not use the results he receives to modify his teaching. If a number of students indicate they struggled in a certain area, he fails to re-teach it in a way that is more accessible to them.

3) **The data matches the decisions and actions taken based on it.**
If teachers are to achieve this, the teacher has to demonstrate that:

a) **The feature that is claimed to be measured is measured.**
Mr. Thomas has no other requirement of an assessment than preparing the student for the exam, and allowing both he and the student to decide if a student understood what was being taught in the classroom. Within the narrow boundaries set up for the work, it measures what it claims to measure, but only if students are interested what the results they receive in a homework tells them. Most students care about what they score in homeworks, but only in as much as whether they got a passing grade and if they

did better than their friends. There are some students who do not care all that much about how they did in their homework questions. When asked why this is, they suggest it is because there are no consequences attached to their scores.

b) **Assessments are authentic.**
The questions that Mr. Thomas draws on for his assessments come from exam papers from previous year. As such they are authentic assessments of how well students answer exam questions. This is a core goal for Mr. Thomas and is the primary criterion for his assessments. His assessments do not speak authentically to areas like connecting what is learned to "real life," however, because he does not attempt to address these other areas.

c) **Student performance is the same in similar tasks.**
It is a challenge to accurately answer this point because very little background is held on the students, making it difficult to state that a certain student will do well or badly on a certain type of homework.

Examination of Mr. Thomas's homework marks, however, suggests that those students who score highly in the initial homeworks that are set within a unit, continue to score highly, and those who do not attain high scores initially within a unit will continue to struggle.

d) **Students have adequate opportunities to achieve.**
Mr. Thomas sets homework regularly. There might be some concern that he fails to do enough to motivate those students who are not motivated in his class (for example, he does little to vary his lesson structure in a way that encourages engagement from the disenchanted), but his open sessions after school, regular testing and clear and predictable lesson structure gives students the opportunity to achieve if they are motivated to participate in class.

e) **Assessment data gives consistent decisions over time.**
Mr. Thomas uses the same, or similar, questions across a number of years to assess students at similar stages in their development. He believes that these assessments give consistent decisions over time, but has no evidence to support this belief beyond the fact that those students who do well in the AP class do well in the homeworks he sets.

4) **Assessment practices must be fair.**
If teachers are to achieve this, the teacher has to demonstrate that:

a) **Assessment tasks must be reviewed for appropriateness.**
After a number of years teaching science in general and chemistry in particular, Mr. Thomas feels that he does not need to overly review his work, that his experience and training will cover most of this issues raised with assessment. He is, however, re-trained to teach AP and Pre-AP Chemistry at regular intervals across his career. Couple

this with the regular meetings that he has with other AP Chemistry teachers in the district and it could be argued that the assessment tasks that he sets are appropriate.

b) **Large-scale assessments must be used to identify bias.**
This does not occur. Mr. Thomas assumes that any questions he selects will be without bias because they are drawn from previous exam papers. Once assessments are written, he examines them for any superficial evidence of bias, but nothing more. He does not test them to check if any subsequent evidence of bias arises.

c) **Assessments must meet student needs.**
No students have any obvious physical handicap. Mr. Thomas makes no attempt to adapt his assessments to meet student needs, with the same assessment being used for all students in all the classes he taught.

While it is possible that he does not teach students with difficulties under IDEA (the Individuals with Education Disabilities Act), it is hard to believe that all the students that he teaches will find his work equally accessible, or that none require some changes of the assessment.

d) **Assessments must be set in a variety of contexts.**
This does not occur. Mr. Thomas uses three types of assessment that test only one area. He uses exam questions in his homeworks and end-of-unit tests to assess both

student understanding of the subject matter and their exam skills and his weekly mini-test to see if the students are keeping on top of things.

Mr. Thomas makes no effort to use other ways to assess students. The students do no practical work, never make presentations or use the computer to demonstrate their understanding, and only about half the class makes an attempt to answer questions in class. The questions he asks in class are typically "closed," requiring the students to give little more than the answer to a calculation.

5) **The inferences made about student achievement must be sound.**
Examination of which students are doing well in homeworks and tests tells Mr. Thomas which students are likely to do AP Chemistry and continue on to the national AP exam, though Mr. Thomas might not state this fact quite as baldly as that. In addition, it is worth noting that he does not seem to use these assessments to target marginal students.

   a) **When making inferences, state assumptions.**
   This does not occur. It does not seem to occur to Mr. Thomas that he needs to state his assumptions. His assessments tell him who is doing well and who is doing badly. Why they might struggle can be established by further examination of the work, but any work beyond looking at which questions the students got wrong (and why) does not occur.

Course Content

The "Classroom Content Standards" cover a number of areas that are applicable to high school. Not all the standards apply to chemistry, however. One area, for example, applied pretty strongly to biology and was not taught in chemistry. In many ways, this is an unsatisfactory state of affairs, because some aspects of prior learning were not built upon and this might impede understanding of the subject. It is, however, how chemistry is taught at the high school level at Martin Van Buren.

When these standards are considered, it is important to remember that Martin Van Buren uses a didactic approach to teaching science. This is important because this thinking will color when and how the standards are taught. As in previous sections, the standards in this section are either quoted verbatim, or simplified for presentational purposes. Irrespective of how the standard is presented, however, the meaning of the standard is usually clear. Where a standard is not clear, they are explained before they are applied to the classroom.

Turning now to the assessment standards, the standards, which are in bold, cover the following areas:

1) **As a result of activities, students should develop:**

   a) **Abilities necessary to do scientific inquiry.**
   Scientific inquiry involves a number of skills that include a certain amount of basic knowledge, coupled with how to think logically, design processes that will give answers to problems (given that basic knowledge), and an ability to interpret a variety of data points (given their knowledge). This did not occur, in its entirety.

Students are given a certain amount of background knowledge, as might be expected in any course, and how to interpret this knowledge to answer questions. The students, however, miss certain skills related to scientific interpretation because they fail to do practical work.

As an example, some questions that the students answer involve descriptions of an imaginary practical. As these word problems describe the practical, they give the students data points. The students are expected to realize that certain data points work in pairs together, so that manipulating them become easier. A number of students could not visualize what was occurring in the described practical, making it harder for the student to answer the question.

b) Understanding scientific inquiry.

This is a difficult area to judge given that neither scientific inquiry nor scientific thinking is explicitly taught at Martin Van Buren.

The students are taught fairly explicitly how to answer "exam style questions." In so far as the exam questions test "scientific inquiry," the students are taught to understand it. Given that questions tend to focus more on facts, however, the students' understanding of science inquiry is limited.

2) **As a result of their activities, students should understand:**

   a) **Structure of atoms.**
   This is a core idea to AP Chemistry and while this subject was not taught during the period under observation, it was extensively covered in the Winter 2005 semester and was built upon in the classes observed.

   b) **Structure and properties of matter.**
   As with the previous subject, this area is important when teaching AP Chemistry. While this subject was not taught during the period under observation, it was extensively covered in the Winter 2005 semester and was built upon in the classes observed.

   c) **Chemical reactions.**
   A number of chemical reactions were taught during the period under observation. This gave rise to some interesting differences between the teaching of Chemistry in the US and the UK.

   The most obvious differences focus on the teaching of "dot and cross" diagrams and how ionic and covalent bonding work. In the UK these would be covered (in their simplest forms) in the British equivalent of 8^{th} Grade (and earlier with the most able students). These subjects, while taught very quickly, seemed fairly novel to the students and seemed to cause these able 11^{th} and 12^{th} Grade students a number of problems, when it came to understanding what was going on.

The most obvious similarity between the US and some of the curricula taught in the UK is the emphasis on math in chemistry. A variety of constants that describe reactions (K_{sp}, K_c and K_{eq} for example) are common to both countries.

d) Motions and forces.

