Science Education European Platform

GRANT AGREEMENT NUMBER:2009-3815/001-001

Student Learning Styles, Aptitude and Career Choice in Science

SEEP Research Report

2010

Authored by: Dr Deborah Chetcuti , University Of Malta, on behalf of the SEEP Research group

A project coordinated by

Università degli Studi Guglielmo Marconi

This project has been funded with support from the European Commission. This document reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Education and Culture DG

Lifelong Learning Programme

Student Learning Styles, Aptitude and Career Choice in Science

SEEP Research Report

Introduction

In the twenty first century learning is an important aspect of daily life. Learning occurs throughout an individual's daily activities, occurs formally in school settings and informally in out of school settings, and learning takes place individually and within a community. Hohenstein and Manning (2010, p. 68) define learning as "a relatively permanent change in thought or in behaviour that results from experience". There are many theories of learning ranging from behaviourist theories which suggest that learning takes place as a response to stimuli in the environment, to constructivist approaches to learning which suggest that learning is a process which is active and based on previously constructed knowledge. In today's world, however, learning is no longer seen as a process carried out by the individual, but new ideas about learning put forward the view that learning takes place within a social context and within a community of learners. For Stoll, Fink, & Earl (2003, p. 24), "learning is a dynamic process that requires both energy and process and is both individual and social".

But how do students learn? How do they learn science and what is the relationship between how students learn and their aptitude towards learning science? Do students have particular learning styles which influence their aptitude towards learning science? Do these learning styles and aptitudes influence the ways in which students eventually make career choices related to science? There is a large body of research which has looked into the ideas of student learning styles. Implicit within the ideas of constructivism and situated learning is the need for learners to be motivated to learn. Motivation is in fact linked with aptitude, since for students

to have an aptitude for science they must be motivated to learn science. Research also indicates that students with a positive attitude to science are more likely to choose a science oriented career.

How students Learn

Before we can understand different learning styles, we need to try and understand how students learn. This is important because as stated by Bell (2005, p. 17) "the ways in which we view learning can determine the ways in which we approach teaching and assessment in the classroom; the ways in which we think about being a teacher and how we view and conceptualise students and their needs". There are many theories of learning and it is important to understand theories of learning in terms of how we view learners and our definition of learning styles and their impact on aptitudes to science and career choice.

For Osbourne and Dillon (2010), most learning theories are either behaviourist or cognitivist and some theories are variations of both. The major theories which have influenced the way in which we teach science are behaviourism, cognitivism, constructivism and sociocultural theory.

Behaviourism

The main ideas of behaviourism are that children come into the world as a *tabula rasa*. Children then learn about their world through various forms of association and by responding to stimuli in the environment. Classical conditioning (Pavlov, 1927) is a form of training using

stimulus and response, such as a dog salivating to the stimulus of food which is then replaced by a bell. In operant conditioning (Skinner, 1974), behaviour is shaped through the use of rewards and punishments (Osbourne & Dillon, 2010). This form of behaviourism is no longer popular with science educators, since more modern theories of learning have been developed and teachers have realised that students come into their science classrooms with ideas about the nature of science which they have developed from experience.

Cognitivism

For Hohenstein & Manning (2010, p. 71), "many contemporary approaches to learning place some value on the internal workings of the mind in contrast to behaviourist theories. An early cognitivist theory of this kind proposes that learners progress through a series of stages, each affording a greater degree of intellectual ability". One of the main proponents of stage theories was Piaget (1952) who in his work suggested that children pass through various stages of development. Piaget's ideas have had a great influence on the teaching of science in schools since the development of science curricula have been related to Piaget's stages of development. More recently stage theory has also been critiqued in that research has shown that the developmental process of children is not necessarily related to their age and that while some children progress rapidly through all of the stages, some of them never go beyond a particular stage of development.

