THE BALANCED USE OF LEARNING STYLES IN E-LEARNING

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ABSTRACT
This research investigates how the learning styles of a class of thirteen year twelve physics students fit with existing e-learning applications. The “fit” was assessed using engagement indicators, assessment of learning and feedback from students.

Data were gathered from observation of classes using ICT, questionnaires, interviews and assessment.

The report concludes that there is insufficient evidence to link types of ICT to students preferred learning styles. However, there was a correlation between the interactivity of ICT applications and student engagement. It offers suggestions as to how e-learning can be used in today’s classrooms with Digitally Native students of varying learning styles.

In addition to the above, the author presents a critique of learning style theories.
ACKNOWLEDGEMENTS

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- Sitech Systems for lending of PRS equipment.
- Gough Technology for loan of Data logging equipment.
- D-Link New Zealand for loan of camera.
- Taradale High School for cooperation and access.
**INTRODUCTION**

**My situation:**
I am a secondary high school teacher of science and physics at Taradale High School, a school of 900 pupils in Hawkes Bay. I have been in this position since 1991 and also have the responsibility of being assistant Head of Department.

During this period the Physics Department has actively used e-learning in its programme. For some time we used eight Apple Macs to run data logging technology. The data loggers included smart pulleys, temperature, heart beat, radiation and free fall measurement sensors. Where appropriate we have also included video analysis and curriculum specific technology applications.

More recently we were forced to abandon the Apple Macs as the older Macs became unreliable. We adopted a PC platform based on Pasport data logging technology. The newer technology is more intuitive and versatile. The data can be quickly analysed using Data Studio software. A wider range of sensors is now used including smart pulleys, sonic rangers, current-voltage and rotary devices.

The advantage of using this technology is the quick set-up and analysis of experimental situations enabling rapid repeat and changing of variables. The hands-on experience enables students to conceptualise the physics principle under study.

I have also been experimenting with other e-learning approaches in the classroom, particularly using a data projector and interactive whiteboard. These allow greater flexibility in presenting lessons and interaction with students.

Additionally, I have been investigating the use of learning style preferences over the past three years. I initially undertook training with The Creative Learning Company, completing a diploma with them. The concepts and techniques put forward in this training seemed promising and as such I have selectively used them during this period of time.
My Core Interest:
The aim of the research is to discover the effect on students’ engagement and learning of giving them the opportunity to use e-learning in ways that relate to their own learning style modalities.

Why this is important:
Prashnig (2002) argues that the ideal situation is to teach to all learning style modalities at each learning opportunity. She asserts that when this is done the learning of all students is enhanced.
Furthermore, Gilbert (2001) asserts that student engagement in science is poor.

“…if we continue to teach science in traditional ways, we are unlikely to be able to produce the kinds of ‘new’ knowers that, the ‘knowledge society' literature argues, we need now, and the number of students choosing to study science will continue to decline”……

Walter Erdelen (2004) lamented young people's lack of interest in the sciences and held up technology as part of a possible solution

This may be the key. We need to get students interested in science to stop the decline in numbers taking the subject. New Zealand needs as many people contributing to the knowledge society as possible. E-learning may provide answers as outlined in this research.

Research Question:
According to Jukes and McCain (2006) students are very familiar with e-learning technology. They assert that teachers are not so familiar with the technology. I suspect, after discussions with colleagues, many teachers believe that most e-learning applications appeal to students. Learning style theory would contend that this is not the case and the learning styles of students need to be considered when using e-learning applications for effective learning to take place Prashnig (Debating Learning Styles personal communication February, 2006). I have decided to investigate how the students’ interest in the material being presented is affected by the e-learning application and attempt to relate that back to the students’ preferred learning styles.
My research question is:

What is the effect on students’ engagement and learning of giving them the opportunity to use e-learning in ways that relate to their own learning styles?

Sub-question

Which types of e-learning are suitable for use in today’s classroom with students who have grown up with this ICT?
LITERATURE REVIEW

All teachers use e-learning to a greater or lesser extent. Teachers face the daunting task of familiarising themselves with the technology existing in the schools and then using it productively. Many teachers do not have the time to spend learning to use the applications effectively in the classroom. I believe it to be most productive for computer literate teachers to assist with effective use of e-learning technology, particularly if the use fits naturally with effective student learning.

The use of learning style theory does not always marry well with the traditional use of e-learning. Sitting students in front of a computer does not automatically lead to the use of all learning style preferences. The kinaesthetic modality is rarely catered for and, for example, use of Power Point presentations may engage only visual learners with images on the screen and auditory learners with material spoken by the presenter.

Learning style theory can be represented by a variety of models. A popular model, based on that of Dunn and Dunn (Prashnig, 2002), assumes that the use of visual (learn by seeing), kinaesthetic (learn by doing), auditory (learn by hearing) and tactile (learn by using hands) modalities will enhance learning. This is the model I will use in this research.

It is important to note that learning style theory is controversial in education. Some academic researchers such as Markham (2004) and Coffield, et al. (2004) assert that there is no significant research evidence that supports the claims that use of learning styles enhances student learning. However, there is a significant groundswell of practitioners who support its use and two meta-analytical studies by Dunn et al. (1995) and Lovelace (2005) indicate student learning is enhanced.

There exists a multitude of e-learning applications on the market. We need to be selective and make cost effective e-learning purchases that will enhance learning and promote interest in science in comparison to more traditional teaching methods.

Defining the problem

One of the challenges in teaching is trying to meet the needs of a variety of students. This is particularly challenging in schools where many teachers are entrenched in their particular style of teaching and caught up with heavy workloads and time demands. Students who have a learning style compatible with that of the teacher and course tend to do better and be more motivated than those who do not. Since many science teachers teach with a similar style, many students are left out (Felder, 1993).

In a study of college science instruction, Sheila Tobias (1990) defines two tiers of students, entering college (university) in the United States. The first consists of those who go on to earn science degrees and the second are those who have the initial intention and the ability to do so but instead switch to non-scientific fields.

“The thrust of Tobias's study is that introductory science courses are responsible for driving off many students in the second tier. The negative features of the courses she cites include their (1) failure to motivate interest in science by establishing its
relevance to the students' lives and personal interests; (2) relegation of students to almost complete passivity in the classroom; (3) emphasis on competition for grades rather than co-operative learning; and (4) focus on algorithmic problem-solving as opposed to conceptual understanding” (Felder, 1993).

This is remarkably similar to the situation in most New Zealand schools. Many students leave science because they become disenchanted or think that credits are more easily obtained in other subjects. The original concept of contextual science in secondary schools has fallen by the wayside for many in favour of “easy” teaching from text books in the junior school and the pressure of assessment in the senior schools. It is so much easier to teach “what” rather than “why”.

According to Felder (1993 p.286):

“Recent educational research provides theoretical support for Tobias's assertions which are based largely on anecdotal accounts. The research shows that students are characterized by significantly different learning styles: They preferentially focus on different types of information, tend to operate on perceived information in different ways, and achieve understanding at different rates. Students whose learning styles are compatible with the teaching style of a course instructor tend to retain information longer, apply it more effectively, and have more positive post-course attitudes toward the subject than do their counterparts who experience learning/teaching style mismatches. All of the points raised by Tobias about the poor quality of introductory college science instruction can be expressed directly as failures to address certain common learning styles.”

**Dimensions of learning style**

If teachers are to address learning styles in their instruction then they must come to grips with what is meant by learning styles.

There exist many interpretations of “Learning Style”. Learning style theory has been used since the 1970’s by educationalists and researchers. There exist a multitude of definitions, theoretical models and learning style instruments. De Bello (1990) suggests that there exist almost as many definitions as there are theorists working in the area. Curry (1991) highlights the failure to identify and agree upon style characteristics as a major concern for educationalists. She adds that weaknesses in reliability and validity of the theories and the confusion surrounding definitions are further concerns.

Below are two interpretations of the field of learning styles: Coffield et al. (2004) and Desmedt and Velcke (2004).

**Interpretation 1.**

(Coffield et al. 2004) from the University of Newcastle upon Tyne identified 71 different theories of learning style. They collated the theories into “families” as in figure 1:
Learning styles and preferences are largely constitutionally based including the four modalities: V(visual) A(uditory) K(inaesthetic) T(actile).

Learning styles reflect deep-seated features of the cognitive structure, including ‘patterns of ability’.

Learning styles are one component of a relatively stable personality type.

Learning styles are flexibly stable learning preferences.

Move on from learning styles to learning approaches, strategies, orientations and conceptions of learning.

<table>
<thead>
<tr>
<th>Dunn and Dunn</th>
<th>Gregorc</th>
<th>Bartlett</th>
<th>Betts</th>
<th>Gordon</th>
<th>Marks</th>
<th>Paivio</th>
<th>Riding</th>
<th>Broverman</th>
<th>Cooper</th>
<th>Gardner et al.</th>
<th>Guilford</th>
<th>Holzman and</th>
<th>Klein Hudson</th>
<th>Hunt</th>
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<th>Messick</th>
<th>Pettigrew</th>
<th>Witkin</th>
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<tr>
<td>Apter</td>
<td>Jackson</td>
<td>Myers-Briggs</td>
<td>Epstein and Meier</td>
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<tr>
<td>Allinson</td>
<td>Hayes</td>
<td>Herrmann</td>
<td>Honey</td>
<td>and</td>
<td>Mumford</td>
<td>Kolb</td>
<td>Felder</td>
<td>and</td>
<td>Silverman</td>
<td>Hermanussen,</td>
<td>Wierstra,</td>
<td>de Jong</td>
<td>and</td>
<td>Thijsen</td>
<td>Kaufmann</td>
<td>Kirton</td>
<td>McCarthy</td>
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</tr>
</tbody>
</table>

McLoughlin (1999), following previous attempts by Curry (1990) and Riding and Cheema (1991), summarised her exploration of the learning styles area by giving the following definitions of the various terms used by writers. These may be helpful in interpreting the terminology given in the headings to Figure 1.

- Learning preference: favouring one method of teaching over another
- Learning strategy: adopting a plan of action in the acquisition of knowledge, skills or attitudes
- Learning style: adopting a habitual and distinct mode of acquiring knowledge
- Cognitive strategy: adopting a plan of action in the process of organising and processing information
- Cognitive style: a systematic and habitual mode of organising and processing information

Coffield et al. (2004) refer to the groupings in Figure 1. as a continuum. Their reasoning is that the continuum represents a simple way of organizing the different models according to the overarching ideas behind them. The continuum moves from styles that are claimed by the authors to be constitutionally based and relatively fixed to styles that
are claimed to be more flexible and open to change. At the left hand side of the continuum are placed the models based on the belief that genetics have a strong influence. These styles are believed to remain relatively stable and teachers should address these fixed styles. Moving to the right learning style models are based on the dynamic interplay between self and experience. At the far right the models are concerned with factors such as motivation and the environment. The Newcastle Group put the models into families, representing steps in the continuum. They commented that some models sat on the borders of the families.

The basis of their groupings was derived from Curry’s Onion Model (1983) see Figure 2.

**Figure 2. Curry’s Onion Style Model (1983)**

The inner layer is more stable and complex in learning while the outer layers become easier to modify but the less important in learning.

**Interpretation 2. Desmedt and Velcke (2004)**

In their article as “Mapping the Learning Styles Jungle,” Desmedt and Velcke (2004) divide the “jungle” into cognitive style (i.e. a systematic and habitual mode of organising and processing information) and learning style (i.e. adopting a habitual and distinct mode of acquiring knowledge) groups.

These authors have systematically researched the literature to put papers contributing to learning and cognitive styles into their respective groups.