This subject came as somewhat of a surprise given the fact that in the UK this subject would in large part be covered in the equivalent of AP Physics, with only minimal coverage in Chemistry (the internal atomic bonds that "hold protons and electrons in place" would be explained in some detail, but little else would be covered).

In the US, however, this is covered in some detail in AP Chemistry, and while this subject was not taught during the period under observation, it was obvious that ideas that this subject had been taught in the past.

e) Conservation of energy and increase in disorder.

In the US, as in the UK, this is a core idea to AP Chemistry and while this subject was not taught during the period under observation, the ideas mentioned here were used extensively in the classes observed, making it was obvious that ideas that this subject had been taught in the past.

f) Interactions of energy and matter.

This is taught across a variety of subjects with ideas being raised in Integrated Physics and Chemistry, Physics and Chemistry. The impact of "discreet packets of energy" (called quanta) on atoms was neither talked about nor used during the period of observation, but the Electromagnetic Spectrum and the equation that is often associated with it were used to answer questions that Mr. Thomas set, both in class and for homework.

It is possible to argue that the following 3 units, while not explicitly related to chemistry, have some "Chemical Content." They are certainly taught as chemistry classes in the UK.

3) As a result of their activities, students should understand:

a) Natural Resource and energy in the Earth system.

The idea of energy on a global scale (as in the idea of natural resources and "what energy is") is taught, at least in part, in both Integrated Physics and Chemistry (IPC) and geography. They are not taught in Pre-AP and AP Chemistry.

The scientific concept of the "Conservation of Energy" is taught as a way to think about the energy changes in chemical reactions in both Pre-AP and AP Chemistry.

b) Geochemical cycles.

Elements of this concept are taught in the IPC and geography course that the school offers. It is developed more explicitly in the geology course that the science department offers. It is not covered in either the Pre-AP or AP chemistry course that the school offers.

c) Origin and evolution of the Earth and the universe.

In much the same way that geochemical cycles are taught, elements of this concept are taught in the IPC and geography course that the school offers. It is, however, more explicitly taught than the "Geochemical Cycles" unit in the IPC course. It is not covered in either the Pre-AP or AP chemistry course that the school offers.

4) As a result of activities, students develop:

a) Abilities of technological design.

Some "technological" content is taught in the freshman Integrated Physics and Chemistry course and sophomore computer science courses, but is not taught as part of either the Pre-AP or AP Chemistry courses.

b) Understanding about science and technology.

With the focus being on what Mr. Thomas calls the "real content," the link between science and technology is not really taught in the classes that were observed.

5) **As a result of activities, all students understand:**

   a) **The environment and natural and man-made hazards.**
   Any teaching of the environment and environmental occurs in Integrated Physics and Chemistry, geography and geology and not in either Pre-AP or AP Chemistry.

   c) **Science and technology in local and global challenges.**
   "Global Challenges and Science" is taught in the same way that the environment is taught, with the content being covered by Integrated Physics and Chemistry, geography and geology and not in either Pre-AP or AP Chemistry.

6) **As a result of activities, students should understand**

   a) **Science as a human endeavor.**
   By and large, any attempt to demonstrate that science is a human endeavor occurs in Integrated Physics and Chemistry. Even here, however, this only occurs when the discovery of a scientific idea can be directly linked to the human endeavor.

   As an example, no discussion of gravity would be complete without mention of the apple falling on Newton's head and no discussion of the small pox vaccine would be complete without discussion of Jenner secretly injecting both cow pox and small pox into young children.

   Those human endeavors that are only tangentially related to the "real content" that students have to learn in science, however, are not mentioned at all in Martin Van Buren science lesson.

b) **Nature of scientific knowledge.**
This is not addressed directly, but by encouraging the students to think in a certain way, teachers hope that they encourage an understanding of the nature of science.

c) **Historical perspectives.**
When certain scientific concepts are introduced, some important scientists are talked about. For example, no discussion of gravity would be complete without mention of Newton and no discussion of radiation would be complete without Marie and Pierre Curie.

This having been said, the department tends to focus on what is necessary to pass the TAKS exam and so there is no attempt, within the science department, to frame the current position of science in terms that include any of its historical growth.

Given that Mr. Thomas is breaking so many of the rules assigned to what defines a "good science lesson," why are students selecting chemistry at all? There are a number of possible reasons for this. They are discussed in detail later in the chapter, but:

1) The students might need Pre-AP and AP Chemistry for future careers.
2) Parental expectations might push students toward Pre-AP and AP Chemistry, despite its problems.
3) It is what the students expect to see in chemistry.

4) Students with any thoughts of college at Martin Van Buren have to do some chemistry, so why not select Pre-AP and AP Chemistry?
5) Friends of a particular might encourage them to join them in a class, against their better judgment.
6) What choice do the students have? There is little evidence that other teachers meeting the "good lesson" rules, so the students are just selecting what they perceive as the lesser of a number of evils.

Summary

Martin Van Buren High School breaks either the spirit or the letter of the law when it comes to the "National Science Standards." In many ways they cannot be blamed for this, however, do to the growth of "high stakes testing" and the importance attached to the passing of exams.

The emphasis on students learning as much material as possible to do well in terminal exams forces many teachers into a didactic teaching style where they do what they feel is necessary to get the students to pass an exam. In Martin Van Buren, however, students are not helped by an experienced member of staff who might be less well aware (than some of his younger colleagues) of modern teaching techniques that produce greater levels of student involvement.

There are a number of reasons why students might persist with chemistry in the face of some poor teaching that breaks the rules for good teaching. These reasons are examined in the remainder of this chapter.

Alternative Reasons for AP Chemistry Selection

Given that the structure of the class apparently does not encourage students to select AP Chemistry, is there another discernable factor (or combination of factors) that could have encouraged the students to select AP Chemistry? Perhaps more important are the questions: "If factors that encourage students to do AP Chemistry are discernable, what are they? What should schools do?"

Given the data that are available, the factors that encourage students to study AP Chemistry must come from either the teachers or the students. Consequently, the results from the surveys and questionnaires that were undertaken by these groups will be examined for evidence of factors that could encourage students to take AP Chemistry.

Teacher Focused Factors

As was indicated at the start of this chapter, it seems unlikely that the structure of the science lesson is the reason why students are selecting AP Chemistry at Martin Van Buren. This does not, however, mean that other teacher behaviors fail to contribute to the students selecting this subject.

Examination of the results generated by the Comprehensive Assessment of the School Environment (or CASE) surveys gave the following interesting results:

	Percentile Rank
Opportunities for Advancement	78%
Co-Workers	67%
Behavior Values	43.5%
Parents & Community	43%
Teacher Student Relations	42%
Student Activities	42%
Academic Orientation	38%
Student Relationships	37.5%
Student Responsibility and Discipline	37%
Community	35.5%

The percentile rank system presented in these results should not be viewed as a raw score, but as a measure of how the teachers feel the school compares to other schools. When it came to "Opportunities for Advancement," for example, teachers ranked the school higher than 77% of other teachers, when asked about the schools in which they taught. When the teachers rank the "Community," however, they only ranked it higher than 35% of teachers, at other schools.

These results confirm the observation that the teachers do genuinely seem to enjoy each other's company. They also reinforce the observation that the teachers feel the Head of Department supports them when they have a problem with a student. Throughout the observation, teachers indicated he would support them *if they come to him first*.

Extrapolating from these results to make suggestions for the future, it is possible to believe that if teachers who are particularly good at encouraging student persistence were to start at the school, he (or she) would feel happy there and gain promotion, which would make them more inclined to stay.