Constructivism

Constructivist learning theory incorporates "the view that individuals actively construct knowledge and understanding" (Santrock, 2001, p.112). Constructivists suggest that learning depends on the ways in which the learners create new mental schemas based on previous knowledge and that learning is strongly correlated to motivation to learn (Hohenstein & Manning, 2010). Driver et al. (1994) describe a constructivist position as being one where "knowledge is not merely transmitted directly from the knower to another i.e. the teacher to the pupil, but is actively built up by the learner him or herself" (p.5). A related theory to constructivism is that of social constructivism which focuses on the social and situated aspects of learning (Wickmann, & Ostman, 2002). The individual meaning-making is not solely the product of the individual mind's undertakings but also of the cultural context in which the individual is interacting (Fairclough, 1992). This theory is based on the ideas of Vygotsky (1978) who argues that ideas are first encountered by learners in the social environment in the form of language. Vygotsky also states that learning occurs through the Zone of Proximal Development which as described by Hohenstein & Manning (2010) is the area between what people can accomplish on their own to that which they can achieve with the help of someone more experienced.

Sociocultural theory and Situated Learning

Sociocultural theory emphasises the importance of sociocultural experiences in influencing development (Rogoff, 2003). Hohenstein & Manning (2010) describe how knowledge of a

learner's cultural experience can help determine how best to organise learning. The learners become part of a community where participants engage with each other and learn from one another. Within this perspective, learning occurs in a 'community of practice' (Wenger, 1999; Lave, & Wenger, 1991), a group whose members are bound by a common interest and a commitment to share experiences with the aim of developing themselves. In other words, according to Bell (2005, p. 44) "learning is seen as a process that takes place in a co-participation or co-constructivist framework, not in an individual mind".

An overview of these theories of learning is important since the way in which we view *Learning Styles* is closely related to the way in which we view the learning process. *Learning Styles* can in fact be a window in the learning process and its implication for developing positive attitudes towards science learning. Related to the idea of *Learning Styles* there is also Gardner's theory of Multiple Intelligence. Although there are strong links between Learning Styles and Multiple Intelligence they are considered to be distinct and independent of each other. Gardner (1999, p. 84-85) makes the following distinction:

> People with strengths in particular intelligences must still decide how to exploit these strengths. For example, someone gifted with linguistic intelligence might decide to write poetry or screenplays, engage in debates, master foreign languages, or enter crossword puzzle contests. Perhaps the decision about how to use one's favoured intelligences reflects one's preferred style. Thus, for example, introverted people would

be more likely to write poetry or do crossword puzzles, whereas extroverted ones would be drawn to public speaking, debating, or television talk shows.

Learning Styles

Students learn in different ways. It is important to identify how students learn and different learning styles in order to be able to identify a pedagogy which will capture the immagination of students and motivate them to learn science. A variety of teaching approaches will increase the positive attitude of students towards science. There have been many models presented regarding the different learning styles. Reiner (2010) describes a learning style, as a preferred mode of learning, distinct from ability and independent of content area. For example, a visual learner is not necessarily better at learning math or geography than other students, but is a better learner when material is presented visually, compared to other modes of presentation.

For Lerner (2005, p. 212) a learning style is the "general behaviour, attitude, and temperament when presented with a learning task". For Lerner (2005), learning styles influence the effectiveness of learning. She suggests that when a student's learning style is incongruent with the teaching approach, this might give rise to learning difficulties. The development of a student's learning style can also reflect the values of the learner's culture. This reflects the ideas of sociocultural learning theory, which also stress the importance of the social context in learning.

Bartolo (2007, p. 120) states that the term Learning Styles can be used interchangeably with Cognitive Styles which he defines as "an individual's characteristic and consistent approach to organising and processing of information. These have sometimes been claimed to be part of one's innate constitution comparing it to handedness." Over the years learning styles have been investigated in numerous studies. There are now at least 100 different instruments which claim to identify different learning styles (Reid, 2005).

Some Definitions

Cassidy (2004) distinguishe between Cognitive Style and Learning Style. He also identifies the ideas behind Learning Strategy, Learning Preferences and Learner Aptitude. The definitions given below are adapted from Cassidy (2004).

Cognitive Style:

An innate habitual approach to processing information when engaging in cognitive tasks such as problem solving, thinking, perceiving and remembering. It has a high degree of stability and consistency.