Figure 3a represents authors who fit into the cognitive style. Figure 3b represents authors who fit into the learning style. Desmedt and Velcke (2004) have then sub-grouped the authors based on the particular type of contribution each has made. This is particularly valuable since it immediately allows the reader of any article to classify where that particular aspect of research lies in relation to the big picture.

The numbers in each rectangle represent the number of authors represented in the cluster found by the research and their relative impact. The impact was determined by analysing the number of times the author was cited in literature.
The cognitive style has not been examined in this research project but explanations of each group in the cognitive style have been included for completeness. More detailed explanations have been included for the learning style group.

**Figure 3a: Groups of Cognitive Styles According to Desmedt and Velcke (2004)**

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Focus of cluster</th>
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</table>
| **Witkin (122)** | This is mainly centred on Witkin’s work (Witkin, Oltman, Raskin and Karp, 1971) and cluster A. According to Witkin et. al. (1971), Cognitive Styles are:  
“*The characteristic, self-consistent modes of functioning which individuals show in their perceptual and intellectual activities*” |
| **Kirton (14)** | Cluster B is mainly based on Kirton (1976). He defined Cognitive Styles as:  
“*different, potentially equal valuable, modes of problem perception and problem solving that form a basic dimension of one’s personality.*” |
| **Beck (23)** | Cluster C is represented mainly by Beck (1976). This focuses on the relation between cognitive processes and dispositions on the one hand and emotions and behaviour on the other. |
| **Tetlock (16)** | Cluster D is mainly represented by Tetlock (1983). It studies the openness/ rigidity in people’s belief system as aspects of personality. |
| **Benbasat (23)** | Cluster E. Benbasat and Dexter, (1982) looked at how designers of decision support systems and management information systems should |
take account of individual differences in handling information

Cluster F. Bogen (1969) and Kingsbourne (1972) investigated research in neurology to establish that the brain consists of two parts with different characteristics and functions.

**Figure 3b: Groups of Learning Styles According to Desmedt and Velcke (2004).**

Cluster A is represented by Kolb (1976) and Dunn and Dunn (1978). These two are explained in more detail below. Significantly the Dunn and Dunn LSI inventory was the first instrument to assess learning styles for students in all grades in primary and secondary school.

Cluster B is represented mainly by Entwistle (Entwistle and Ramsden 1983). The authors distinguish between a deep approach to learning and a superficial approach. This is explained in more detail below.

It is within the learning style area group that this current research project is based i.e. the acquisition of information rather than the processing of information.

Using Curry’s onion style model, (1983) and fig. 2, this group deals with the inner layer. It is here that the learning styles relating to the senses of V, A, K, T reside. As this current research project is based on V, A, K, T a brief account of models will be given

**Kolb's learning theory (1976)**

Kolb's learning theory (1976) sets out four distinct learning styles which are based on a four-stage learning cycle. It offers both a way to understand individual people’s different
learning styles, and also an explanation of a cycle of experiential learning that applies to us all.

Kolb includes this 'cycle of learning' as a central principle his experiential learning theory, typically expressed as four-stage cycle of learning, in which 'immediate or concrete experiences' provide a basis for 'observations and reflections'. These 'observations and reflections' are assimilated and distilled into 'abstract concepts' producing new implications for action which can be 'actively tested' in turn creating new experiences.

Kolb says that ideally this process represents a learning cycle or spiral where the learner 'touches all the bases', i.e. a cycle of experiencing, reflecting, thinking, and acting. Immediate or concrete experiences lead to observations and reflections. These reflections are then assimilated (absorbed and translated) into abstract concepts with implications for action, which the person can actively test and experiment with, which in turn enable the creation of new experiences.

Kolb's model therefore works on two levels - a four-stage cycle of modes:

1. Concrete Experience - (CE) feeling
2. Reflective Observation - (RO) watching
3. Abstract Conceptualisation - (AC) thinking
4. Active Experimentation - (AE) doing

and a four-type definition of learning styles, (each representing the combination of two preferred modes as illustrated below).

Kolb defined the learning style terms as:

1. **Diverging (CE/RO)** These people are able to look at things from different perspectives. They are sensitive. They prefer to watch rather than do, tending to gather information and use imagination to solve problems. They are best at viewing concrete situations several different viewpoints. Kolb called this style 'Diverging' because these people perform better in situations that require ideas-generation, for example, brainstorming. People with a Diverging learning style have broad cultural interests and like to gather information. They are interested in people, tend to be imaginative and emotional, and tend to be strong in the arts. People with the Diverging style prefer to work in groups, to listen with an open mind and to receive personal feedback.

2. **Assimilating (AC/RO)** The Assimilating learning preference is for a concise, logical approach. Ideas and concepts are more important than people. These people require good clear explanation rather than practical opportunity. They excel at understanding wide-ranging information and organising it a clear logical format. People with an Assimilating learning style are less focused on people and more interested in ideas and abstract concepts. People with this style are more attracted to logically sound theories than approaches based on practical value. These learning style people is important for effectiveness in information and science careers. In formal learning situations, people with this style prefer
readings, lectures, exploring analytical models, and having time to think things through.

Figure 4. Kolb’s Learning Cycle

![Kolb's Learning Cycle Diagram]
3. **Converging (AC/AE)** People with a Converging learning style can solve problems and will use their learning to find solutions to practical issues. They prefer technical tasks, and are less concerned with people and interpersonal aspects. People with a Converging learning style are best at finding practical uses for ideas and theories. They can solve problems and make decisions by finding solutions to questions and problems. People with a Converging learning style are more attracted to technical tasks and problems than social or interpersonal issues. A Converging learning style enables specialist and technology abilities. People with a Converging style like to experiment with new ideas, to simulate, and to work with practical applications.

4. **Accommodating (CE/AE)** The Accommodating learning style is 'hands-on', and relies on intuition rather than logic. These people use other people's analysis, and prefer to take a practical, experiential approach. They are attracted to new challenges and experiences, and to carrying out plans. They commonly act on 'gut' instinct rather than logical analysis. People with an Accommodating learning style will tend to rely on others for information than carry out their own analysis. This learning style is prevalent and useful in roles requiring action and initiative. People with an Accommodating learning style prefer to work in teams to complete tasks. They set targets and actively work in the field trying different ways to achieve an objective.

The theory claims to provide a framework for the design and management of all learning experiences. According to Coffield et al. (2004) problems with reliability, validity and the learning cycle persist with this model. Few learning style models and instruments have been well validated, so it is questionable whether most existing instruments can accurately identify a student’s learning style. But even though they’re not psychometrically validated, unvalidated learning style instruments may give students constructive clues about how they learn best. This is the case with Kolb’s instruments. This LSI has been subject to 30 years critique and has been improved over this time. It may not work well predictively but works well as a self assessment exercise.

I have done little work with this model preferring the practically classroom oriented model of Prashnig (2002). The now popular visual, auditory, kinaesthetic, and tactile classifications can readily be put into a classroom situation.

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The Dunn and Dunn Learning Style Model (Dunn and Dunn 1978)

The Dunn’s Learning-Style Model is complex and encompasses 5 strands of 21 elements that affect each individual's learning. Some of these elements are biological and others are developmental. An individual’s learning style changes over time. A summary of these elements is provided below (Dunn and Dunn, 1978).

1. **Environmental.** The environmental strand refers to these elements: lighting, sound, temperature, and seating arrangement. For example, some people need to
study in a cool and quiet room, and others cannot focus unless they have music playing and it is warm (sound and temperature elements).

2. **Emotional.** This strand includes the following elements: motivation, persistence, responsibility, and structure. For example, some people must complete a project before they start a new one, and others work best on multiple tasks at the same time (persistence element).

3. **Sociological.** The sociological strand represents elements related to how individuals learn in association with other people: (a) alone or with peers, (b) an authoritative adult or with a collegial colleague, and (c) learning in a variety of ways or routine patterns. For example, a number of people need to work alone when tackling a new and difficult subject, while others learn best when working with colleagues (learning alone or with peers element).

4. **Physiological.** The elements in this strand are: perceptual (auditory, visual, tactile, and kinesthetic), time-of-day energy levels, intake (eating or not while studying) and mobility (sitting still or moving around). For example, many people refer to themselves as night owls or early birds because they function best at night or in the morning (time-of-day element).

5. **Psychological.** The elements in this strand correspond to the following types of psychological processing: hemispheric, impulsive or reflective, and global versus analytic. The hemispheric element refers to left and right brain processing modes; the impulsive versus reflective style describes how some people leap before thinking and others scrutinize the situation before moving an inch. Global and analytic elements are unique in comparison to other elements because these two elements are made up of distinct clusters of elements found in the other four strands. The elements that determine global and analytic processing styles are: sound, light, seating arrangement, persistence, sociological preference, and intake. Global and analytic processing styles will be discussed in detail in the next section.

Coffield, et al. (2004) critiqued the Dunn and Dunn model which was used in this present research. The strengths of the model were reported to be:

“A user friendly model that includes motivational factors, social interaction, physiological and environmental elements”.

Its weaknesses were reported to be:

“The model makes simplistic connections between physiological and psychological preferences and brain activity.”

The report noted strong claims for validity and reliability from its supporters, and contrastingly problems with the design and reliability of key instruments from its critics.

Stevenson and Dunn (2001) assert the Learning Style Instrument, LSI, is easy to administer and interpret. It has been used in research by almost 120 institutions of higher education in the USA. For each element for males and females, the mean, standard deviation, reliability and standard error was calculated. The derived reliability coefficients for the elements fall into the 0.75 to 0.88 range. This means that the profiles of people analysed can be reproduced reliably within the range given. According to Markham (2004) a reliability coefficient of 0.80 should be a minimum. The elements with the highest reliabilities included noise level, light, temperature, design, motivation,
persistence, responsibility, structure, learning alone/peer-oriented, authority figures present, wanting variety versus wanting routines and patterns, perceptual preferences, requiring intake, the preference to work evening/morning/afternoon, needing mobility, and parent and/or teacher motivation.

Critics claim that there is lack of independent evaluation of the LSI and that there are limitations in many of the supporting studies.

It would seem the potential user has a decision to make as to the claims of reliability and validity based on research by the model designers and to warnings of lack of independent verification by critics. As stated in comments on Kolb’s methodology, even though they’re not psychometrically validated, learning style instruments may give students constructive clues about how they learn best.

Figure 5. Dunn and Dunn Learning Style Model (21 elements n.d.)

Figure 5. above pictorially represents the Model. Note the similarities between this and Figure 6., the Prashnig model which was used in the present study. Prashnig has worked closely with the Dunns and has refined their model. The main differences are in separating the senses from the physical/physiological level and different categories in the emotional/attitude level.
Brain Dominance

The brain is divided into two sections, the right and the left hemispheres. It is joined by the corpus callosum. It is possible for the two sides of the brain to operate separately from each other.

In a normally functioning brain each hemisphere will operate differently whether in thinking or in processing information. The left will process logically and sequentially. A person dominant with this type of processing likes lists. The right will process globally or as a whole picture. Mind maps are favoured by those people who prefer right brain processing.

Left brain thinkers are reflective. They will mull over a decision, sizing up all the facts before making a decision. Right brain thinkers are intuitive and will make snap decisions based on how they feel about a situation.