The more worrisome aspect of the results is the negative attitude that teachers have towards the students, the parents and the community as a whole. The teachers ranked none of these areas higher than the 44th percentile and important areas like discipline and academic orientation were seen as particularly negative.

While the sample is not large enough and the questions not precise enough to draw any detailed conclusions from these results, it would suggest that teacher expectations of future student success is not the reason why students persist in chemistry.

Student-Focused Factors

If this investigation accepted the most basic (and commonly stated) reasons why students selected AP Chemistry, the investigation would end here. The students see AP Chemistry as a continuation of Pre-AP Chemistry and as something that will help them when they start college (i.e. it will either help with their degree or allow them to avoid a college course). No matter how the question was framed, this was the response the students gave.

This, however, does not explain how the students started on a path that leads them to AP Chemistry in the first place. Only two students had a career path in mind that meant they *had to* select Pre-AP Chemistry (and so to travel down the path that leads them to AP Chemistry). The remainder positively selected this route in the face of other alternatives. Why was this when the students had other options?

The linearity of student thinking might explain why students continue with AP Chemistry. Having done Pre-AP Chemistry, the AP course is a logical next step. This, however, fails to explain why students select AP Chemistry, given that they have done a variety of Pre-AP subjects and yet still selected AP Chemistry ahead of other AP classes.

The fact that other AP classes were blocked against AP Chemistry and yet students still opted for chemistry can be used to counter the idea that students wanted to avoid chemistry at college. Future class avoidance might be a factor when students select classes, but fails to explain why students positively choose chemistry. Other AP classes would reduce your college requirements, so why take AP Chemistry?

Why Students Actively Choose Chemistry

Given that ideas of future class avoidance and linearity of student thinking are too simplistic, why do students actively select AP Chemistry? Examination of the results that were generated from the CASE and Classroom Environment Surveys (or CES) should indicate if there are any deeper reasons why students selected AP Chemistry.

Examination of the results generated by the Comprehensive Assessment of the School Environment (or CASE) surveys failed to give any interesting results:

	AP Chemistry (Percentile Rank)	**Pre-AP Chemistry** (Percentile Rank)
Schoolwork	55.5%	51.5%
Decision Making Opportunities	54%	52%
Teachers	53%	55%
Communications	53%	49.5%
Teacher Student Relations	51%	50.5%
Student Activities	51%	50%
Activities	51%	49%
Academic Orientation	51%	42%
Administration	49.5%	46.5%
Behavior Values	49%	46%
Students	48.5%	47.5%
Buildings	47.5%	47.5%
Instruction	45.5%	44%
Community	45.5%	38%
Relationships	44.5%	44%
Guidance	44%	46%
Discipline	44%	43.5%
Security	44%	40%

Like the teacher results in the previous section, the percentile rank system presented in these results should not be viewed as a raw score, but as a measure of how students feel their school compares to other schools. When it came to “Schoolwork,” for example, students ranked the school higher than 51% of their fellow students in other schools. When the students ranked “Community” (with all students at the school, and not just people in their class), they only ranked it higher than 37% of students at other schools.

These results have the ring of truth. The students have a positive attitude towards work, teachers and student activities. These are the sort of behaviors you would expect from able students, with few (if any) behavior issues.

Further examination of these results would suggest that there is nothing on a school-wide level that encourages students to study AP Chemistry. This is not surprising, given that the students who responded to this survey are normal students who attend a standard urban high school. There is no obvious school-wide reason why standard urban high schools would do anything on a school-wide level to guide students toward Chemistry. It is possible, however, to rule out guidance as a driving factor in encouraging students to take AP Chemistry. Both classes rated guidance lower than the 50th percentile.

It is more likely that something in the Pre-AP and AP class encourages students to persist in chemistry. The interesting CES results for the AP and Pre-AP classes are:

AP Classroom

	Classrooms In General (Percentile Rank)	**Science Classrooms** Score (std. dev. from exptd.)
Involvement in Class	58%	6.68 (0.50)
Affiliation with Students	64%	8.67 (1.56)
Teacher Support	53%	7.09 (0.28)
Task Orientation	62%	8.23 (1.62)
Competition in Class	58%	6.41 (0.57)
Order and Organization	50%	5.86 (-0.03)
Rule Clarity	50%	5.91 (-0.71)
Teacher Control	51%	3.95 (-0.33)
Innovation	49%	4.86 (-0.06)

Pre-AP Classroom

	Classrooms In General	**Science Classrooms** Score (std. dev. from exptd.)
Involvement in Class	57%	6.48 (0.38)
Affiliation with Students	67%	8.68 (1.60)
Teacher Support	47%	6.26 (-0.21)
Task Orientation	58%	7.66 (1.16)
Competition in Class	64%	7.18 (1.38)
Order and Organization	48%	5.56 (-0.21)
Rule Clarity	52%	6.26 (-0.43)
Teacher Control	50%	3.88 (-0.39)
Innovation	44%	3.80 (-0.73)

The percentile rank system presented in these results works in exactly the same way as it works in the previous sections. When it came to "Affiliation with Students," for example, teachers ranked the school higher than at least 63% of their colleagues in other schools.

When the teachers rank the classroom's innovation, they only ranked it higher than, at most, 46% of the colleagues would rank their schools.

When compared to other classrooms, many of the areas listed in the survey do not look all that significant. It also suggests that many of the actions that the teacher consciously takes in class (like teacher support, teacher control, order, organization, rule clarity and innovation) fail to influence the students to select Pre-AP Chemistry. This is suggested because, at best, they rank the teacher in the 52nd percentile in those areas (and even more poorly when compared to other science classes).

The results do, however, indicate some surprising differences between what a typical high school student and a foreign born teacher might expect to find in the classroom (General Teaching Council, England, 2004). As was indicated at the start of this chapter, the classroom was a mess. In the UK, this would generally be regarded as unacceptable. The section of this survey entitled "Order and Organization" includes questions about the state of the classroom and while the general state of the classroom is not the entire thrust of this section, it clearly was not sufficiently significant in the students' minds to induce them to take a negative view of this area.

The other area that generated some surprise when these results were examined was "Involvement in Class." This was placed in the 57th percentile by the students, much higher than might have been expected, given that as many as two-thirds of the classes have been observed, on occasions, not doing chemistry. These results might be skewed, however, because while many of the "active third" of the classes rated the class 9 and 10 (out of 10), the distribution was very flat, with 9 of the 75 students surveyed ranking the class a 0, 1 or 2.

In addition, it is worth pointing out that the 57th percentile is not necessarily a good place to be. In this instance, while the student ranking of involvement might be considered to be high, when it is compared to what was observed in the classroom, it simply implies that students are used to a very passive style of teaching. Were the students exposed to a more active style of learning, they might learn more or pick ideas up more quickly and enjoy learning more. This passivity might, or might not, be a good thing, but the general passivity of American lessons cannot be over-emphasized, given the high ranking of this passive lesson.

On a more positive note, however, these results confirm what students say when they indicate that there is an emphasis on the task at hand and that they are expected to complete their tasks. It is possible to argue, however, that there appears to be more "task orientation" in the Pre-AP classes than the AP classes (though it could be argued that some students elect to "switch off" in the AP class).

Perhaps the most significant indicator that was generated across both the Pre-AP and AP classrooms was the affiliation the students felt with one another. This affiliation was magnified when it was compared to other science classes, with these classes being between 1.56 and 1.6 standard deviations from the mean.

In addition to this interesting "affiliation result," it is worth pointing out some interesting differences between the Pre-AP and AP classes:

	Number of std. dev. between AP and Pre-AP grps.
Task Orientation	-0.82*
Teacher Support	0.49**
Innovation	0.66**

*There was felt to be more focus on the task at hand in the Pre-AP group.
** These factors favored the AP group.