Learning Style:

An innate pattern of thinking, perceiving, problem-solving, and remembering when approaching a learning task. It is fairly stable and consistent over time and across a wide

variety of learning situations. It is regarded as the application of cognitive styles to learning situations.

Learning Strategy:

A chosen plan of action in how to approach a given learning task. They are deployed depending on the nature of a task, prior experience with a learning situation and motivation. Individuals are usually conscious of strategies.

Learning Preferences:

An expressed personal preference favouring one type of learning environment, method of teaching or instruction over another. May involve preference for group or independent study.

Learner Aptitudes:

Special innate capacities that give rise to competencies in dealing with specific types of content in the world such as spatial patterns, musical sounds, interpersonal relations, body movements, etc.

Learning styles and the way in which learners approach particular tasks have been characterised in a variety of ways. For the purpose of this research report, the approach to learning styles adapted by Gigorenko & Sternberg (1997) will be used.

Three Principal Approaches to Learning Styles

(adapted from Grigorenko & Sternberg, 1997)

The cognition centered approach

This theory focuses on the way in which individuals perform intellectually. Riding (2002) suggests that all cognitive styles can be categorised into two dimensions. The categories are the holistic-analytic and the verbaliser-imager. The holistic learner will process information as a whole, while the analytic learner will process information as discrete parts of that whole. This means that holists will be able to see the whole picture but have difficulty separating an idea into parts while analysts will be able to see the building blocks of an idea, but then have difficulty integrating the parts into a whole. With regards to verbalisers-imagers, verbalisers will tend to be better at working with words while imagers prefer to see things visually.

Another model which has been used is that of Field Dependence versus Field Independence. This model outlined by Jonessen & Grabowski (1993) suggests that Field Dependent Individuals are more likely to be better at recalling social information such as conversations and relationships. They approach problems in a complete manner because they can see the whole picture within a given context. Field independent individuals on the other hand are better at seeing the individual pieces and can take things out of a context. They therefore tend to be more analytic.

The personality-centered approach

This approach in described in Bartolo (2007) as going back to personality traits described by Carl Jung. The personality dimensions which influence learning and described by Myers-Briggs are:

- *Sensation/Intuition:* Sensing individuals process information gained in the present through their senses while intuitive individuals tend to focus on ideas from their sub-conscious.
- *Extroversion/Introversion:* Extroverts tend to like to work with others and in a group while introverts prefer to work on their own and focus on their own thougths and ideas.
- *Thinking/Feeling:* Thinkers base their decisions on concrete logical facts. Feeling individuals tend to base their decisions on their subjective feelings.
- *Judgement/Perception:* Individuals who prefer to judge tend to like to work in a planned and organised manner. Individuals who prefer perceiving tend to be more flexible and spontaneous.

The activity-centered approach

This approach outlined by David Kolb (1985) focuses on learning situations. The four different learners described are diverging, assimilating, converging and accomodating learners.

Diverging:

An individual with a diverging learning style can look at situations from many different points of view. Diverging learners are therefore good in brainstorming sessions since they like to listen

and work with people in a group. They have many cultural interests and can be immaginative and creative.

Assimilating:

An assimilating individual is capable of taking a large amount of information and organising it into a logical sequence. They are interested in abstract concepts and ideas and prefer to work on their own. They like to think through ideas and are more interested in theory than practical applications.

Converging:

Individuals with a converging learning style like to find practical solutions for ideas and theories. They function best when they are problem solving and taking decisions based on the solutions which they have come up with. They prefer to work on technical tasks rather than with people and like to work mainly in the area of technology.

Accommodating:

Individuals with this type of learning style prefer to work in practical situations. They are highly intuitive and rely on knowledge gained from other individuals rather than on their own analysis of the situation. They like to work with others in challenging situations and prefer to work in the field.

As stated previously, although these categories have been established, it is not necessary for every individual to match each bullet in the category. It simply gives an indication of the type of learning tasks and learning situations which can be created in the classroom.

Dunn and Dunn (1978) descibe learning styles in terms of the way in which the learners adapt to the learning environment. The Learning Styles Network (2006) describes learning styles in terms of:

Immediate Environment

The sound, light, temperature and physical environment such as seating.

Emotionality

The motivation and state of mind of the learner.