Eden (2006) asserts that there are specific functions of each side of the brain, as outlined below

<table>
<thead>
<tr>
<th>Left brain functions</th>
<th>Right brain functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>uses logic</td>
<td>uses feeling</td>
</tr>
<tr>
<td>detail oriented</td>
<td>&quot;big picture&quot; oriented</td>
</tr>
<tr>
<td>facts rule</td>
<td>imagination rules</td>
</tr>
<tr>
<td>words and language</td>
<td>symbols and images</td>
</tr>
<tr>
<td>present and past</td>
<td>present and future</td>
</tr>
</tbody>
</table>
math and science  philosophy & religion
can comprehend  can "get it" (i.e. meaning)
knowing  believes
acknowledges  appreciates
order/pattern perception  spatial perception
knows object name  knows object function
reality based  fantasy based
forms strategies  presents possibilities
practical  impetuous
safe  risk taking

Sensory modality
The sensory modalities refer to how a student prefers to take in information. These are generally taken as visual, auditory, kinaesthetic and tactile. Students may have one preference or more. The more preferences a student has the easier it will be for them to partake in any given lesson. The preferred learning style modality is a key factor when difficult new material is presented. It becomes less important as the material is easier to understand or if the student has a keen interest in the material. (Prashnig 2002)
Visual refers to taking in information with the eyes. It includes reading and seeing or watching. Prashnig (2002) includes imagination as a visual category.
The auditory sense refers to listening and talking or discussing. Once again Prashnig (2002) includes another sub-category being self-talk.
People with a kinaesthetic preference will like to get their whole body involved in the learning. This may include acting and dramatisation or just doing practical experiments.
Tactile learners learn best by using their hands and will manipulate things to assist their learning.

Physical Elements
Each person may have a preference for particular physical factors while assimilating material. This may include moving around, food and water intake and a different time of the day. It is now well known, for instance, that senior school students are not morning people and a few schools open later to accommodate for this.

Environmental
Quite often the environment can have a big bearing on learning. Students will have different lighting requirements, temperature requirements, some may like music and even an informal study area. It is recommended that the sound be strictly monitored. Classical music with a beat of 60-80 beats/minute is the best to use (Prashnig, 2002, pp 161-169)

Social
Each student will have different social needs when learning. Some prefer to work alone, others in pairs. Still others will prefer peers only or group learning.

It is argued by Dunn and Dunn (1978) that the above preferences are genetically based and deep seated. The remaining category based on attitudes is referred to as being learned behaviour. Each student will bring in a different attitude based on their personal experiences.
Entwistle’s model (Entwistle, Hanley, & Hounsel, 1979)

Entwistle’s model, rather than analysing the process of learning is concerned with the orientation of the learner to studying. Entwistle examined the intentions of students in their studies and the ‘styles’ they then used to achieve their objectives.

Entwistle identified three main orientations to study:

1. **Meaning orientation**: These learners have an intrinsic desire to study and relate new material to their lives. They tend to adopt a deep approach to learning. They question conclusions given in lectures and in set texts.

2. **Reproductive orientation**: Learners tend to adopt a surface approach to learning. They will memorise facts but may be unable to incorporate new facts into a wider body of knowledge. They are characterised by an extrinsic desire to learn – ‘I need to know this to pass the exam’.

3. **Achievement orientation**: Learners will do whatever is necessary to get good grades. They will adopt a deep approach if forced to by their teacher, but will often learn superficially if they can get away with it.

These three orientations to study allowed Entwistle to classify learning into two main categories: deep learning and surface (or superficial) learning. Some students study with the ultimate intention of understanding the subject and integrating the new material with their prior knowledge. Some however, simply seek to reproduce the course material (rote learning), without the intention of understanding, to enable them to meet course requirements. Achievement oriented students are aiming for high grades and will employ a variety of strategies to achieve their goal; these include learning to understand, and at times rote learning.

This type of learning style has proved worthwhile in the tertiary level of education. It is valuable where motivated learners and teachers can share ideas about effective and ineffective strategies for learning. In the secondary context it may be more valuable as a mentoring tool rather than a classroom tool. The University of Newcastle group (Coffield et al. 2004) refers to this as a potentially useful model, successful in higher education, but requiring significant development and testing.

**Critique of learning styles**

The area of Learning Style research and application is controversial.

There exist many proponents and opponents of the use of Learning Styles typology. Reports by the Coffield et al. (2004) and Markham (2004) suggest that there has been no substantive research that supports the use of learning styles.

The opponents of learning styles suggest that there exist no longitudinal studies, with strict control of variables, which prove the validity of learning styles in enhancing learning. Further they suggest that the learning style instruments used to determine a student’s preferred modality lack reliability. Markham (2004) suggests that in most cases the reproducibility factor is less than 0.8 i.e. students repeating the survey or assessment of learning style answer the same questions with the same answer less than 80% of the time.
(Coffield et al. 2004) researched 13 major theories and has given a detailed analysis of each. It reports that there are continuing problems in the learning style field. These include:

- The large number of models used leads to “theoretical incoherence” and “conceptual confusion”.
- Labeling, vested interests and overblown claims. Reynolds (1997) also refers to “a bedlam of contradictory claims”.
- Variable quality of models. Curry (1990) believes that the learning style models are of variable quality where many models have been marketed with limited substantive data to support them
- Psychometric weaknesses. This claim is echoed by Markham (2004)
- Lack of communication between different research perspectives on pedagogy.
- The report of Coffield et al. (2004) points out also that there has been little research into varying socio-economic groups or ethnicity of students

Prashnig (Debating Learning Styles personal communication February, 2006) defends the use of learning styles based on her experience of 12 years working with students of all ages and teachers from many countries. The missive outlines objections to criticisms summarised above. Prashnig states that:

- Learning Style Instruments are complex have built in mechanisms to detect cheating. Contrary to assumptions of critics instruments do not assess psychological traits.
- Critics rarely define learning styles which is the way new or difficult information is taken in.
- Complex style combinations are oversimplified. A learning style should be viewed in a more holistic way and not reduced to simple VATK. (visual, auditory, tactile and kinaesthetic)
- Claims that learning styles are fixed over time are incorrect as individuals will change over time. She asserts that this has been discovered by research on the Dunn and Dunn model and by international field studies on the Learning Style Instrument.
- Learning style concepts have been developed for educators to use in the classroom and not for psychological work. Their value is in their practical use and not as theoretical models to be dissected by academics.
- Researchers rarely consult with classroom practitioners who have had great success with learning style theory.

Teachers at all levels of education continue to use the applications and give highly positive feedback on their use. (Barbe and Milone, 1981), (Claxton and Murrell, 1987), (Corno, 1986), (Felder, 1988), (Felder, 1989), (Felder, 1990), (Godleski, 1984), (Kolb, 1984), (Lawrence, 1982), (Schmeck, 1988).

A meta-analysis carried out on research involving the Dunn and Dunn model (Lovelace, 2005) stated:

“Mean effect-size results for achievement from the present and previous meta-analyses were consistent. The author suggested that, on average, learning-styles responsive instruction increased the achievement or improved the attitudes toward learning, or both, of all students. Although several moderating variables influenced the outcome,
results overwhelmingly supported the position that matching students’ learning-style preferences with complementary instruction improved academic achievement and student attitudes toward learning. The Dunn and Dunn model had a robust moderate to large effect that was practically and educationally significant.”

This analysis was based on 76 original research investigations, which met the criteria of the meta-analysis.

The results were consistent with a previous meta-analysis reported in 1995 (Dunn et al. 1995).

The Newcastle report also noted that:

“Those teachers who have incorporated the Dunn and Dunn model into their practice speak movingly at conferences of how this re-categorisation of the problem (where students’ failure to learn is reformulated as teachers’ failure to teach appropriately) has transformed their attitude to students they previously dismissed as stupid, slow, unmotivated, lazy or incapable of being educated. This is not an inconsiderable achievement.”

Prashnig (Debating Learning Styles personal communication February, 2006) comments:

“Whether assessment instruments are good or bad, reliable or non-valid, it remains a fact that every human being has a learning style which can consist of contradictory components, often leading to inner confusion and uneasiness. Style mismatches between teaching and learning, physical learning environments not conducive to information intake and unmet physical needs during the learning process can lead to frustration, stress, learning problems, underachievement, low self esteem, discipline problems among younger students, and “dropoutism” in high schools. Initial dislike for theoretical learning not based on style preferences, leads ultimately to the inability of achieving academically.”

Learning style analysis and use of learning style theory continue to be widely used in all levels of education and in business.

At this stage I don’t see any reconciliation of the two viewpoints. Reconciliation could only come about after stringent and prolonged research. This is unlikely to occur.

Caution needs to be taken in the use of Learning Styles and they should not be seen as a panacea and used instead of other valuable teaching techniques such as meta-cognition or formative assessment (Hipkins 2006).

The role of e-learning

Ian Jukes, a Canadian teacher, says that only 28% of 12th-grade high school students believe that school work is meaningful; 21% believe that their courses are interesting; and a mere 39% believe that school work will have any bearing on their success in later life (Jukes, 2006). Teachers acknowledge the difficulty in teaching to today’s student. Reflective teachers continually seek to enhance their skills to address the need to maintain engagement of students.
An independent research report in the UK showed that ICT can help raise standards (Harrison et al. 2003). ImpaCT2 is a project commissioned by the Department for Education and Skills and managed by Becta with the aim of evaluating the progress of the ICT in Schools Programme. It was a major study carried out between 1999 and 2002 involving 60 schools in England and is one of the most comprehensive investigations into the impact of information and communications technology (ICT) on educational attainment so far conducted in the United Kingdom.

The key findings from the study are:

- Differences in attainment associated with the greater use of ICT were clearly present in more than a third of all comparisons made between pupils’ expected and actual scores in National Tests or GCSEs, though these were not large.
- In none of the comparisons was there a statistically significant advantage to groups with lower ICT use.

Here it seems is a way of improving students’ achievement. But what is the best way of using ICT and how does it sit with pedagogy and students’ learning styles?

Evaluations of new educational technologies show that they tend to concentrate on the learning outcomes of material being presented. They do not take into consideration the pedagogical effectiveness of the method being used to deliver the material or differences in learning styles of the students who are using the technology (Parson, 1998) and (Russell, 2001). What is frequently forgotten is that technology is just a medium used to attain particular purpose; that it is a means to an end, and some researchers feel strongly that those ends should be educational, not technological (Bruen, 2002). Educationalists are taking much more heed of pedagogy as a priority in evaluating new software (Parson, 1998). Technology, multimedia and software can go a long way in filling the gaps caused by a dichotomy between learning styles of students and teaching styles but:

“...whether or not the processes of teaching and learning are enhanced by the use of ICTs depends more upon the pedagogic designs devised by educators than upon the characteristics of the technologies themselves” (Kirkwood 1998; Bruen 2002).

“A designer of an e-learner course has to make provisions for the learning styles of students. Today it is widely accepted that during the design and development of educational material attention must be focused on the learners’ characteristics and requirements”. (Del Corso et al. 2002)

Prashnig (Creative Learning in Action, personal communication September, 2005) states:

“This is where “blended learning” comes in and why it is so important for many students. Teachers involved in ICT are well aware, it is learning which combines online and face-to-face approaches, and as I see it, this is the only way to accommodate learning needs of highly kinesthetic learners”.

“They (kinaesthetic learners) need to get away from the computer, move their body and DO something with the information they have just received via the screen. Learning sessions for these students will only be successful (and hopefully lead to understanding, skills, competencies, and knowledge) when they have physically experienced and/or done something.”
The implication of what Prashnig is saying is that teachers should assess which learning styles have been addressed by the computer program. If the preferred learning style modalities of all students in the class have not been addressed by the program then the teacher should present the material to be learned in an additional way such that all learning style modalities are covered.

Ian Jukes (2006) makes some pertinent points about the use of e-learning.