No students cited “affinity with other students” as a deciding reason for selecting Pre-AP or AP Chemistry, but it is possible that this factor was an element in their original selection of the subject. If this affinity was combined with feeling an element of support from the teacher, a certain attitude to the amount of competition there in the class, and a willingness believe the level of innovation was acceptable (it was not high for either group), then it is possible to define what sort of behaviors might be expected from someone who is interested enough to persist with chemistry beyond the Pre-AP level.

The Importance of Affiliation

The idea of affiliation and having friends who think as you do is important because there is some international evidence to suggest that this factor ranks third behind parental influence and enjoyment of the subject as a factor that students use when they select chemistry (Papanastasiou & Zembylas, 2002).

Affiliation, and the importance of friends in decision making, is an important concept, when major corporations consider how to manage their products. When the marketing department of any major corporation is presented with a product that it has to sell, it starts by considering three areas:

1) Product.
2) Brand and Brand Equity.
3) Customers.

The Product

At its most basic, the product is the asset that is being sold by the vendor. It can be a tangible (cars, white goods, industrial cleaners or houses, for example) or a service, which is less tangible (like financial advice or classroom subjects).

When deciding customers are asked to assess the quality of the product, they look at the following areas:

1) What the product does. Does it meet the customers' need?
2) The attributes of the product. Do the associated perceptions of the product speak to the customer (for example, Volvos are perceived as safe)?
3) Is the product a quality product? Does the product give value for money?
4) Do additional attributes meet the customers' needs (4-wheel drive vehicles are still cars, after all, but they have characteristics other cars do not possess)?

These are not the only factors on which customers base their decision. Customers often buy on emotion and instinct as well as good judgment (they deliberately elect to buy American, for example, even if quality might be an issue). Those side issues, however, are just as valid as the core issues that the customer has with the actual product and have to be addressed by those that market the product (they might want to emphasize, for example, that the name on the car is foreign, but it is manufactured locally, a practice that is common in the UK – both Ford and Nissan are called "local manufacturers" there).

Any decision that a company makes about how a brand is perceived has nothing to do with the product, but everything to do with the brand and "brand equity." These ideas are examined in the next section.

The Brand

Put simply, a brand is a strategic asset that has to be managed (Aaker, 1994). Chemistry, like any other subject, is a product offered by schools. The students know it comes in 4 varieties, 3 of which they can access immediately. And, like any other product, chemistry has equity invested in it by both consumers and producers. It is this equity that has been invested in chemistry that differentiates the product from the brand.

"Brand Equity" is a set of assets, liabilities and symbols that are linked to a product (or service). They either add to, or subtract from, the value assigned to a product by customers (Aaker, 1996). These assets, liabilities and symbols are found in four main areas related to the product:

1) Brand Name Awareness
2) Brand Loyalty
3) Perceived Quality
4) Brand Associations

Brand Awareness

At its simplest, brand awareness assesses two things:

1) **Name recognition**
   When presented with a brand name, the consumer should be able say what the brand is related to. For example, when presented with the name Ford, people should say that they sell cars.

2) **Ability to recall a brand's name and associations**
   This is the reverse of the first section. When presented with a sales market (cars for example), marketers are interested in how quickly you remember the brand they are marketing along with the brand's associations.

   Names, when applied appropriately, improve quality. Evidence suggests, for example, that in blind tastings, the application of a reputable name to peanut butter improves the taste of the food (Aaker, 1996).

Perceived Quality

Perceived quality is a key factor when people make decisions. All other things being equal, people chose the items to which they assign more quality. This is an idea that could be important when it comes to high school subject selection. Given the choice of two seemingly similar classes, students will probably select the one to which they assign more quality. Affiliation with the subject and fellow students, a relationship with the teacher, and perceived understanding of the task orientation in the class are all factors that students could weigh when they assign quality to the subject that they plan to take.

It is, however, important to remember certain things about the perception of quality within a product. These are:

1) Just because something is perceived as a quality product, does not mean that it has actual quality.
2) Once a brand is perceived negatively, it is harder to promote the brand, even if the problems with the brand have been resolved.
3) When attempting to improve perceptions of a brand, listen to the consumers to find out what they want, rather than attempting to change the things you think they want changed.
4) Once habits have been developed, vendors need to motivate people to change, by demonstrating why it is a good idea to buy their brand.

Brand Loyalty

When it comes to making purchases or investments (of either time or money), customers have a choice. They could buy your product or they could buy a similar product from a competitor. Brand loyalty is a spectrum of decision making explanations that help producers understand why customers make the decisions they do.

Customers can be broken down into 5 broad categories:

1) **Non-Customers**
These potential customers buy a competitor's product or service. This is one way of thinking about some of the students at school. It is unlikely, however, that they will be encouraged to sign up for AP Chemistry in the short term, if they avoid taking any chemistry in school at the moment.

2) **Price Sensitive**
For these customers, price is the deciding factor. It would be wrong to assume, however, that price is the only factor. As an example, Wal-Mart is renowned for offering low prices, but still only manages to get 30% of the customers in the sectors they inhabit. In other words, 70% of customers are selecting a product (sometimes the exact same product) based on other, non-price related factors, despite the fact they know they are paying more for it (Fishman, 2006).

3) **Fence Sitters**
This is another group that could be applied to the students at school. These customers could move one way or another. This group contains customers who are typically are given incentives to select one brand over another (though non-customers and the price sensitive take advantage of these offers too).

4) **Passively Loyal**
This group could describe many of the students in Pre-AP Chemistry (and AP Chemistry for that matter). They turn up and they do what is asked of

them. They might have complaints, but fail to act on them very often. Vendors have difficult recalling facts, either negative or positive about these customers.

These customers are often taken for granted, with producers not really making an effort to find out what they really want. Were producers to do this, they might become more actively loyal.

5) **Committed**

These customers are actively engaged in their product. Much of the profit that a company makes on a product comes from these customers. This however, does not mean the company should sit on its laurels with respect to these customers. It should be possible to improve their loyalty if they are asked what they want and need. The most actively involved actually advocate for the product, becoming "brand champions."

It is also worth nothing, however, that if too many benefits are given to those customers who switch brands regularly, the commitment of the most committed will be reduced because they will feel underserved.

Brand Associations

When a customer hears the name of a product, they do not just think of the product. They think of ideas related to that product. Those ideas are "Brand Associations." They include symbols (the Ford blue oval for example), slogans (Coke is it!), characters (the GEICO talking lizard), tunes (the signature tunes TV shows), and spokesmen (news anchors).

These brand associations are not just created by the company, however. Customers apply their life experiences to products, creating associations that the producer does not expect. Consequently, there needs to be a constant dialogue between customers and the company to ensure that the company is seeing the product in the same way as the customers (and so market it in a way that maximizes the product's potential for the firm).

Factors that Inhibit Effective Branding

Branding and brand equity might seem simple. So simple, in fact that it might beggar the question: "Why has branding not been used already?" The answer is simple. There are a number of problems that are associated with branding (Aaker, 1996). These are:

1) **Price pressures are a problem.**
Developing a new brand (and rejuvenating bad brands) cost money. That money has to come from the consumer, which they might not appreciate.

2) **Fear of cannibalization.**
Cannibalization occurs when customers switch among products produced by the firm. Gains in chemistry mean that other subjects lose students, which might not be popular.

3) **The proliferation of competitors.**
Customers do not have to buy any particular product and as a market grows, so does the number of alternatives customers have. In this case, the customers (the students) have a number of alternatives when it comes to the subjects that they can take.

4) **Fragmented markets and media outlets.**
Customers do not just learn about a product from one area. The variety of places that students learn about science means that the brand has to be promoted in a variety of channels.