Sociological factors

The preferred working mode, alone, in pairs, in a team.

Physiological factors

Auditory, visual, tactile and/or kinesthetic preferences.

Psychological factors

The way in which information is analysed, in a logical or intuitive manner.

A profile of each individual can be built using tests such as the Learning Styles Inventory (Dunn & Dunn, 1992). This profile of strengths "may be one of the reasons why we preferred to study science at school rather than some other subjects" (Parkinson, 2002, p. 17).

Multiple Intelligences

Howard Gardner has made it quite clear that multiple intelligences is a theory of abilities, not of styles. The current learning styles theory defines "mode of learning" as a preferred sensory channel, either visual, auditory, or kinesthetic, but there have been many ways of defining "mode" in the past (Reiner, 2010). Athough, learning styles and ability are considered to be different theories, in reality they are closely related to the way students learn science and to the way in which teachers present science to their students in the classroom. Howard Gardner (1983) proposes a model of intelligence which goes beyond the model of intelligence as a single entity which can be measured. Gardner (1983) states that,

> …the conviction that there exist at least some intelligences, that these are relatively independent of one another, and that they can be fashioned and combined in a multiplicity of adaptive ways by individuals and cultures, seems to me to be increasingly difficult to deny (p. 8/9).

Gardner (1983) in his theory of multiple intelligences suggests that culture, language and environment all influence the individual's learning profile. Gardner (1999) identifies at least eight intelligences:

- visual and spatial
- mathematical and logical
- linguistic
- kinaesthetic
- musical
- intrapersonal

- interpersonal
- naturalistic.

Parkinson (2002) states that all individuals have strengths and weaknesses in each of these areas of intelligence. Stoll, Fink & Earl (2003) stress the importance of Gardner's work in terms of the shift from the idea of intelligence as a single entity to the idea that there may be more than one way of being intelligent and that it changes the question from 'How smart are you?' to 'How are you smart?' Stoll, Fink & Earl (2003) argue, that:

> It also opens a window of understanding of how different people learn and how to help them learn. It doesn't mean that it's all right if someone has difficulty learning to read (linguistic) but is very musical; rather, it means that drawing on their musical intlligence may be a way to help them learn to read (p. 40).

A critique of Learning Styles

Olson (2006) states that the idea that children learn best when instruction is tailored to their learning style is intuitively appealing and may seem to be supported by classroom experience. She describes how some students appear to thrive when asked to express ideas through a role-play activity or through music. Others don't seem to understand an explanation until the teacher draws a picture or uses manipulatives to illustrate a concept. However, in reality, research has shown that that when students received instruction specifically tailored to their preferred learning style, they performed poorly on tests of the material (Salomon 1984). In fact,

a comparison group who received instruction in formats different than their preferred style scored significantly better on the same tests.

Other research studies show that learning styles on their own have very little effect in terms of effective classroom pedagogy (Coffield, Mosely, Hall & Ecclestone, 2004). The research carried out by Coffield et al. (2004) seems to indicate that assigning a particular learning style to a student has very little effect on the learning of students. Reid (2005, p. 54) states:

> Some theorists see learning styles as a fixed, perhaps genetically determined trait like size and hair colour...(But) It is well known that environmental influences are very powerful in determining a young person's characteristics both in terms of learning and behavioural factors...One is treading on dangerous territory therefore when attempting to ascribe a learning style to an individual as a fixed trait.

Many researchers have in fact suggested that rather than focus on learning styles, educators should focus on the basic processes of learning It is the ability of students to identify what learning style is best appropriate for a particular learning task that will help to increase understanding. The ability to identify different styles of learning by the learner is therefore more important than being labelled as a particular learner and trying to always learn using the identified learning style. Once learners acquire this understanding of different ways of learning, their aptitude towards learning science is more likely to become positive. In summary Olson (2006, p. 57) states:

> Teaching toward students' preferred learning styles has no solid basis in research and may lead to decreased effort and performance in the classroom. Using appropriate representations that carefully consider how to best convey the content is important. In addition, we need to scaffold between concrete and more abstract representations, being sensitive to the abilities of our students to handle abstractions. Finally, when students struggle to understand, we need to look at both the nature of the content as well as the prior experiences of our students. When we carefully select how we represent concepts and take into account students' thinking, we optimize learning opportunities for all of our students.