- technology is a tool to help us be more productive
- The central issue is about how technology can be organized around student learning, not how student learning can be organized around technology.
- We need to see technology as helping students think and communicate effectively
- Tomorrow’s students will not struggle with technology. Rather, they will allow it to empower them
- The student needs to focus on the task while the technology works in the background.
- Educators must understand the power of technology and information to transform everything they teach. They must be willing to accept the problems associated with paradigm paralysis (being stuck in past pedagogical beliefs) and be willing to do something about it.

Prensky (2001) is a strong proponent of computer games in education, which allow for all the above attributes. However, I believe it is not necessary to use games to get the desired effects. Simulation games work only with theory and results will map the theory. Data logging works directly with real life situations and mimic what real scientists do to create the theory. At present there is little gaming software for physics applications. Work is being carried out by Andrew Carswell, a 2004 e-fellow. He has designed two educational games in microbiology (VQuest MicroB, 2006) and a Maori context (VQuest Marae, 2006).

Galarnaeau (2006) in a keynote address to the U-learn conference indicated that Microsoft is not interested in developing educational gaming software when there exists a large market for recreational software. It would appear that gaming software would need to be developed by niche developers.

So where does that leave teachers in providing suitable ICT based lessons?

Culligan (2006) states:

“The challenge facing educators and trainers is to identify learning strategies that are appropriate for Digital Natives, recognizing the different ways they process information and developing learning tools that maximize the potential of their unique cognitive approach”.

He cites examples of the army developing “an array of gaming simulations”, of private corporations adopting simulation technologies that borrow heavily from the computer gaming industry and universities adopting computer-based gaming in the classroom.

So do we as teachers need to develop gaming simulations for our subjects and classrooms? Most teachers would throw up their hands in horror at such a thought.
However, despite Microsoft’s abdication, there are developers already moving along this path. Apart from Andrew Carswell as indicated above, Derek Wenmouth (2006) in his blog talks of the educational advantages of gaming and cites the examples of “Second Life” and “Darfur is Dying” as educational web based games. Futurelab (2006), a U.K. based organization, has completed a one year research project on how games can be used in schools along with some present applications available. Based on these examples there will be software in the future that will be adapted to Digital Natives in the classroom.

Prensky (2001) claims that teachers and software developers need to be aware that students of today’s generation are “digital natives”. According to Jukes and McCain (2006) a great deal of neuroscientific brain research has been undertaken in the past few years. They claim this research is validating much of what was suspected from the psychological research, particularly the psychological sciences. This view is supported by Prensky (2001) who develops the theory based on referenced articles. Students think and process information differently from the way the current generation of teachers do; we are “digital immigrants” who use e-learning with an “accent” e.g. Most digital immigrants prefer the telephone over IMing and texting, the newspaper over CNN.com, the weatherman over WeatherBug, face-to-face visits over e-mail exchanges, journals over Google, maps over MapQuest, bookstores over Amazon.com, a daily planner over a palm pilot or blackberry, CDs over MP3s, a dictionary over Dictionary.com and still feel more comfortable walking to and around the library than searching online journal databases or Google (Jukes 2006)

“Digital Natives are used to receiving information really fast. They like to parallel process and multi-task. They prefer their graphics before their text rather than the opposite. They prefer random access (like hypertext). They function best when networked. They thrive on instant gratification and frequent rewards. They prefer games to “serious” work” (Prensky 2001).

The following attributes of Digital Learners compared to Digital Immigrants have been developed by Prensky (2001) and give us some idea of the divide between Teachers and Students.

- Twitch speed vs. conventional speed. The advent of computer games has conditioned the brain to the speed and interactivity of the games. This is compared to the conditioning of the previous generation to television, a much slower requirement. The generation prior to television was conditioned to reading.
- Parallel processing vs. linear processing. Students raised with a computer develop hypertext minds, they leap around. Their cognitive structures are parallel, compared to the linear structures developed through watching television or reading.
- Random access vs. linear thinking. Similarly students using a computer can randomly access information which has been conditioned from parallel processing compared to the linear development of thinking of the prior generation.
- Graphics first vs. Text first. The function of gaming has been to condition the student to a graphics interface. The previous generation used text when accessing knowledge and information.
- Connected vs. Stand Alone. The introduction of the internet/ World Wide Web and mobile phones means today’s student is constantly connected to others. Prior
generations were constantly in a lone situation limited to the immediate surroundings.

- Active vs. Passive. Today’s student is constantly interacting with computers and games. This is in contrast to the passive nature of reading and watching television.
- Payoff vs. Patience. Games give immediate reward and feedback. Digital Immigrants are conditioned to wait for outcomes over a longer period of time.
- Fantasy vs. Reality. Digital Natives are constantly involved actively in fantasy situations rather than watching ‘real’ TV or reading novels.
- Technology as friend not as foe. Having grown up with technology it becomes natural to interact with it and use it, rather than come to it and be faced with the inevitable ‘crashes’ and ‘freezes’ that alienate Digital Immigrants.

So how do we bridge this digital divide?

Both Prensky (2001) and Jukes (2006) suggest teachers learn to communicate in the native language and style of their students. This does not mean changing the focus on what is important or what is going to be measured, but it does mean that we have to change our instructional styles.

Additionally, Jukes (2006, p. 75) states:

- This requires more making learning fun and more relevant to them and their world.
- This means going faster so they can receive information quickly.
- This means less step-by-step instruction and more random access, hyperlinked, just-in-time learning experiences.
- This means less text and more pictures, sounds and video wherever possible.
- This means providing more opportunities for multitasking, networking and interactivity.
- This means applying what we now know from the brain and mind research about learning

There are now an enormous number of tools to bring about this revolution. Consider the situation, 15 years ago. Teachers had access to a blackboard and chalk, OHPs, banda copiers and videos. Computers were emerging but very few knew how to operate them, even fewer had any idea how to use them in teaching. Information was limited to books and microfiche.

Fast forward to now. White boards replaced blackboards and data projectors overtook OHPs. Interactive whiteboards are starting to make inroads. Bandas gave way to photocopiers and videos are being replaced by DVDs.

Computers are widely used giving freedom to produce lessons ahead of time, which are more interactive, and to produce materials which are of high quality. The advent of the World Wide Web accessed via the internet makes any information available through smart search engines. E-mail and online chat enables communication world wide.

Peripherals such as digital cameras and video cameras enable images to be downloaded directly onto the computer and manipulated for projection in the classroom.
Data loggers and microscopes can be coupled to computers to enable rapid processing of data.

Resources on the web are increasing at an enormous rate. Lessons can be downloaded, assessments are available online and applets show demonstrations not available in the classroom.

The array of tools on the web is increasing faster than the average teacher can keep pace with. How many of us had heard of blogs, wikis, modding and podcasts just 12 months ago?

New e-learning tools are arriving all the time; the personal response system (PRS) is one of the later arrivals.

The learning opportunities are rapidly expanding. Learning opportunities in many instances mirror the teaching tools. However, by having a computer at home the student has access to the internet and web. Information is available at the touch of a button. Communication with other students is enhanced and conferencing via chat rooms is available. Software enables digital storage and reproduction of resources. Not to be overlooked is the rise of the cell phone enabling instant communication anytime and anywhere (almost).

Teachers can take advantage of technology to increase interaction and communication with students. The use of interactive whiteboards with pads and interactive applications such as PRS enable the teacher to communicate with all students continuously throughout the lesson. Even the most reticent student is free to communicate in a non-threatening and enjoyable manner. Through the PRS system student understanding and progress can be monitored.

The advent of mobile phones and e-mail enables communication at any time. The Autoassign program, for instance, enables students to complete assignments on-line at home and then have their work graded online. Individual communication is enabled through an e-mail facility built in to the program.

Wikis can be set up to enable a class to conference. Over a period valuable dialogue can be established amongst the whole class that supports the subject objectives and student learning.

Although e-learning can enable new forms of teaching and learning to take place, it cannot ensure that effective and appropriate learning outcomes are achieved. It is not technology, but educational purposes and pedagogy that must provide the lead, with students understanding not only how to work with e-learning, but why it is of benefit for them to do so. Knowing about students’ use of media as well as their attitudes and experiences can help teachers and instructional designers develop better courses (Kirkwood and Price 2005). They assert better courses are based on pedagogy and scholarship irregardless of the media/ICT tricks.

**Summary of key points from literature review**

Science does not maintain the interest of students through to Year 13. One of the reasons for this could be a mismatch between the teaching style of the educator and the learning
style of the student. Students of today are digital natives. Blending e-learning, with appropriate software, and teaching to the learning style preferences of students may result in an increase in engagement and achievement of our students.
METHOD OF DATA COLLECTION

Methodology

The methodology of the research was a “quasi-experiment” using an intervention.

The intervention used various forms of ICT during the teaching of a physics module. ICT applications were used that could be identified with one or more learning style modalities, i.e. visual, auditory, kinaesthetic and tactile.

As a precaution to ensure learning was not impeded by the intervention the subject material was also presented in ways that addressed each of the learning styles.

Participants and consent

Student selection:
A group of physics students aged 16-18 and of mixed gender, were used in the study. They comprised a year 12 physics class. The class was selected for the following reasons:

• Accessibility – The class was taught at my employing school with a teacher who agreed to co-operate with the research.
• Familiarity with the subject – I had taught the subject for several years.
• Room set-up – the room was well set up for e-learning. It had an interactive white board as well as having undergone renovations to suit learning style modalities. The renovations allowed for natural lighting and compartmentalised heating, addressing the physical needs of the students. The walls had been stripped to minimise distractions.
• Teacher – the teacher, who normally taught the class, was experienced in teaching physics and was conversant with e-learning and learning style methodology.
• Maturity – The age and focus of the students made them “good informants” about their experiences.
• Attitude – Prior teaching experience indicated that this type of student was more likely to be motivated to learning, reducing the effect of variation in motivation.

Consent
Written consent was received from all students, the teacher and the school for the research. The students were given the rights to:

• Decline to answer any particular question.
• Withdraw from the study at any time.
• Ask any questions about the study at any time during participation.
• Provide information on the understanding that their name would not be used unless permission was given to the researcher.
• Be given access to a summary of the project findings when was concluded.
• Ask for the audio/video tape to be turned off at any time during the interview.

The research met the ethical criteria of Core Education Ltd.
Data collection and instruments

Data was collected for each student in the following manner:

1. The learning profiles were collected using a “Learning Style Analysis” form provided by “Creative Learning Systems” (downloaded from http://www.creativelearningcentre.com May, 2006). An example of the data analysis for each student is provided in Appendix III.

2. Classes were observed during activities involving a web-based tutorial, data logging, PowerPoint presentation and PowerPoint combined with a personal response system. The classes were observed on two occasions for each activity. Each student was observed at 5 minute intervals to check engagement. A record sheet was kept for each activity. At the time of observation the student was checked against the list of indicators for signs of engagement (Appendix II). If a positive match was found a tick was placed against the student. Appendix V shows a typical record sheet for one activity. Appendix IV shows a summary of engagement for one student over all activities.

3. Students were surveyed to provide feedback on their impressions of the ICT learned in terms of engagement, learning and enjoyment. A typical student response is shown in Appendix IV.

4. Students were individually interviewed to provide further feedback on their ideas on ICT in Physics. A typical student response is shown in Appendix IV.

5. The students were assessed using the PRS (which assessed immediate understanding of the PowerPoint lesson), the web based assignment, Autoassign (which assessed short term understanding) and a topic test (for longer term overall learning). A typical student achievement is shown in Appendix IV.

Typical results for a student are included in Appendix IV.

Lesson Organisation

The unit observed was a study of light, which was part of Achievement Standard 90254, and was taught during the second part of term 2.