5) **The complexity of the customers.**
The brand takes time to develop if it is to really meet the customers' needs. This pressure acts against pressures from other areas, which often request a manager's time and money.

6) **The urge for quick results.**
Changes in people's perceptions do not occur overnight, but producers often want an immediate demonstration of some success (why should they pour good money after bad). This is often tied into short term thinking when it comes to investment decisions.

7) **Producers have a bias against innovation.**
Many people are suspicious of change, especially if the change is big.

8) **Teachers might be suspicious of business ideas.**
Often there is a mental division between the private and public sector and ideas that are common in one might be treated with suspicion in the other.

Should any attempt at branding occur, these factors will have to be considered by anyone who develops the marketing plan for the "New Chemistry."

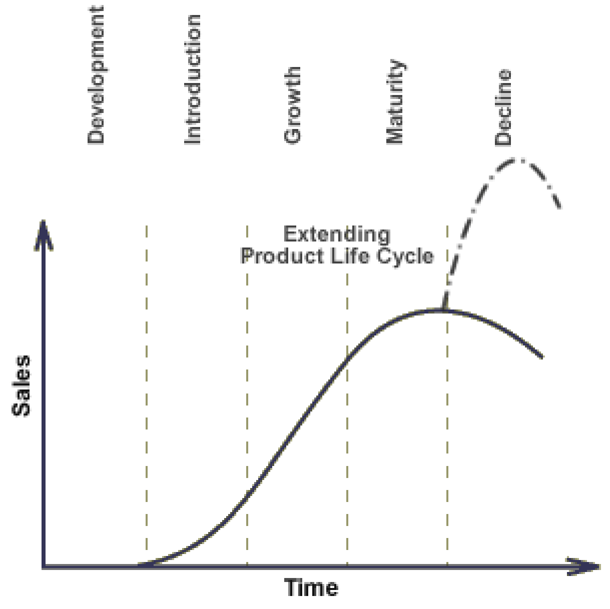
The Customers

This thinking about the product, branding, and brand equity, is done with the customers in mind, because, without customers, a product is just a good idea. What, however, does this talk of branding and customers have to do with high school chemistry?

A brand has positive, customer-based brand equity if a consumer reacts more favorably to the price, promotion or distribution of the brand than they do to a different product with the same marketing mix (Keller, 1993). This is what is wanted if the number of students in Pre-AP and AP Chemistry is to grow.

At present, Pre-AP and AP Chemistry draws from 4 groups at Martin Van Buren: "Band and Orchestra" students, Asian students, Student Council students and Tennis players. These groups account for almost all students in the classes. In theory, however, if chemistry was branded correctly, these classes would draw from other student groups.

For students, the life cycles of AP and Pre-AP Chemistry looks a little like this:



(Mack, 2006)

The development of “New Chemistry” would start with a development phase, during which time the branded chemistry is developed. As it is introduced, students (often called “Innovators”) from differing groups are encouraged to take the subject, with the result that the numbers taking the subject grow rapidly. This rapid increase in growth cannot be maintained indefinitely, but should reach a steadier level of growth (those that elect to opt into the subject at this stage are called “Early Adopters”) for a period of time before leveling off. This leveling off is called the “Mature Phase” and any who join at this stage are often called the “Early Majority” or “Late Majority,” depending how early in that section they elect to study chemistry. With time, however, numbers fall (as the subject becomes old hat), and anyone electing opting into the area at that stage is a “Laggard.”

It is during either the growth or mature phase that changes to the “Upper Level Chemistry” brand must occur. This change occurs because, with time, customers change and unless the brand changes with them, the sales will eventually fall. The current state of chemistry in high schools could be viewed as a good example of this sales deterioration.

The current “Upper Level” Chemistry brand might well have been attractive 10 or 20 years ago, but with fewer than 1 in 20 students electing to take these courses now, it fails to be attractive to people now.

Branding, therefore, becomes an issue of trust. How are “Innovators” encouraged to trust their teachers enough to select upper level science? One part is how science is branding. If a subject is branded correctly, students are more likely to believe in their abilities and select that subject. The other part is the relationship with the teacher (which, clearly has to begin before the students select the subject if the linearity of student thinking is to be used effectively). In any school it is the teacher who reaches out to students and encourages them to select a subject, so a part of the initial selection has to be a belief in promises made by the teacher.

This is an idea that gains some support from the results that were obtained in the investigation. While affiliation was clearly the most significant driver when it came to class selection, the sizeable difference between Pre-AP and AP Chemistry class when it came to their relationship with the teacher might lead some to conclude that it, too, was an important factor when it came to class selection.

Students' trust in their own abilities and their relationship with a teacher comes from a number of areas. It starts with teachers, students and the institution believing that the other groups in the relationship have the ability and intention to trust each other in the longer term. From this trust grows a willingness to demonstrate their shared values, which is followed by an ability to communicate freely and both groups acting in ways that demonstrates they trust one another (Papadopoulou, Kanellis & Martakos, 2001).

At its simplest, this trust relationship results in promises being made by (and to) the teacher (because both the teacher and student intend to keep the promise). During the process of keeping the promise, the teacher and student exhibit behaviors that encourage both sides to keep their promises. So when the promise is fulfilled, both sides are more likely to work with each other in future (Papadopoulou, Kanellis & Martakos D, 2001).

It is, therefore, possible to say that a combination of national, regional and local branding, coupled with local trust between the student and teacher are important when it comes to subject selection.

Examples of a Trust Relationship in Schools

At Martin Van Buren the Pre-AP and AP classes were taught with a specific contract in mind. While no one explicitly stated that "It means no practical work, but if you work, you should be able to do the AP Chemistry exam at the end of the course," that was the underlying culture of the class.

The advantage of dropping the practical requirements in upper tier chemistry is that it allows you to spend more time focusing on the core areas of the curriculum that will be covered by the examining board. It might result in a more tedious lesson for the students, but if success in the final exam is your overarching goal, some might feel that is a price worth paying.

Private schools, unlike their state sponsored counterparts, rely on their reputation. Though they might not say it explicitly, they are being paid to develop a certain type of student. As part of that relationship, a student who graduates a private high school is expected to attain a certain level of academic achievement in subjects, like chemistry.

Given that the parents of students at private school are more likely to want academic excellence from their children as part of their child's experience, it could be argued that classes in private school are more likely to be didactic than their public school counterparts. This raises the question as to whether or not this really the case.

While private schools have to emphasize academic excellence in their efforts to attract students, this cannot be the only factor that matters when it comes to educating their students. It could be argued that the school is expected to produce a "certain sort of student" after 4 years of private high schooling. The students that are produced in such a manner are expected to be more than just academically able.

Given the differing expectations of a private high school, the question therefore becomes; does the structure of an upper level chemistry lessons look any different at private schools? To answer this question, Leafy Hollows School was approached. They were asked if it would be possible to observe a small number of Pre-AP and AP chemistry lessons, to see if a private school emphasizes academic success above all else, or if they focus more on a rounded view of the individual.

Leafy Hollows School

Leafy Hollows School is a small K-12 private school based in Western Independent School District (ISD). Across all 13 grades, there are approximately 1120 students, with about 100 students attending the school in each of the four high school grades. It has a sister school in Central ISD called Leafy Grove School and both schools teach a similar ethnic and demographic group of students.

Leafy Hollows has two chemistry teachers. One teaches approximately 70 sophomores and juniors "Regular Chemistry," while the head of department teaches 45 sophomores Pre-AP Chemistry and 15 juniors AP Chemistry in 2 chemistry labs that are similarly equipped to the labs at Martin Van Buren.