Vondracek (2009) shows how what is important is the use of multiple methods of teaching rather than teaching to specific learning styles. A variety of learning methods recognises the multiple learning preferences among students in the class. "When we use a variety of methods in the classroom, we ensure that all students have the opportunity to succeed" (Vondracek, 2009, p. 41).

A study by Pashler, McDaniel, Rohrer & Bjork (2008) has provided a critique of the use of learning styles to guide curriculum, instruction and assessment in schools. The authors carried out a comprehensive review of the literature on learning styles. They describe learning styles in the following way:

> The term ‘‘learning styles’’ refers to the concept that individuals differ in regard to what mode of instruction or study is most effective for them. Proponents of learning-style assessment contend that optimal instruction requires diagnosing individuals’ learning style and tailoring instruction accordingly. Assessments of learning style typically ask people to evaluate what sort of information presentation they prefer (e.g., words versus pictures versus speech) and/or what kind of mental activity they find most engaging or congenial (e.g., analysis versus listening), although assessment instruments are extremely diverse. The most common—but not the only—hypothesis about the instructional relevance of learning styles is the meshing hypothesis, according to which instruction is best provided in a format that matches the preferences of the learner (e.g., for a ‘‘visual learner,’’ emphasizing visual presentation of information) (p. 105).

The authors’ major critique of learning styles theories is that none of these theories has been soundly tested to show that they actually result in improved learning. They suggest that while there is plenty of evidence from experience to suggest that individuals have different aptitudes for different kinds of thinking and ways of processing information, the impact of these ideas has not been tested scientifially. Therefore Pashler et al. (2008, p. 117) conclude that, “Given the capacity of humans to learn, it seems especially important to keep all avenues, options, and aspirations open for our students, our children, and ourselves. Toward that end, we think the primary focus should be on identifying and introducing the experiences, activities, and challenges that enhance everybody’s learning”.

Implications for Teaching and Learning

The question we need to ask ourselves as science educators is how we are going to use our knowledge of different learning styles to the benefit of the students in our science classrooms. Traditionally, science subjects have been linked with students who are predominantly mathematical and logical learners. It is usually these students who have a positive aptitude towards science, who choose science subjects in schools and continue to pursue careers in science. However, the scope of identifying learning styles should go beyond simply catering for students with a specific learning style. As science educators our main aim should be to try and help all students, whatever their learning style to gain an understanding of science.

Within this theoretical framework, the purpose of identifying learning styles is to enable teachers and educators to cater for a range of different needs. The different learning styles can be matched to learning activities and it is these activities which will enable students to understand science better. This according to Parkinson (2002, p. 17) "strengthens the argument for including a variety of activities in science lessons in order to benefit from the wide range of expertise amongst the pupils to maintain an interest in science". **Table 1** shows how learning styles can be linked to specific learning activities.

Characteristics	Linked Learning Activities
Visual Spatial Have artistic talent Are able to easily visualise things in three dimensions Can easily find their way around text	▪ Model building ▪ Preparing visual displays ▪ Identifying key points in texts with appropriate markers ▪ Role play ▪ Drawing and interpreting diagrams
Mathematical and Logical Are good with numbers See patterns easily Organised in their approach to work Measure things accurately Adopt a problem-solving approach to tasks	▪ Calculations ▪ Organising work e.g. preparing summary diagrams and lists, flow charts, creating links between related topics ▪ Producing graphs and charts ▪ Using computers
Linguistic Enjoy communicating, sometimes through writing and talking and sometimes just through one method Are good at spelling Have a good vocabulary	▪ Creative writing ▪ Role play ▪ DART exercises ▪ Researching a topic by themselves ▪ Contribution to class discusssion
Kinaesthetic Are good at sport, good hand and eye coordination Are good at dance Can be restless if required to sit still for long periods	▪ Role play ▪ Practical tasks ▪ Model building ▪ Science quizzes and games ▪ Identifying key words in a text
Musical Enjoy listening to, and sometimes playing music Have a good appreciation of rhytm and movement Appreciate that the word and sound groupings can often lead to change in mood and feeling	▪ Writing poems, raps, etc. ▪ Learn with background music ▪ Use music to relieve stress
Intrapersonal Often enjoy working alone They are metacognitive learners	▪ Researching a topic by themselves ▪ Homework ▪ Thinking up questions for the teacher to answer ▪ Working alone on the computer ▪ Setting personal targets for improvement ▪ Preparing their own concept maps
Interpersonal Relate well to others Are at ease in groups Are prepared to take on the role of team leader	▪ Group work ▪ Contribution to class discussion ▪ Concept mapping ▪ Peer teaching ▪ Role play