The intervention was designed and the e-learning technology adapted according to the unit.

The Technology and associated Learning Style modality(s) are shown in Table 1:

- Each ICT was assessed to determine what learning style was associated with it, based on the definitions of Visual, Auditory, Tactile and Kinaesthetic learning styles (see sensory modalities p. 15)
- The unit was developed to maximise the use of technology and deliver lessons that maximised learning opportunities appropriate to each Learning Style modality. A lesson by lesson plan was developed. (Appendix I)
- Each lesson subtopic allowed opportunities for students to learn using their preferred learning modality(s) either in an e-learning context or otherwise.

E-learning applications used.

The applications available made it impossible to select separate applications to uniquely suit each learning style. Some applications suited two or more Learning Style modalities.
This research did not attempt to address Auditory Learning by e-learning means. It subsequently emerged only one person had a preference for Auditory Learning.

The list below indicates the e-learning applications used and the Learning Style modalities that they addressed. The learning styles that they addressed were determined by comparing the learning style definitions for each sense with the characteristics of the technology. For instance the online tutorial has no sound and does not involve the student in a bodily fashion. The tactile modality is limited to scrolling with a mouse.

**Table 1: Technology and Associated Learning Style Modality(s)**

<table>
<thead>
<tr>
<th>E-learning Technology</th>
<th>Learning Modality(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Online Tutorial</td>
<td>Visual</td>
</tr>
<tr>
<td>PowerPoint</td>
<td>Visual, Auditory</td>
</tr>
<tr>
<td>Data logging</td>
<td>Kinaesthetic, Tactile</td>
</tr>
<tr>
<td>PowerPoint with Personal Response System</td>
<td>Visual, Auditory</td>
</tr>
</tbody>
</table>

**Online tutorial (Henderson 2004)**

This covered in detail the aspects of physics in this topic. The tutorial is presented in the form of notes to be read and interactive review problems at the end of each lesson. There are applets in some lessons e.g. reflection of light. The learning style modality associated with this application is mainly visual. Specifically it is reading only with some tactile movement required to scroll the pages.

**PowerPoint**

The PowerPoint presentations covered areas of the topic by using condensed notes with verbal explanation and step by step diagrams which were sequenced to show how light behaved in various situations, such as reflection in a mirror. The learning style modalities associated with this were visual for reading and watching the diagrams and auditory for listening to the teacher.

**Data logging**

The data logging equipment consisted of a sensor which could be linked directly to a computer or to a remote data storage device. Software on the computer enabled analysis of the data collected in either tabular or graphical form.

The hardware used was the Pasco Pasport range supplied by Gough Technology (www.goughs.co.nz). The data was analysed using Data Studio software. The advantage of this type of hardware is that it is “plug and play” and very intuitive to operate. The learning style modalities associated with this activity were mainly kinaesthetic. Students were able to be physically involved and were able to manipulate and handle the equipment.
The task sheet for the activity is shown in Appendix VI.

Figure 7 shows the data logging equipment being prepared for use to measure light intensity. Pictured is a light sensor attached to an Xplorer remote data logger.

**Figure 7: Data Logging Equipment (personal photograph November 7, 2006)**

Personal Response System (PRS)

The PRS is an interactive e-learning tool. The students respond to questions presented via a data projector using infrared remote devices. The questions are typically multi-choice to enable the response to be a number or letter pressed on the remote. The response is collected by a detector and fed to the computer. Students get instant feedback on their response and a graph displays the class answer distribution. Student responses can be made anonymous. The data is stored and can be retrieved for analysis by the presenter.

The questions can be presented as a stand alone quiz or as part of a PowerPoint presentation.

**Figure 8: Using the PRS system (PRS_image)**
PowerPoint with PRS

This was a combination of the two techniques above. A PowerPoint presentation with inbuilt PRS questions was used to review student understanding of the presentation.

Autoassign (Autoassign 2006)

This is a web based program which enables questions to be posted on the site via a free account. Students are invited to log into the site. Once they have authorisation they complete the questions online. The answers can be either set up to be marked by the program or marked later. Results are stored online or can be transferred.

The teacher has the ability to e-mail the students from the program.
DATA ANALYSIS
Data analysis followed the following sequence

1. Determining the learning profiles of the students.
The learner profile analysis forms were entered into the web site program of “Creative Learning Systems” at (http://www.creativelearningcentre.com/). See Table 2. The learning style analysis provided by Creative Learning Systems provides data over a wide range of learning style preferences as indicated in Figure 6. A detailed analysis of each student is provided in Appendix I. This present research considered it necessary to control as many variables as possible and focus only on the four sensory modalities, VAKT, as these could be matched to the ICT used.
   a. The Auditory learning style considers listening.
   b. The Visual learning style considers reading and seeing/watching
   c. The Kinaesthetic learning style considers use of the body
   d. The Tactile learning style considers manipulation of learning material

2. Matching students to engagement for types of ICT.
Each student was observed each five minutes and engagement/disengagement recorded. The engagement for each activity was calculated as a proportion of number of times students were observed to be observed engaged to total number of observations expressed as a percentage. This analysis is presented in Table 3. The learning styles of the students and the activities are presented to allow for a comparison. The table shows three categories of learning style preference. According to Prashnig (2000):
   The “preference” indicates the modalities the student would most like to use when learning difficult material.
   The “flexibility” indicates the student can use this modality when interested in the material to be learnt
   The “non-preference” indicates the student finds it difficult to learn difficult material when presented in this modality.

3. Comparison of learning styles’ engagement for activities.
Tables 4-7 compare engagement of students whose learning styles match those of a particular activity to those whose learning styles do not match a particular activity. The average engagement for the matching students and the non-matching students was calculated along with a standard deviation to give some estimation of the spread of the data.

4. Rating of activities.
Table 8 shows the students’ rating of each activity. This data was collected from written surveys completed by each student. The students were asked to rate the activities on the basis of enjoyment, learning and engagement using a 1-4 scale.

5. Collating learners assessment results.
This involved comparing assessment for the PRS, Autoassign and Summative test, Table 9. The results of the Summative test were then compared with the Summative test of other modules taught throughout the year, Table 10.
**FINDINGS**

**Learning profiles**

Table 2 shows the Learning Style modalities for the auditory, visual, tactile and kinaesthetic modalities of students in the 12Phy class. The students are identified by number. The numbers correlate with the numbers in Appendix III. The sum at the bottom gives an indication of the number of preferred modalities in the class. Because some students are multi-modal the number of preferences is higher than students.

<table>
<thead>
<tr>
<th>Student (by number)</th>
<th>Learning style modality(s) of each student</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Auditory</td>
<td>Visual</td>
<td>Tactile</td>
<td>Kinaesthetic</td>
</tr>
<tr>
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</tr>
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<td>8</td>
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</tr>
<tr>
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<td>X</td>
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<td>13</td>
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<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>Total preferences in class</strong></td>
<td>1</td>
<td>9</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

✓ A definite “preference” for this sensory modality

✗ A definite “non-preference” for this sensory modality

A blank indicates the student is “flexible” to this modality

Table 2 indicates that the majority of students have a preferred ability to learn in more than one modality. The implication for the research was that they engaged in more than one of the e-learning activities using a preferred modality for that activity.

Four of the students do not have any preference but do have the “flexibility” to learn in several styles. This means they can use a flexible learning style if they find the material interesting (Prashnig 2000).

There are very few “non-preferences” in the table. Listening and kinaesthetic are those with the non-preferences. The two students who have a non-preference for kinaesthetic learning are a concern considering that physics is a practical based subject. As will be
seen later the data logging, primarily a kinaesthetic activity, was not popular with some students. This is counterbalanced to some extent by the preferences and flexibilities for the tactile modality.

Only one student has a preference for listening. Visual and tactile preferences are the most preferred modalities.

**Engagement**

Table 3 shows engagement of students in e-learning activities. The numbers represent the percentage of time the students were recorded as being engaged in the activity. The engagement indicators, as included in Appendix II, were used as a positive sign of engagement.

**Table 3 Engagement of Students in Different e-learning Activities (shown as percentage of time engaged)**

<table>
<thead>
<tr>
<th>Student</th>
<th>Preferred Learning Style(s)</th>
<th>Data Logging</th>
<th>Tutorial</th>
<th>PowerPoint A, V</th>
<th>PowerPoint PRS A, V, T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>V, T, K</td>
<td>100</td>
<td>100</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>V, T, K</td>
<td>80</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>V</td>
<td>75</td>
<td>60</td>
<td>90</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>AV</td>
<td>80</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>T</td>
<td>abs</td>
<td>60</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>V</td>
<td>80</td>
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<td>100</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>8</td>
<td>VT</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>50</td>
<td>40</td>
<td>60</td>
<td>90</td>
</tr>
<tr>
<td>10</td>
<td>VKT</td>
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<td>100</td>
<td>60</td>
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</tr>
<tr>
<td>13</td>
<td>V, T, K</td>
<td>abs</td>
<td>40</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Average engagement in activity</td>
<td>86</td>
<td>77</td>
<td>87</td>
<td>98</td>
<td></td>
</tr>
</tbody>
</table>

**Key:**

A = Auditory  
V = Visual  
T = Tactile  
K = Kinaesthetic  
abs = absent

The personal response system proved to be the most engaging of all the e-learning applications used across all modalities. In terms of engagement there was almost 100% engagement. The PRS was new and different but also was the e-learning application that matched most of the learning style modalities (Visual and Tactile) and was a good fit with digital native requirements (Jukes 2006).

The engagement was reduced for other ICT techniques. It appeared to be that the fewer the number of modalities in the activity the lower the engagement of the students.
The *PowerPoint presentations* covered visual (reading) and aural (listening) modalities. The *Data Logging* covered the kinaesthetic (doing) and tactile (touching, handling) modalities. These had a similar level of engagement, 87% and 86% respectively on average.

The lowest level of engagement occurred when the e-learning was presented in only one modality, as in the Online Tutorial. The Online Tutorial was quite verbose and challenging for all.

Each activity was then analysed to determine the engagement of the students whose learning style matched that of the activity compared to the engagement of the students whose learning styles did not match that of the activity. The average and standard deviation of each set of data have been calculated to give some idea of the extent of engagement and the spread of data. For the data logging activity and web tutorial activity a chi-squared analysis has been carried out to determine whether there is a significant difference in the two sets of data. These are summarised below.

### Table 4 Engagement of Students in the Data Logging Activity (K,T)

<table>
<thead>
<tr>
<th>Students who match activity</th>
<th>Learning style preferences</th>
<th>Engagement (%)</th>
<th>Students who do not match activity</th>
<th>Learning style preferences</th>
<th>Engagement (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VTK</td>
<td>100</td>
<td>3</td>
<td>V</td>
<td>75</td>
</tr>
<tr>
<td>2</td>
<td>VTK</td>
<td>80</td>
<td>4</td>
<td>AV</td>
<td>80</td>
</tr>
<tr>
<td>5</td>
<td>T</td>
<td>75</td>
<td>6</td>
<td>V</td>
<td>80</td>
</tr>
<tr>
<td>8</td>
<td>VT</td>
<td>100</td>
<td>7</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>10</td>
<td>VTK</td>
<td>100</td>
<td>9</td>
<td>-</td>
<td>50</td>
</tr>
<tr>
<td>13</td>
<td>VTK</td>
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<td>12</td>
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<td>12</td>
<td></td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>

Average % engagement 92.5  
Standard deviation 12  

<table>
<thead>
<tr>
<th>Significance: $\chi^2 = 3.35$</th>
<th>Probability of null hypothesis $0.10&lt;P&lt;0.05$</th>
</tr>
</thead>
</table>

Data Logging does not show a significant correlation between the learning style preference of the student and the learning style of the activity. The probability between 5% and 10% is slightly above the conventionally significant level of 0.05, so the null hypothesis (that the two sets of data are the same) is not disproved. It is therefore quite conceivable that the engagement of Kinaesthetic/Tactile learners and non-Kinaesthetic/Tactile learners is the same. While there appears to be a marginal difference between the average engagement of “matching” students and the “non-matching” students the data is not significantly different in statistical terms.