Seven classes were observed at Leafy Hollows over a period of two weeks at the school. Of those seven classes, six were Pre-AP Chemistry, one was an AP class. The most obvious difference between these classes and those observed at Martin Van Buren were the ethnic and gender break down of the classes.

	Pre-AP Groups	**AP Group**
Percentage Caucasian (Comparative Van Buren Figure)	90% (15.51%)	93.3% (22.73%)
Percentage Hispanic (Comparative Van Buren Figure)	2% (44.8%)	6.7% (31.82%)
Percentage African-American (Comparative Van Buren Figure)	2% (17.24%)	0% (4.55%)
Percentage Other (Comparative Van Buren Figure)	2% (25.51%)	0% (40.9%)
Percentage Male (Comparative Van Buren Figure)	53.3% (47.27%)	80% (40.91)

While the most differences between the two schools might have been the ethnic and gender balance of the classes, there were a number of other differences that were observed as the classes progressed. These included:

1) All but one of the students were engaged in activities relevant to the class *at all times*.

2) Students were obviously thinking about the *implications* of what they were taught rather than learning materials for exams.

3) A wide number of students were called on to give answers to questions and volunteered answers.

4) A wider variety of activities were employed, from lab time and demonstrations to the internet, project time and relevant discussions.

These observations, however, are not necessarily the evidence of effective teaching that is required of this work, however; so the "National Standards" (NRE, 2004) that were applied to Martin Van Buren were applied to the classes that were observed.

Classroom Teaching Standards

In this section, the National Standards that the NRC generated in a number of areas will be applied to Dr. Jones' classroom management at Leafy Hollow (NRC, 2004). As happened in the earlier sections, the "National Standard" is either quoted verbatim, or simplified to make presentation clearer. It is worth pointing out that because the time spent at Leafy Hollow was limited, not all the standards could be assessed. Those that were not assessed were left out. Dr. Jones assured the investigator they get addressed, but they are not mentioned unless there are confirmatory observations from the inspector.

Turning to the "Classroom Standards", the standards, which are in bold, cover the following areas:

1) **Teachers of science plan inquiry-based science programs for their students.**
   If teachers are to achieve this, the teachers have to demonstrate that they:

   a) **Develop a framework of year-long and short-term goals.**
      Here Dr. Jones has a two strand approach: he focuses on end of unit and end of semester exams that tie into a final exam that the students take, but he also gives the students a number of projects that they have to complete. These projects are more relevant to the real world and give the student another set of short, intermediate and long term goals to work to.

b) **Adapt curricula to the needs of the students.**
There is very little evidence that this occurred within these classes with the same subject matter being taught in the same way across multiple Pre-AP classes.

c) **Select strategies that support student understanding.**
Dr. Jones uses a variety of different approaches to learning material; he does lab work and demonstrations, uses research projects, the internet and magazines as sources, and challenges his students to learn in a variety of different ways. This is in marked contrast to the didactic approach observed at Martin Van Buren.

g) **Work with colleagues across disciplines and grades.**
When a student changes class (either because they have been promoted to another year or because they change classes within the year), the teacher who gains the student is given data about how the student performed and what was covered by the teacher who taught the student previously. In addition, because this is a K-through-12 school, the better communication that this gives ensures the teachers have a better knowledge of what is specifically taught in middle school.

2) **Teachers of science guide and facilitate learning.**
If teachers are to achieve this, the teachers have to demonstrate that they:

a) **Focus and support inquiries.**
There was evidence that the students were thinking about relevant side issues during every class that was observed.

This was encouraged by Dr. Jones, who involved the observer in these discussions when a student asked what happened in other countries.

b) **Orchestrate discourse among students.**
During practical and research activities, the students were encouraged to speculate why the things that they observed had occurred.

c) **Challenge students to accept responsibility.**
During practical and research activities, Dr. Jones would pass through the class and discuss with the students what they were doing *and why they were doing it*.

d) **Encourage students to participate fully in science.**
Most students asked questions in class. The questions they asked showed they were thinking about what was being taught. Those students that did not ask questions were asked questions by Dr. Jones to see if they were following.

h) **Encourage and model the skills of scientific inquiry.**
Given the number of classes observed, this was hard to assess, but Dr. Jones encouraged the students to understand for themselves why things occurred, and to ask questions when they did not understand what they were taught.

3) **Engage in ongoing assessment of their teaching and of student learning.**
If teachers are to achieve this, the teachers have to demonstrate that they:

a) **Use multiple methods to assess students.**
Dr. Jones uses regular testing, homeworks, projects and questioning to assess the students' progress.

4) **Design the learning environments to meet the students' needs.**
If teachers are to achieve this, the teachers have to demonstrate that they:

a) **Ensure students engage in extended investigations.**
The students do practical work on a regular basis and do three extended projects each semester (these projects tie into what they are being taught in class at the time). This is in contrast to the Martin Van Buren, where no extended investigations occurred.

b) **Create a setting that is flexible and supportive.**
Dr. Jones used a variety of different approaches to teaching (suggesting flexibility). Students would come by his class at breaks and lunch, suggesting a supportive atmosphere in the classroom.

c) **Ensure a safe working environment.**
Dr. Jones is an experienced teacher. As a matter of course, the classroom was safe, even during practical activities.

d) **Make materials accessible to students.**
During the period under observation, the students used the internet, libraries, magazines and newspapers as sources that supported their learning.

e) **Identify and use resources outside the school.**
The students used the internet, libraries, magazines and newspapers as sources that supported their learning for their project work.

f) **Engage students in designing the learning environment.**
Some student work was displayed in the classroom, but this was not as widespread as was observed in the lower school and biology classrooms.

5) **Teachers of science develop communities of science learners.**
If teachers are to achieve this, the teachers have to demonstrate that they:

a) **Display respect for the experiences of all students.**
Dr. Jones appeared interested in what the students contributed to discussion, asking questions like "Why?" or "How did you decide that?" when they contribute.

b) **Nurture collaboration among students.**
This occurred during practical and project activities. The students were expected to work in groups to come up with solutions to problems. When Dr. Jones suspected a group was not working effectively together, he was prepared to break groups up.

c) **Structure ongoing formal and informal discussion.**
Each observed class had 10 minutes of discussion. Five minutes of this saw the students discuss their ideas, and the remainder saw Dr. Jones ask for opinions from the groups.

Assessment

The approach used here is the same as the approach used in previous sections. The standard is either quoted verbatim, or simplified for presentational purposes. It is important to reiterate, however, that because the time spent at Leafy Hollow was limited, not all the standards could be assessed. Those that were not assessed were left out. Dr.

Jones assured the investigator they get addressed, but they are not mentioned here unless there are confirmatory observations from the inspector.

Turning now to the "Assessment Standards," the standards, which are in bold, cover the following areas:

1) **Assessments and decision making must be consistent.**
   If teachers are to achieve this, the teacher has to demonstrate that:

   a) **Assessments are deliberately designed.**
      Homework sheets, lab write ups and projects have been developed over a number of years and have been demonstrated to work to Dr. Jones' satisfaction. A variety of structures are used, depending on what Dr. Jones wants to achieve with the assessment. When he wants to be sure the students know what was covered, the questionnaires are very fact spare. When he wants the students to explain or apply knowledge, he fills the questionnaires with more information.

   b) **Assessments have explicitly stated purposes.**
      Dr. Jones would introduce practical activities and projects by giving "broad brush" instructions about what was expected of the students. His plan is to fill in gaps as the students do the work themselves.

2) **Achievement and opportunity to learn must be assessed.**
   If teachers are to achieve this, the teacher has to demonstrate that:

   a) **Attention must turn to opportunity to learn.**
      Through his use of a variety of learning tools, students were given a variety of opportunities to learn.