Table 1: Linking multiple intelligences to learning activities (Parkinson, 2002, p. 18).

Learning Styles and Aptitudes in Relation to Career Choice

Schreiner & Sjoberg (2004, p.18) state that "students who develop an interest for science in school are likely to pursue such interests in later life. And pupils who learn to hate mathematics and science at school are likely to avoid mathematics and science – and to retain this feeling all through their life". In addition the authors of the ROSE (Relevance of Science Education) project argue that affective factors (and hence learning styles and aptitudes) play an important factor in how students view their future. Attitudes towards school science are important determinants when it comes to choice of school subjects and science related careers.

Sjoberg & Schreiner (2010) report that the results of the ROSE questionnaire which was carried out in several countries indicate that although children have positive attitudes towards science, the attitude towards school science is not so high. They report that although results vary for different countries, there seems to be a gender difference in attitude, with girls being less positive towards science than boys. Also in many cases the students who participated in the study felt that school science was not opening their eyes for exciting jobs in science and did not increase their career chances. The conclusions reached by Sjoberg & Schreiner (2010) are that students experiences and interests need to be taken into consideration when developing curricula and ways of teaching science. The authors state that teaching needs to be:

> ...motivating, meaningful and engaging. It has, in some way to link up to the values and interest that the learner brings to the classroom, if not, no other learning than rote

> memory based on duty is likely to occur. If this is the situation, the learner is likely to develop negative attitudes, and will turn their backs to SMT when they make their decisions about future life, be it as students or as citizens (Sjoberg & Schreiner, 2010, p. 29).

Learning needs to be related to a context and to be relevant for the students. These are the basic tenets of "constructivism", "socio-cultural theory" and "situated learning" which were described briefly at the start of this research report. Therefore according to Sjoberg & Schreiner (2010), student' attitudes views, values, learning styles and aptitudes all need to be taken into consideration in the teaching of science. "Teaching material and teaching practices that do not engage students in meaningful learning is not likely to give lasting positive results" (Sjoberg & Schreiner, 2010, p. 29).

Osbourne & Dillon (2008) show that most science curricula are based on the assumption that school science is the first step in the process to educate the future scientist. Many of the research on Learning Styles seems to imply that working with students on their learning styles and aptitude will give them a more positive attitude which will engage them with school science and increase the probability that they will choose science careers in the future. The argument which is being made in this research paper is that positive attitudes towards science and the likelihood of choosing a science career is not dependent on a particular learning style or aptitude but rather on the way in which science in taught in schools. Presenting science in a

fun and interesting, relevant context is more likely to hook students on to science rather than any particular innate aptitude. Working with the interests, values and attitudes of students within a relevant context will enable them to see the relevance of science as part of our modern culture. In fact providing "good science teaching" for all, will give better positive attitudes towards science than simply catering to particular learning styles and aptitudes.

Developing a Pedagogy for Science Teaching

As has been argued throughout this research report, one of the most important determinants of a positive attitude towards science is to have a pedagogy which stresses "good science teaching". The characteristics of good science teaching (adapted from Chetcuti, 2009) are as follows:

Use An Inquiry Based Approach

Inquiry based lessons are based on the ideas that learning is a social endeavour and takes place within a context. Inquiry learning not only contributes to better understanding of scientific concepts and skills but, because science inquiry in school is carried out within a social context, it also contributes to the children's social and intellectual development. In an inquiry classroom, students work collaboratively to brainstorm questions, design experiments for testing their predictions, carry out investigations, and ask thoughtful questions about other students'

conclusions. This mirrors the science that takes place in the real world (Ansberry & Morgan, 2005).