The Online Tutorial (Table 5) also shows a significant difference between the “matching” students engagement and the “non-matching”. The probability of a null hypothesis is between 0.1% and 1%, well below the accepted figure of 5%. However the data this time is much more variable and widespread. Some “matching” individuals such as students 3 and 9 show much lower levels of engagement than other individuals whose learning styles “match”.

37
Table 5 Engagement of Students in the Online Tutorial (V)

<table>
<thead>
<tr>
<th>Students who match activity</th>
<th>Learning style preferences</th>
<th>Engagement (%)</th>
<th>Students who do not match activity</th>
<th>Learning style preferences</th>
<th>Engagement (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VTK</td>
<td>100</td>
<td>5</td>
<td>T</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>VTK</td>
<td>100</td>
<td>7</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>V</td>
<td>60</td>
<td>9</td>
<td>-</td>
<td>40</td>
</tr>
<tr>
<td>4</td>
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<td>8</td>
<td>VT</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>VTK</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>13</td>
<td>VTK</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average % engagement 85  Average % engagement 65  
Standard deviation 23  Standard deviation 34  
Significance: $\chi^2 = 8.35$  Probability of null hypothesis $0.001 < p < 0.01$

Both the PowerPoint Presentation and the PowerPoint Presentation with PRS show no discernable difference between matching and non-matching students

Table 6 Engagement of Students in the PowerPoint Presentations (VA)

<table>
<thead>
<tr>
<th>Students who match activity</th>
<th>Learning style preferences</th>
<th>Engagement (%)</th>
<th>Students who do not match activity</th>
<th>Learning style preferences</th>
<th>Engagement (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VTK</td>
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<td>5</td>
<td>T</td>
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<tr>
<td>2</td>
<td>VTK</td>
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<td>3</td>
<td>V</td>
<td>90</td>
<td>9</td>
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<td>4</td>
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<td>11</td>
<td>-</td>
<td>70</td>
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<td>VT</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>VTK</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>VTK</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average % engagement 87.5  Average % engagement 86  
Standard deviation 21  Standard deviation 19
Table 7 Engagement of Students in the PowerPoint Presentations with PRS (VAT)

<table>
<thead>
<tr>
<th>Students who match activity</th>
<th>Learning style preferences</th>
<th>Engagement (%)</th>
<th>Students who do not match activity</th>
<th>Learning style preferences</th>
<th>Engagement (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VTK</td>
<td>100</td>
<td>7</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>VTK</td>
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<td>9</td>
<td>-</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>V</td>
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</tr>
<tr>
<td>4</td>
<td>AV</td>
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</tr>
<tr>
<td>5</td>
<td>T</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>V</td>
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<td>VT</td>
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<tr>
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</tr>
<tr>
<td>13</td>
<td>VTK</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average % engagement 97.8
Average % engagement 97.5
Standard deviation 7
Standard deviation 5

Rating of activities

The students were asked to put the activities they preferred in order. Table 8 shows the e-learning activity ratings of each student. A rating of 4 being the most preferred and 1 least preferred. The preference is a combination of how the student enjoyed the ICT, how engaged they felt and how much they learnt from the activity.

Table 8: Rating of E-learning activity by each Student

<table>
<thead>
<tr>
<th>Student</th>
<th>Preferred Learning Style(s)</th>
<th>Data Logging T, K</th>
<th>Tutorial V</th>
<th>PowerPoint A, V</th>
<th>PowerPoint PRS A, V, T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>V, T, K</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>V, T, K</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>V</td>
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<td>3</td>
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<tr>
<td>8</td>
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</tr>
<tr>
<td>12</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13</td>
<td>V, T, K</td>
<td>abs</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

These results compared the e-learning used on the criteria of enjoyment, perceived amount learned and perceived engagement.

The PRS rated very highly. It was interesting to observe the class during one of these lessons and note the excitement that this e-learning generated. Comments of “cool” and
in a similar vein were common. The PRS was used in another class and with teachers and generated much the same reaction. Not only did it raise engagement but there was genuine enjoyment in its use. A typical comment was:

“I like the PRS with the PowerPoint presentation as it makes sure you understand and have taken in what has just been said.”

The immediate feedback was the key element that was voiced by most students. Two students also mentioned the competitive element of the PRS.

The PowerPoint Presentations were also rated very highly. Comments were in the vein that

“There was not much reading”, “they were interactive and made the material easy to understand”.

A typical comment was:

“very good – interesting and different; an enjoyable change to the usually boring work.”

This was from a kinaesthetic person, who obviously needed to have their interest raised to get involved.

Data logging was favoured by the kinaesthetic and tactile modalities, as expected. Typical comments were:

“It’s easier to understand the principles of physics when actually doing the experiment or demonstration”.
“Data loggers and PRS were cool”.

The online tutorial was the least preferred across all modalities. Some comments from two kinaesthetic learners were:

“The online tutorial was really long and boring”.
“The online tutorial was wordy and made it hard to take in”.

One multimodal person commented:

“If the online tutorial was summed up a bit more with bullet points it would be more effective.”

**Assessment results**

The assessment was completed in three stages.

1. The PRS results give percentages of correct answers given by students during a PowerPoint presentation. It gives immediate feedback on understanding following a visual presentation with verbal explanation. This is valuable in assessing whether there was any correlation between the preferred learning style modality of the student, the teaching style modality of the PowerPoint presentation and the learning in this particular situation.

   It was interactive and allowed discussion, clarification and reinforcement of ideas immediately they had been presented. This was a powerful tool. Additionally,
responses were recorded for later analysis. Individual and group lack of understanding could be followed up. Table 9 indicates that there were three students who were V, T, K as preferred modalities. It was expected that the V, T preferred modalities would suit the PowerPoint with the PRS. However two of these students (2 and 10) performed very poorly in this assessment compared to the Autoassign assessment and final test. Both these students were among the lower engagers for the PowerPoint only. The raw data collected also indicates that student 10 engaged only during the PRS section of the assessments.

2. AUTOASSIGN gives:
   - The number of questions attempted online as a percentage of those available to be attempted.
   - The percentage correct answers from those that were attempted.

The AUTOASSIGN testing program was attempted after each subsection of the work was completed. Students had the opportunity to use all learning styles and use any resources while doing the assignment. The Autoassign offered immediate response for simple answers or graded response for more complex answers. Students could see their progress and gauge where they were ranked in the class. The teacher could communicate directly with students via e-mail, also a powerful tool. Students had the opportunity to complete the assessment out of class time by logging on to the site. Most students completed 25 or more questions which gave a representative sample of the work covered. Two students (4 and 11) completed 9 questions only which were unrepresentative of the work covered. The uniformity of the achievement and the level of achievement indicate that all learning style modalities appear to have had the opportunity to learn throughout the trial period.

3. The test was a summative test of all work and was attempted at the completion of the unit. The students were not told to study for the test (results may have been affected by home revision). It was an indicator of “in-class” learning during the unit of work. It was a written test of similar standard to the external assessment for this achievement standard.

Parts 2 and 3 allowed testing of the intervention on a whole to assess short term and long term understanding of the material presented.

The data is summarised in Table 9 below.
Table 9: Assessment during the research by each student

<table>
<thead>
<tr>
<th>Student</th>
<th>Preferred Learning Style(s)</th>
<th>PRS</th>
<th>Autoassign</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Attempted (Number)</td>
<td>Achieved</td>
</tr>
<tr>
<td>1</td>
<td>V,T,K</td>
<td>57</td>
<td>42</td>
<td>74</td>
</tr>
<tr>
<td>2</td>
<td>V,T,K</td>
<td>22</td>
<td>24</td>
<td>71</td>
</tr>
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<td>V</td>
<td>63</td>
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<td>84</td>
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</tr>
<tr>
<td>10</td>
<td>VKT</td>
<td>25</td>
<td>27</td>
<td>63</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>63</td>
<td>9</td>
<td>66</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>50</td>
<td>25</td>
<td>44</td>
</tr>
<tr>
<td>13</td>
<td>V,T,K</td>
<td>a</td>
<td>25</td>
<td>86</td>
</tr>
</tbody>
</table>

Key
The letters represent attainment as per NCEA:
N = Not achieved
A = Achieved
M = Merit
E = Excellent
a = absent

Table 10 compares the achievement of the students in this unit with their achievement in two other completed units outside of the intervention. The level of achievement for each student during the intervention is as good as, or better, than that outside of the intervention.

Table 10: Assessment of research unit, mechanics unit and atoms unit.

<table>
<thead>
<tr>
<th>Student</th>
<th>Preferred Learning Style(s)</th>
<th>Light Unit</th>
<th>Mechanics Unit</th>
<th>Atoms Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>V,T,K</td>
<td>M</td>
<td>A</td>
<td>M</td>
</tr>
<tr>
<td>2</td>
<td>V,T,K</td>
<td>A</td>
<td>N</td>
<td>A</td>
</tr>
<tr>
<td>3</td>
<td>V</td>
<td>E</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>4</td>
<td>AV</td>
<td>a</td>
<td>M</td>
<td>A</td>
</tr>
<tr>
<td>5</td>
<td>T</td>
<td>a</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>6</td>
<td>VT</td>
<td>a</td>
<td>A</td>
<td>N</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>M</td>
<td>M</td>
<td>A</td>
</tr>
<tr>
<td>8</td>
<td>VT</td>
<td>A</td>
<td>N</td>
<td>A</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>10</td>
<td>VKT</td>
<td>M</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>M</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>13</td>
<td>V,T,K</td>
<td>a</td>
<td>N</td>
<td>E</td>
</tr>
</tbody>
</table>

Key
The letters represent attainment as per NCEA:
N = Not achieved
A = Achieved
M = Merit
E = Excellent
a = absent
DISCUSSION AND CONCLUSIONS

Learning styles and e-learning

The main question asked at the start of this research was:

What is the effect on students’ engagement and learning when given the opportunity to use ICT in ways that relate to their own learning style preferences?

The number of multi-modal students and the small sample makes it difficult to come to any definitive conclusion as to whether students’ engagement had any relationship to their learning style being compatible with that of the activity.

The online tutorial showed a difference between the engagement between “matching” learning styles and “non-matching” learning styles. However, as the standard deviations indicate, there is a wide spread in the percentage engagements in both sets of data.

For instance, students 3 and 13, both visual learners, showed low engagement in the tutorial which is a visual activity. The online tutorial was quite long and verbose. If the students were not interested in the material presented then this could provide a reason for the low level of engagement. From the preference table it can be seen that the tutorial was the least favoured activity.

It strongly suggests that asking students to sit at computers and digest large amounts of material is not a worthwhile exercise.

There was a tentative suggestion that the kinaesthetic and tactile learning styles had a higher engagement than the other learning styles in the data logging activity though not proven by the chi squared test. The kinaesthetic learners also rated this activity as the 1st or 2nd most favoured of the activities. This tends to illustrate Prashnig’s (Prashnig, B. Personal communication 2005) point that kinaesthetic learners do need to do something physical with the information that they receive in order to process it. My recommendation is that in Physics kinaesthetic learners need to be catered for by providing as much practical work as possible. The market is providing more and more excellent ICT tools that enable rapid analysis, feedback and interaction that will appeal to all students. The Pasport equipment used in this research is an example of this; however there are many options available.