3) **The data matches the decisions and actions taken based on it.**
   If teachers are to achieve this, the teacher has to demonstrate that:

   a) **Students have adequate opportunities to achieve.**
      Dr. Jones sets a variety of different tasks for the students. All these allow him to assess the progress of the students. The classes were not observed for long enough to make a definitive statement about this area, but on the balance of probabilities, this area is probably addressed.

4) **Assessment practices must be fair.**
   If teachers are to achieve this, the teacher has to demonstrate that:

   a) **Assessments must be set in a variety of contexts.**
      Dr. Jones sets a variety of different tasks for the students. They are aimed at one of three things. They either prepare students for exams, tweak students' interest, or broaden the mind of the individual by making the individual learn about something novel and new. While this is not very broad, it is an improvement on what was observed at Martin Van Buren.

Course Content

Like the previous sections the standards here are either quoted verbatim or simplified for presentational purposes. It is important to stress here, however, that because the time spent at Leafy Hollow was limited, not all the standards could be assessed. Those that were not assessed we left out. Dr. Jones assured the investigator they get addressed, but they are not mentioned unless there were confirmatory observations from the inspector.

Turning now to the "Course Content" standards, the standards, which are in bold, cover the following areas:

1) **As a result of activities, students should develop:**

   a) **Abilities necessary to do scientific inquiry.**
   It is fair to say that students do a number of activities that encourage them to think through an issue for themselves.

   In addition, it is worth noting that the way that Dr. Jones sets up lab work (which requires students to design experiments that answer questions he pose) encourages students to develop the skills needed to perform science inquiries.

   b) **Understanding scientific inquiry.**
   This area was not explicitly taught during the period that the classes were observed, but the way in which Dr. Jones sets up practical investigations suggests that students might have an unwritten understanding of scientific inquiry.

2) **As a result of their activities, students should understand:**

   a) **Structure of atoms.**
   This idea is core to the teaching of AP Chemistry. While it was not taught during the period under observation, several classes suggest that it had clearly been covered in the past.

   b) **Structure and properties of matter.**
   This too is important to AP Chemistry. While this subject was not taught during the period under observation, several classes suggest that it had clearly been covered in the past.

c) **Chemical reactions.**
This is key to AP Chemistry. While this subject was not taught during the period under observation, the way Dr. Jones taught suggested that it had been covered in the past.

Summary

While the investigation into Leafy Hollow School is not as extensive as what occurred at Martin Van Buren, those areas that were observed suggest that Dr. Jones is making more of an effort to meet the "National Standards" produced by the National Research Council (NRC, 2004).

This having been said, it is interesting that like Martin Van Buren, only a third of all students who start the Pre-AP Chemistry class continue on to the AP Chemistry class (though, by observation, it is fair to say the two groups of AP student are still very different). This suggests that meeting standards and the use of a particular teaching style are not the only factors that influence students when it comes to students selecting which AP class they take.

Suggestions for Future Research

It makes no sense to reconsider the way a school subject is taught, based on the content of one school. No one school will ever be sufficiently typical for the ideas generated in this research to become generalizable to more than a small fraction of the schools that exist in the US.

If the idea of branding school subjects is to become more than a simple idea, other students, in other schools, will need to be assessed to verify that "classroom affiliation" is a significant factor in their selection of school subjects. Consequently, research must, at least initially, focus on "classroom affiliation."

Once research has been completed on the idea of affiliation being tied into subject selection in high school, the next step would be how to brand classroom subjects. Different countries and cultures have different views on how a particular subject is defined in their mind. These perceptions might be the reason why they are not studying chemistry. Therefore, research would need to be undertaken into how students currently frame chemistry in their minds and how it could be framed differently in future so that more students are encouraged to study chemistry.

In addition, it is important to point out that branding chemistry probably needs a long term national study which cannot be completed quickly if it is to be done well. If America is to maintain a competitive advantage in the short term, it needs immediately to produce more students who are qualified in science. Research certainly needs to be undertaken in how to reach out to groups of students who are in the class now, so that they are encouraged to study more science.

Implications for the Future

This idea of branding in chemistry has implications for the future in four different areas:

1) With Teachers
2) Within Schools.
3) Within the Curriculum.
4) Across the Country.

With Teachers

The idea of branding will be a challenge to many teachers. Teachers often have a fixed point of view when it comes to teaching science and changing the focus of how teachers approach the subject will be difficult (McComas, Clough, & Almazroa, 1998). This will be especially hard given that teachers often have fixed views about how the teaching of science should proceed (Brickhouse, 1989, Tobin & McRobbie, 1997, McComas, Clough, & Almazroa, 1998), and what is recommended here is a sea change in how teachers are encouraged to think about science.

The change in teacher thinking from one where the teacher almost expects certain types of student to study the course, to one where the teacher remolds how the subject is presented to target different groups means that teachers need to be retrained to think differently about their classes. Facilitating this will cost both time and money for those that are managing the change. The financial costs will be both direct (in as much as the trainer, support materials and the hiring of rooms for the training cost money) and indirect (taking the teacher off time table would require that a substitute be found to cover classes for example). These costs can be reduced if one or two teachers who are taken off timetable are used to train their colleagues, but there will be a considerable cost basis all the same.

It is also worth pointing out that this retraining cost might not fall with time. The ability to brand an idea evolves with time and will probably be mimicked by other subjects as they try to compete with chemistry. Consequently, teachers (even newly qualified teachers who are trained to brand during their training) will have to receive refresher courses so that they can maintain their competitive edge over other subjects.

In addition to these financial constrains that might impact teachers, it is important to consider the "political impacts" of changing how teachers think about teaching. This does not necessarily just apply to unions and professional bodies that, it could be said, have the potential to disrupt the introduction of branding. The bigger concern could lie directly with the employees. When employees join an organization, they form an implicit psychological contract with the organization. This contract consists of the mutual expectation employees and employers have of each other. The psychological contract is based on the belief that both employees and employers have obligations to one another (Kolb, Rubin & Osland, 1995). Changing the psychological contract can cause employees to either reflexively say no to change, or say yes, but not act on it, once it is implemented (which is often called the "kiss of yes," Kawasaki & Moreno, 2000).

Employee concern about any change can be (in large part) ameliorated by effectively understanding how the staff feel during the change (and addressing many of their concerns in advance), involving staff who can effect psychological change in an organization in the planning introductory phase, using staff as promoters of the idea, and by being in constant contact with staff (Parker, 1995). For this to occur, however, the "nuts and bolts" of implementation of branding need to occur at the local level, because a national organizer cannot be in true contact with employees about issues in Nebraska and Oregon on the same day.

Within Schools and Districts

Once a school or a district decides (or is mandated) to reframe science, assessment of school and district needs need to be undertaken. Not all teachers will have the same needs when it comes to understanding branding and how to develop ideas related to it. This is especially true when it comes to new teachers. If schools of education train students to think in terms of branding, they will need less training once they are in the profession to keep their skills up to date.

As the title of this section suggests, there are two levels to the consideration of this area, the school level and the district level. Turning first to the district, there are two immediate issues that become obvious, the need for time and money. There will be increased costs at the district level, because the district will have to employ someone to:

1) Develop local standards for the most appropriate way to brand chemistry.
2) Develop criteria by which effective assessment of the program's effectiveness can be measured.
3) Assess potential programs and how well they will meet local needs.
4) Assess school and departmental needs.
5) Determine criteria as to which employees are most appropriate to train (and on which programs).
6) Implement the continuing day-to-day management of the program.
7) Assessment of teachers to ensure program standards are being met.
8) Develop a response mechanism if the program either runs into problems or identifies teachers who are struggling.

In addition, officers and the school board will have to devote some time to manage this new program, creating additional time constraints for already busy officials.