The National Research Council (2000) identifies five main characteristics of science inquiry:

1. Learners are engaged by scientifically oriented questions.
2. Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.
3. Learners formulate explanations from evidence to address scientifically oriented questions.
4. Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.
5. Learners communicate and justify their proposed explanations.

Grech (2010) in a study in which she implements an Inquiry based teaching approach in a Maltese physics classroom shows how the use of an inquiry based approach increased her students positive attitude towards science and motivated them to learn science. An inquiry based approach engaged the students in such a way that they became active and involved learners. The students in this case study also began to see the relevance of learning physics and that physics could be important in their daily lives.

Teaching and learning should cater to individual needs

When developing their science lessons teachers should take into consideration the individual needs and interests of their students. The science which we teach is common and universal, but the context in which it is taught cannot be common and universal. It needs to be context relevant and culture specific. Hildebrand (1996) argues that there is no such thing as value-free gender, value-free science or value-free assessment. Our values and social context are implicit in all the choices that we and our students make. This is why it is important to take into consideration the experiences of students and their needs and to also provide multiple learning and assessment strategies for them. The individual needs of students are also emphasised by Parker and Rennie (2002) who state:

> …a supportive learning environment which emphasises communication, interpersonal negotiation, interaction amongst all participants, harassment free discussions, active participation by students; second, real-life contexts; third, school-based, informal assessment procedures, with relatively open-ended tasks drawing on contexts which are familiar to both boys and girls; and fourth, attention to the students' self-awareness of the extent to which their education related decisions and experiences are socially constructed…The pedagogy and assessment procedures should take account of the diverse ways of knowing, viewing and describing the world (p. 882).

Use a multisensory approach

Learning takes place in a participation framework as part of ongoing activity in a social context (Lave and Wenger, 1991). Therefore to learn about science requires students to participate in the practices of science in which professional scientists engage, what is known as culturally authentic science learning (Murphy, Lunn and Jones, 2006). In order to cater for these different learning styles as suggested by Bancroft (2002), we need to use multi-sensory teaching strategies and multi-sensory assessment tools. This can be done through practical, oral, drama, creative writing, and use of ICT. This will ensure that all the different talents and ways of learning, of students are taken into consideration.

Use relevant contexts

Bancroft (2002) suggests the use of imaginative contexts which motivate and engage pupils as they prepare for learning. The use of context as 'an organiser for science content' and a 'problem situation' is important for students to see the authentic relevance of what they are learning in science (Murphy, Lunn and Jones, 2006). Research has shown that what is relevant for girls might not be relevant for boys, and a study by Murphy and Whitelegg (2006) suggests that girls are more likely than boys go want an emphasis of social application. However, I would agree with Murphy, Lunn and Jones (2006) who argue that if the social situations are challenging enough then boys' interest in science learning is also enhanced.

Use role models and narratives of scientists

Murphy, Lunn and Jones (2006), suggest that authentic science learning needs to model the real life practices of scientists. Brickhouse (2001) takes this idea a step further and argues that a new vision for science education could reshape the character and nature of science and this can only be done if students are presented with role models and narratives of scientists including modern day scientists who have moved away from the traditional norms of practicing science.

Use the principles of assessment for learning

The way in which we assess students, the assessment tasks we choose, and the context of the questions chosen all influence the performance and achievement of students. "Assessment tasks have social consequences… (which) manifest themselves in the form of differential performance between different sub-groups" (Elwood & Murphy, 2002, p. 396). In my view like Gipps (1994, p. 15), I would argue that "assessment does not stand outside teaching and learning but stands in dynamic interaction with it". The main focus is on "assessment for learning (assessment whose purpose is to enable students, through effective feedback, to fully understand their own learning and the goals they are aiming for)" rather than on "assessment of learning (assessment for the purposes of grading and reporting with its own established procedures)" (Elwood & Klenowski, 2002, p. 244). This form of formative assessment supports and enhances learning and encourages achievement irrespective of differences among students be it due to gender, race, culture, religion or ability.