The other activities either did not show any difference between matching and non-matching learning styles or there were some anomalies that do not fit with such a hypothesis.

Students 2 and 10, both VKT, showed low engagement with the PowerPoint presentation. This fits with the hypothesis if they were solely kinaesthetic learners but not with the associated visual learning modality. Both these students had low achievement in the PRS assessment based on the PowerPoint presentations. This appears to correspond with the low engagement.

The findings also indicate that learning is as least as good as or better than when “normal” teaching techniques are used (Table 10). It should be noted that students had
the opportunity to learn using their particular learning style preference for all parts of this topic, whether in an ICT mode or more “conventional”.

Limitations
Difficulties with the research included:
• The small number of students.
• The small number of trials.
• The small range of e-learning applications.
• Finding e-learning applications to match a single learning style.
• The students with multiple learning style modalities.

The time available put constraints on the size of the exercise. The multiple learning style modalities will be a problem in any population, however, the larger the population the more chance of discriminating between individual modalities. Some recommendations are suggested below for improving the reliability and processing of results:

Population:
Increase the size of the population to include other physics classes. This could be all of year 12 who do the same monitored ICT activities. The population will be a limited by the population of students doing the same work.

Longevity:
Allow the study to extend over all of the year 12 units and into year 13 units. The length of this study was approximately four weeks. An extended study could then run into approximately 50 weeks over the two years with the same population. This will allow activities to be repeated and data replicated.

Data analysis:
Set up a template on Excel to allow easy entry and rapid analysis of data.

Refine Activities
Each of the activities could have been modified to make them more engaging. For instance:
• The online tutorial was long winded, verbose and hence boring to the students. It addresses mainly a visual modality. As an improvement each topic and subtopic can be summarised and bullet pointed to include main concepts, including images. Regular interactive feedback should be provided. Reference can be made to applets and appropriate sites on the internet for further study and interest. The tutorial could be constructed through web access via interact or free web based sites. Moodle provides an excellent tool for providing an interactive session.
• The data logging was clumsy in its set-up in that it required students to record results onto a hand held device and then take these to a computer for downloading and analysis. The learning becomes much more relevant if the feedback is instant, and this also allows for altering of variables when “what-if” questions are asked. This can be achieved by taking the activity to the computer suite, supplying laptops to the classroom or using a handheld
computer for analysis. A number of companies now supply these. The MOTIS project (2005) being conducted in Wellington is investigating similar technology in the classroom. This is an excellent kinaesthetic/tactile activity but can be utilised visually and in an auditory fashion

- The PowerPoint presentations provide a valuable means of communicating information. Presentations can be made more interesting if presented in story mode as outlined by Atkinson (2005) and Reynolds (2006). The interest in the presentation can be enhanced by adding video and sound where relevant. By increasing the interest level it will assist kinaesthetic and tactile learners who find learning visually and aurally more difficult

- The PRS proved a valuable tool in improving the interactivity of the lesson and engaging all students. It also was a valuable tool for assessing understanding of individuals and the class as a whole. The trial would have been enhanced by assessing learning after each activity using this tool. It enables inclusion of tactile learners into this type of presentation.

- In this trial a strictly aural activity was not provided. Podcasts with summaries of key concepts could be provided for students to download onto MP3 players.

Reproducibility
The reproducibility of the learning style analysis could be checked by re-conducting the analysis after a specified period of time such as 3 months. This would allow sufficient time for the familiarity of the questions to wear off without being too long a period that would allow doubt to occur as to whether the student had altered learning style modalities.

Indicators:
The indicators used tended to be “over-specified”. The complete range in Appendix II is wide ranging and all encompassing. However having embraced them they provide a valuable tool for practical use in the classroom observation phase. My recommendation is that in any given situation they be modified to suit.
In practice I found the body language behaviours most helpful followed by inquisitive behaviours. These behaviours could be easily identified from a distance by direct observation.
The least useful in my particular situation were the “Passion and Self-motivation”, “Verbal behaviours” and “Collaborative Behaviours”. Aspects of all sections were, however used on different occasions.
The “Passion and Self-motivation” behaviours required questioning of the student to seek qualification of the behaviour or a judgement to be made of the behaviour. “Verbal behaviours” required close contact with the student and the activity with the risk of interfering with the “natural process” of events. Collaborative behaviours were not so easy to observe or once again required close contact or questioning of the student’s behaviours.

Teachers can take from this research the need to examine critically any teaching mechanism used and ensure that the mechanism is used in such a way that all learning
style modalities are addressed. Prashnig (2005) also highlights this point and alerts teachers to be aware of the needs of kinaesthetic learners. The findings of this research tentatively support this statement. Each learning outcome should encompass activities that address kinaesthetic modalities. It is fortunate that physics lends itself to kinaesthetic activities. Physics teachers should embrace the opportunity to allow students to have hands on experience with physics to allow a context for the theory to be developed. ICT tools are becoming more prolific in the marketplace. They are intuitive to use and allow rapid retesting of practical situations.

Bruen (2002) and Felder (1993) both point out the need for software developers to provide applications that address the learning style modalities of students. Canavan (2004) discusses how the computing department at Dublin University is developing personalised e-learning through learning style aware adaptive systems. Learning style information is integrated into an Adaptive Hypermedia System to offer increased personalisation. A prototype course was developed which incorporated this model into an adaptive system. The program assesses the student’s learning style modalities and automatically configures itself to match these. My findings suggest that kinaesthetic students need to get up and do something physical with the information. It is difficult to see an Adaptive Hypermedia System addressing the needs of kinaesthetic learners. In a teacher directed classroom there would appear to be little need for such adaptive systems, especially in a physics situation.

These types of programs are a step in the direction of improving engagement of students when direct teacher instruction is not available. However, I also believe we need to critically analyse the way the material is presented. As this research demonstrates, students do not like over verbose non-interactive presentations. The role of ICT delivery is further examined below.

E-learning in the classroom

Sub-question
What e-learning is suitable for use in today's classroom with students who have grown up with this technology?

The results in this research show clearly that we need to be selective in the e-learning activities that we use and how they are used. The Online Tutorial is a good example that did not appeal to any of the learning styles and certainly not to a Digital Native.

The use of the data loggers in this research was of a passive nature and tended not to be popular i.e. the use in this project was to record the data and then take the data to a computer for analysis. The instant analysis of data at the site of the activity provides feedback and interactivity that links what the student is doing to the physics “map” created (i.e. the physics theory). Additional activities can flow with rapid trial and analysis. The lesson to be learned from this is that the data logging activity needs to be adapted so that the students get rapid responses and can work through a variety of situations. Having a computer or hand held computer in these situations allows multi testing and the asking of “what-if” questions.

The PRS is an example of real time learning with rapid interaction and feedback. The learning becomes more active and less passive. For instance, an auditory/visual lesson such as PowerPoint can engage tactile learners and to some extent kinaesthetic learners.
Some suggestions that may go part of the way to address learning style and interactive ICT requirements are:

- Develop interactive whiteboard lessons coupled with interactive pads. Design lessons such that the tactile and kinaesthetic learners are involved interactively with this equipment.
- Use PowerPoint presentations that tell a story and contain sound and video and applets. The story engages the student. If the PowerPoint is graphical and not bullet pointed the imagination of the student is engaged. Video and applets engage auditory and visual learners.
- Get students to video practical demonstrations and analyse the video; Vernier software market an application that does this as well. The student is engaged using all modalities, VAKT. The Vernier software allows direct comparison between the concept of what is happening and the physics “map” produced.
- Develop interactive data logging sessions. This research project indicates the higher the interactivity the greater the engagement. The instant feedback allows for expansion on the data collecting and asking “what if?” questions.
- Use personal response systems as interactive on-going assessment tools. The students are provided with instant feedback on their learning and misunderstandings can instantly be remedied. Teachers have recorded individual and class trends in the understanding of the work. The highly interactive nature of the PRS engages the student.
- Provide podcasts for all topics. Auditory learners can use these beneficially with their MP3 players. They provide a valuable revision technique for this style.
- Develop interactive wikis or use a platform, such as Moodle, that allows online interactive assignments. Students can have 24 hour access to the work. Teachers get rapid response to their students’ application and achievement.

Table 11 below summarises the above suggestions in light of learning style and interactivity.

Table 11. Summary of ICT Suggestions

<table>
<thead>
<tr>
<th>ICT</th>
<th>Learning Style Addressed</th>
<th>Interactivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interactive whiteboard and tablet</td>
<td>Visual, tactile, kinaesthetic</td>
<td>High</td>
</tr>
<tr>
<td>PowerPoint</td>
<td>Visual, auditory</td>
<td>Low</td>
</tr>
<tr>
<td>Video analysis</td>
<td>Visual, auditory, tactile, kinaesthetic</td>
<td>High</td>
</tr>
<tr>
<td>Data Logging</td>
<td>Visual, tactile, kinaesthetic</td>
<td>High</td>
</tr>
<tr>
<td>PRS</td>
<td>Visual, auditory, tactile</td>
<td>High</td>
</tr>
<tr>
<td>Podcasts</td>
<td>Auditory</td>
<td>Low</td>
</tr>
<tr>
<td>Wikis</td>
<td>Visual, tactile</td>
<td>Medium - high</td>
</tr>
</tbody>
</table>

Developing lessons that are pedagogically sound and address the attributes of learning style, especially kinaesthetic, and interactivity would appear to be a step in more meaningful engagement of today’s student.
Summary:

- These findings do not conclusively show that the use of activities based on matching the learning style of the activity to that of the student results in increased engagement and learning.
- There is some evidence to suggest that a higher degree of interactivity and feedback leads to higher engagement, as with the PRS. The trial would need to be extended for a longer period to allow the novelty of the activity to dissipate.
- Sitting students in front of computers does not necessarily lead to learning.
- The lower the number of modalities involved in an activity the lower the engagement.
- This conclusion agrees with the Coffield et al. (2004) and Markham (2004) where both indicate that extended longitudinal research is required to verify the use of learning styles in education. The promising results of the meta-analyses carried out on research involving the Dunn and Dunn model (Lovelace 2005) suggest that this research is worthwhile.
- I recommend lessons provide multi-modal learning opportunities and be highly interactive.