It is worth pointing out, however, that some districts have officers that are responsible for curriculum management. These officers could be used to introduce this scheme, thereby reducing some costs, but this assumes that these departments have sufficient time and money to manage this approach. Once the scheme is "up and running," however, the cost of maintaining the scheme should decrease, even if the actual "continuous improvement training" required by this idea does not.

At the school level, the problem might be more of a time issue, as often busy members of senior management are asked to:

1) Consider how best to implement the program.
2) Identify staff that could most effectively use the training.
3) Develop plans to assess how the plan is implemented.
4) Take corrective action if problems arise.

It is unlikely that that the management of the program will cost more at the school level. As was indicated earlier, however, the training required by this program will cost schools a certain amount, because schools will have to take staff off timetable and buy courses that ensure they are trained. This training is a continuing element of teacher development, because as ideas about branding change, so to do the needs of teachers who implement it. If they are to implement it effectively, therefore, they need to thoroughly understand how it works. This can only be done through regular training.

"Te kiss of yes," where employees say yes, but really mean maybe or no (Kawasaki & Moreno, 2000), is also an issue at this level. When presented with something new, employees may doubt that the branding of chemistry could be effective. This reinforces the need to understand the staff that are undergoing the change (and address their concerns in advance), involving staff who can effect psychological change in an organization in the planning and introductory phases, using staff as promoters of the idea, and the need to be in constant contact with employees (Parker, 1995). Without their acceptance of this program, it is unlikely that it will succeed.

Because of the scale of what is being argued here, it would not make sense to roll the idea of branding out too fast. Consequently, it would make sense to pilot the idea of brand management in chemistry in a small number of representative school districts to see if the idea of branding is manageable, financially feasible and able to draw students from other subjects before it is rolled out on a widespread basis.

Within the Curriculum

The idea of branding could impact the curriculum in two ways. It could result in:

1) The curriculum content remaining the same but students learning how to view the curriculum differently.
2) The curriculum content changing to attract new customers.

At present the curriculum content is presented to students in a way that is attractive to some students, but unattractive to others. The goal of branding is to make the curriculum attractive to a broader basket of students. The question becomes, therefore, how will branding impact what content is taught?

In Chapter 1 it was suggested that curricula and textbooks are written such that:

1) They contain too much unnecessary information (Schmidt, McKnight, and Raizen, 1997, Stevenson, 1998, Schmidt, McKnight, Houang, Wang, Wiley, Cogan, and Wolfe, 2001).
2) They leave challenging subject matter till much later in a child's school experience than other countries (Schmidt, McKnight, and Raizen, 1997), with most grades being presented with little new material (Flanders, 1987, Eyelon and Linn, 1988).

3) There is less coherence and inter-connectivity than in other countries (Venesky, 1992, NCES, 2000a).
4) They fail to encourage the practices that are demonstrated to produce the best results (NCES, 1997).

Any re-branding of chemistry will result in these areas being addressed. Branding is more than an issue that solely covers how teachers present the subject. It will see national bodies and large corporations working with states to develop curricula that present chemistry in a consistent way across large areas so that is attractive to as many students as possible, and useful to the large corporations that will one day employ them.

In addition to working together to develop curricula, states, national bodies and large corporations must work with publishers about the content of their textbooks. Publishers must present chemistry in their textbooks in a way that is consistent with the curriculum and how teachers teach the subject, if they are to reinforce the branding changes that occur in chemistry.

These changes to the curriculum might lead some to consider fundamentally changing what taught as chemistry. This is not something that should be rushed into. As was indicated when the idea of brands was introduced, managers want immediate results. If the results fail to materialize quickly, they start to change things, and one of the things they could change is the curriculum.

This would not necessarily be a good idea, because the premise of this work is the assumption that schools should play a hand in preparing students for the world of work. If the curriculum loses its alignment with the world of work, then the point of this work will be lost too.

Teachers might struggle to accept the explicit linkage of work and school through the curriculum, but it will help to address the question “What’s the point of chemistry?” and the explicit link, if emphasized in the branding of chemistry, might encourage students to select chemistry over and above other subjects.

Across the Country

At present, adults, children, the government and industry all have different perceptions of what chemistry is, and what it should do. This thinking has an impact on how teachers and students act towards chemistry in school.

As the branding of chemistry is introduced, teachers and students will change how they see chemistry. This change in perception will, hopefully, slowly increase the number of students who are knowledgeable about chemistry and willing to take Pre-AP and AP Chemistry in high school.

The increased interest in chemistry and the associated increase in numbers taking Pre-AP and AP Chemistry will not happen overnight. It will grow if the branding is done effectively, but will take time (Aaker, 1996). This will result in the population changing its perceptions of chemistry, with time, if it is branded carefully over a prolonged period.

Increased interest in chemistry will have the knock on effect of encouraging the children of those who are interested in chemistry to persist in this area (Jacobs, Finken, Lindslay-Griffin, Wright, 1998, McNeal, 1999). As a result, a virtuous circle could be set up with time where the parents encourage their children to study chemistry because they have an interest in chemistry themselves.

The development of parents with interests in the science and the resultant development of a virtuous circle where they encourage (either directly or indirectly) their children to learn chemistry assumes that no other school subject responds to the branding challenge that chemistry implements in an attempt to garner more students. Should other subject areas rise to the challenge that chemistry sets them, and brand their own subject, it is possible that the impact of the branding of chemistry will be reduced.

As the idea of competition among subjects develops, it will be necessary for chemistry to strive to maintain its position as a brand leader if it is to maintain its competitive advantage and continue to attract students to study it as a subject. So while teachers and local administrators implement current structures for branding, a separate group (with input of teachers and administrators), would have to continually to develop "Brand Chemistry" so that it attract students.

Summary

Martin Van Buren's Chemistry Department does not strongly adhere to the rules that define a "good lesson," as defined by the American Association for the Advancement of Science. This is particularly true for the Pre-AP and AP classes, where there was very little correlation between these "good lesson" rules and what goes on in the lesson.

There has to be some reason why students study AP Chemistry in the face of what goes on in the classroom and it is hypothesized here that friendship groups are a determining factor when it comes to selecting what to study. Before this claim can be made more generally, however, investigations have to occur at a variety of similar schools to confirm that friendship groups hold the importance claimed in this piece.

If there is evidence from a variety of schools that supports the assertion that friendship groups are important for students, when it comes to selecting the courses they study, then branding might encourage more students to study chemistry. Branding is a way of framing a product or service in a customer's mind so that they are more likely to purchase the product.

Branding has the potential to encourage students to study science, but also has the potential to impact teachers, administrators, the curriculum and the population more generally, if it is implemented. As a consequence, the impacts and costs of the branding have to be considered before it is implemented on any large scale.

Brands, and people's response to them, do not occur in a vacuum. Once it has been demonstrated that the branding of chemistry is a success, other school subjects might respond in an attempt to maintain numbers in their subject. As a result, it is possible that the impact of branding might be reduced. By constantly evolving how the brand that is "chemistry" is presented, however, it is possible for chemistry to maintain its competitive advantage.

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Abstract

This investigation originally intended to uncover teacher behaviors that encourage students to persist in AP Chemistry in a typical urban Texas high school. As the investigation progressed, however, alternative reasons were sought for the persistence of some students when it became apparent that teacher behaviors might not be a factor in the decision to select AP Chemistry at the school under observation.

In response to this, “Branding”, a business theory which suggests certain attractive aspects of a product are promoted as a way to improve sales, is introduced as an alternative way of thinking about persistence in chemistry. “Branding” can explain why some students continue to select chemistry in the face of disappointing teaching. It is also argued here that “Branding” can encourage more students to take chemistry in the future.