The challenge is laid down. Educators must embrace e-learning in a productive and pedagogical consistent way if kinaesthetic learners and digital natives are to be engaged in our classrooms.
**GLOSSARY**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Becta</td>
<td>British Educational Communications and Technology Agency</td>
</tr>
<tr>
<td>Blog</td>
<td>A personal web based log that allows comments from others.</td>
</tr>
<tr>
<td>DVD</td>
<td>Officially “Digital Video Disc” or unofficially “Digital Versatile Disc”</td>
</tr>
<tr>
<td>ICT</td>
<td>Information and Communication Technology</td>
</tr>
<tr>
<td>LSI</td>
<td>Learning Style Instrument</td>
</tr>
<tr>
<td>MOTIS</td>
<td>Mobile Technologies in the Sciences</td>
</tr>
<tr>
<td>OHP</td>
<td>Overhead projector</td>
</tr>
<tr>
<td>PRS</td>
<td>Personal Response System</td>
</tr>
<tr>
<td>VAKT</td>
<td>Visual, Auditory, Kinaesthetic, Tactile</td>
</tr>
<tr>
<td>Wiki</td>
<td>A website or similar online resource which allows users to add and edit content collectively.</td>
</tr>
</tbody>
</table>
REFERENCES


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we know about students' attitudes and experiences of ICT that will help us design


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## APPENDICES

### APPENDIX I

Lesson Outline for Research Period

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>CONCEPT/ACTIVITY</th>
<th>VISUAL AIDS/TEACHING MATERIALS</th>
<th>HOMEWORK</th>
</tr>
</thead>
</table>
| 1      | Light intensity vs distance | Data loggers, light sensors, Xplorers
Go to web tutorial.
“Reflection and its importance” Lesson 1 | Log into auto assignment site |
| 2      | Reflection and its importance | Web tutorial
“Image Formation in plane mirrors” Laser demo
Mist and laser
Experimental work Ray box, mirror angles | Assignment 1 on computer Angles of reflection |
| 3      | Image formation in plane mirrors | Assignment 2 PRS Mirrors and reflection Light Powerpoint Examples Hair on fire Pinboard Image in plane mirror | Web tutorial “Concave mirrors” Lessons 1-4 |
| 4      | Concave Mirrors | Anatomy of mirror Look at mirror shape Definitions Sun/paper demo Find focus ways Object/image exp Concave mirrors Power point with PRS | Web tutorial “Concave mirrors” Lessons 5,6 Assignment light 3-16 concave mirror problems |
| 5      | Convex Mirrors | Convex mirror images example Practical Power Point with PRS | Web tutorial “Convex mirrors” Assignment 4 |
| 6      | Refraction at a boundary | Experimental work Assignment1 Power Point with PRS | Web Tutorial Refraction and ray model of light “lesson 1” |
| 7      | Mathematics of Refraction | Worked examples Autoassignment Refraction 2 | Web Tutorial Refraction and ray model of light “lesson 2” |
| 8      | Total Internal reflection | Other examples TIR Autoassignment TIR | Web Tutorial Refraction and ray model of light “lesson 3” |
| 9      | Image Formation by Lenses | Experimental work Problem solving Assignment 1 with PRS | Web Tutorial Refraction and ray model of light “lesson 5” Lens Assignment 2 |
APPENDIX II

**Engagement Indicators** (R. Dowling personal communication, February 28, 2006)

<table>
<thead>
<tr>
<th>QUANTITATIVE BEHAVIOURS</th>
<th>QUALITATIVE BEHAVIOURS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Body language behaviours</strong></td>
<td><strong>Passion And Self-motivation</strong></td>
</tr>
<tr>
<td>● Significant number of eye contact instances</td>
<td>● Genuine interest</td>
</tr>
<tr>
<td>● Physically moves towards the group or stimuli</td>
<td>● Forgets time</td>
</tr>
<tr>
<td>● Excitement animated gestures</td>
<td>● Eagerness</td>
</tr>
<tr>
<td>● Leaning forward</td>
<td>● Persistence with task</td>
</tr>
<tr>
<td>● Face and body square on during conversation</td>
<td>● Wondering</td>
</tr>
<tr>
<td>● Palm up gestures</td>
<td>● Commitment to the task</td>
</tr>
<tr>
<td>● Head nodding</td>
<td>● Happiness</td>
</tr>
<tr>
<td>● Excessive nodding</td>
<td>● Focusing on the task</td>
</tr>
<tr>
<td>● Laughing – open mouthed</td>
<td>● and not being distracted from it</td>
</tr>
<tr>
<td>● Tilted head - interest</td>
<td>● Accepting challenge</td>
</tr>
<tr>
<td>● Dilated pupils – wide-eyed</td>
<td>● Excitement</td>
</tr>
<tr>
<td>● Smiling</td>
<td>● Risk is no longer an obstacle</td>
</tr>
<tr>
<td></td>
<td>● Having fun</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Verbal Behaviours</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Hastened excited speech patterns</td>
</tr>
<tr>
<td>● Uses affirming statements about activity</td>
</tr>
<tr>
<td>● Uses superlatives</td>
</tr>
<tr>
<td>● Verbal agreement including changes in pitch, tone volume</td>
</tr>
<tr>
<td>● Makes positive comments</td>
</tr>
<tr>
<td>● Engages in “self-talk” about the task</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inquisitive behaviours</th>
<th>Collaborative behaviours</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Asks questions of the group</td>
<td>● Shares openly with others inside and outside school</td>
</tr>
<tr>
<td>● Asks questions of the teacher</td>
<td>● Asks questions of the group</td>
</tr>
<tr>
<td>● Asks questions of others indiscriminately (ie not necessarily just friends)</td>
<td>● Tutors others</td>
</tr>
<tr>
<td>● Seeks clarification</td>
<td>● Shares innovative ideas and discoveries</td>
</tr>
<tr>
<td>● Looks for information out of class time</td>
<td>● Frequently initiates contact with other students</td>
</tr>
</tbody>
</table>

The bold statements were most useful as indicators
APPENDIX III

Learning Modalities of 12Phy

The diagram below represents the complete learning profile of each student in the year 12 physics class.

<table>
<thead>
<tr>
<th>Group Results</th>
<th>12phy2006</th>
<th>waller brian</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group member code number</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>INFO. PROCESSING</td>
<td>sequential</td>
<td>??</td>
</tr>
<tr>
<td>THINKING STYLE</td>
<td>simultaneous</td>
<td>??</td>
</tr>
<tr>
<td></td>
<td>reflective</td>
<td>??</td>
</tr>
<tr>
<td></td>
<td>impulsive</td>
<td>??</td>
</tr>
<tr>
<td>SENSES</td>
<td>AUDITORY (hearing)</td>
<td>??</td>
</tr>
<tr>
<td></td>
<td>Auditory (external)</td>
<td>??</td>
</tr>
<tr>
<td></td>
<td>Auditory (internal)</td>
<td>??</td>
</tr>
<tr>
<td></td>
<td>VISUAL (words)</td>
<td>??</td>
</tr>
<tr>
<td></td>
<td>Visual (external)</td>
<td>??</td>
</tr>
<tr>
<td></td>
<td>Visual (internal)</td>
<td>??</td>
</tr>
<tr>
<td></td>
<td>TACTILE (touching)</td>
<td>??</td>
</tr>
<tr>
<td></td>
<td>Kinesthetic (external)</td>
<td>??</td>
</tr>
<tr>
<td></td>
<td>Kinesthetic (internal)</td>
<td>??</td>
</tr>
<tr>
<td>MOBILITY</td>
<td>movement needed</td>
<td>??</td>
</tr>
<tr>
<td></td>
<td>not needed</td>
<td>??</td>
</tr>
<tr>
<td>INTAKE</td>
<td>needed</td>
<td>??</td>
</tr>
<tr>
<td>TIME OF DAY</td>
<td>early morning</td>
<td>??</td>
</tr>
<tr>
<td></td>
<td>late morning</td>
<td>??</td>
</tr>
<tr>
<td></td>
<td>afternoon</td>
<td>??</td>
</tr>
<tr>
<td></td>
<td>evening</td>
<td>??</td>
</tr>
<tr>
<td>SOUND</td>
<td>quiet</td>
<td>??</td>
</tr>
<tr>
<td>LIGHT</td>
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<td>team</td>
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<td>??</td>
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<tr>
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<tr>
<td></td>
<td>non-conforming</td>
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</tr>
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<td>STRUCT/GUIDANCE</td>
<td>other-directed</td>
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<td>VARIETY</td>
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<td></td>
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</table>

Key:
- **Strong preference**
- + Preference
- --- Non-preference
- ||| Flexibility
- ?? Inconsistency

Left/right Dominance

Physical

Environment

Social

Attitude

56
APPENDIX IV
Student 1

Preferences

<p>| | | |</p>
<table>
<thead>
<tr>
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<tr>
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<td>Touching</td>
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<tr>
<td>Kinaesthetic</td>
<td>External</td>
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Survey

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<th>Engagement</th>
<th>% Learned</th>
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<td>Personal response system</td>
<td>Power point presentation</td>
</tr>
<tr>
<td>2</td>
<td>Personal response system</td>
<td>On line tutorial</td>
<td>Personal response system</td>
</tr>
<tr>
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<td>Data Loggers</td>
<td>On line tutorial</td>
</tr>
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<td>4</td>
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<tr>
<td>5</td>
<td>On line tutorial</td>
<td>Power point presentation</td>
<td>Data Loggers</td>
</tr>
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</table>

Interview

1. **How do you find physics as a subject?**
   Its one of my favourite subjects. I like using the computers. Some parts are easy. The radioactive topic was easy. The mechanics was pretty hard.

2. **In terms of your learning style, do you think normal teaching methods are effective?**
   Yes, but I am kinaesthetic and I like doing practicals..

3. **What is the best teaching in physics you have encountered?**
   ICT by far. Its way easier than a lecture! I am visual tactile person so I prefer ICT rather than sitting and writing and listening. Data Loggers and Personal Response System were cool. They were highly interactive and really help people like me learn.

4. **Does the introduction of technology help?**
   The introduction of technology helped a lot. I liked thePRS and the computers.

5. **How do you rate ICT use in relation to traditional techniques for your learning?**
   I reckon its awesome! Its fun and it helps me grip the topic better. Its easier to understand the principles of physics when actually doing the experiment or demonstration. I’m visual and tactile so I learn by doing not listening.
### Engagement

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<thead>
<tr>
<th>Activity</th>
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<th>✓</th>
<th>✓</th>
<th><strong>The student was hands on at all times</strong></th>
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### Assessment

**Autoassign**
- Possible 51
- Complete 42
- Correct 31

**PRS**

4/7

**Test:**

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<th>EXCELLENCE</th>
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<tr>
<td>MARK</td>
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<td>6</td>
<td>3</td>
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APPENDIX V
Typical Engagement Record Sheet

ACTIVITY NAME: *Data Logging*  
DATE: *12 June*

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</table>

2 took a passive role watching
9 unfocused
1 was hands on at all times
8 was actively assisting
4 was actively assisting
APPENDIX VI
Task Sheet: Light intensity vs distance

AIM: To establish a relationship between light intensity and the distance from a light source.

EQUIPMENT:
Lamp, Metre rule, Pasco Light meter, Xplorer recorder

METHOD:
1. Set up equipment as in photograph.
2. Ensure the room is as dark as possible.
3. Place the recorder at distances, “d”, from 10cm to 1m and record the light intensity at each point. Measure the distance between the light filament and the light sensor point as indicated by the white lines.

ANALYSIS
1. Download the data using data studio software.
2. Graph the data using Xcel
3. Establish the relationship between light intensity and distance.
APPENDIX VII

Chi-Squared Analysis

Calculation of expected values

<table>
<thead>
<tr>
<th></th>
<th>K, T</th>
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<th>Non- K, T</th>
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<tbody>
<tr>
<td></td>
<td>Observed (O)</td>
<td>Expected (E)</td>
<td>Observed (O)</td>
<td>Expected (E)</td>
</tr>
<tr>
<td>Engaged</td>
<td>38</td>
<td>34.46</td>
<td>43</td>
<td>46.53</td>
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<tr>
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<td>2</td>
<td>5.53</td>
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<tr>
<td>Totals</td>
<td>40</td>
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<td>54</td>
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</table>

Sample calculation:
K,T expected engaged = (81 x 40)/94 = 34.46

Calculation of $\chi^2$

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<th>Non- K, T $\chi^2$</th>
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<tr>
<td>Engaged</td>
<td>0.268</td>
<td>0.197</td>
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<tr>
<td>Not engaged</td>
<td>1.66</td>
<td>1.22</td>
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</table>

$\Sigma \chi^2 = 3.35$
2 d.f. $\Rightarrow$ 0.10 < $p$ < 0.05

Sample calculation for a 2x2 table:

Engaged K, T $\chi^2 = (38-34.46 - 0.5)^2/34.46 = 0.268$