Conclusion

In the classroom, the teacher has to be aware not only of the academic abilities and achievements of students but also differences which can lead to them being marginalised and left out of the science learning community. The classroom pedagogy of science need to "place considerable importance on caring student teachers relationships and attend not only to the intellectual needs of students but also to their emotional needs" (Lyons, 1990, p. 283).

As stated by Murphy (1991) "many children will have meanings, and contexts and experiences in common but treating them as a homogeneous group is not appropriate in a constructivist paradigm" (p. 213). We need to accept and respect diversity and in order to do this we need to know our students and "who they are and who they want to be" (Brickhouse, 2001, p. 286).

References

Ansberry, K.R., & Morgan, E. (2005). *Picture Perfect Science Lessons.* Arlington: NSTA Press.

Bancroft, J. (2002). Developing science materials for pupils with special educational needs for the Key Stage 3 Strategy. *School Science Review, 83*(305), 19-27.

Bartolo, P. (Ed.). (2007). *Responding to Student Diversity Teacher's Handbook.* Malta: Faculty of Education.

Bell, B. (2005). *Learning in Science: The Waikito Research.* New York: RoutledgeFalmer.

Brickhouse, N.W. (2001). Embodying science: A feminist perspective on learning. *Journal of Research in Science Teaching, 38*(3), 282-295.

Cassidy, S. (2004) 'Learning Styles: An overview of theories, models, and measures. *Educational Psychology,* 24(4), 419 - 444.

Chetcuti, D. (2009). Identifying a gender-inclusive pedagogy from Maltese teachers' personal practical knowledge. *International Journal of Science Education,* 31(1), 81 – 99.

Coffield, F., Moseley, D., Hall, E. and Ecclestone, K. (2004) Should we be using Learning Styles? What research has to say to practice. London: Learning and Skills Research Centre http://www.lsneducation.org.uk/research/reports/

Driver, R., Asoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher,* 23(7), 5 -12.

Dunn, R., & Dunn, K. (1978). *Teaching Students through their Individual Learning Styles: A Practical Approach.* Reston, VA: Prentice Hall.

Elwood, J. & Klenowski, V. (2002). Creating communities of shared practice: The challenges of assessment use in learning and teaching. *Assessment in Higher Education, 27*(3), 243-251.

Elwood, P. & Murphy, P. (2002). Tests, tiers and achievement: Gender and performance at 16 and 14 in England. *European Journal of Education, 37*(4), 395-416.

Fairclough, N. (1992). *Discourse and social change.* Cambridge: Polity Press.

Gardner, H. (1993). *Frames of Mind.* New York: Basic Books.

Gardner, H. (1999). *Intelligence Reframed: Multiple Intelligences for the 21st Century.* New York: Basic Books.

Gipps. C.V. (1996). Introduction. In P.F. Murphy & C.V. Gipps (Eds.), *Equity in the classroom: Towards effective pedagogy for girls and boys* (pp. 1-6). London: The Falmer Press.

Grech, A. (2010). *A Shift from a Traditional way of Teaching Physics to an Inquiry Based Approach.* Unpublished M.Ed. (Science) dissertation, Faculty of Education, University of Malta.

Grigorenko, E.L., & Sternberg, R.J. (1997). Styles of Thinking, Abilities and Academic Performance. *Exceptional Children, Vol. 63.*

Kolb, D. (1985). *Learning Styles Inventory.* Boston: McBer.

Hildebrand, G. M. (1996). Redefining achievement. In P. Murphy & C. Gipps (Eds.), *Equity in the classroom: Towards effective pedagogy for girls and boys* (pp. 149-172). London: Falmer.

Hohenstein, J., & Manning, A. (2010). Thinking about learning: learning in science (pp. 68 – 81). In: J. Osbourne & J. Dillon (Eds.). *Good Practice in Science Teaching.* New York: Open University Press.

Jonassen, D.H., & Grabowski, B.L. (1993). *Handbook of Individual Differences, Learning and Instruction.* Hillsdale N.J.: Lawrence Erlbaum.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* Cambridge: Cambridge University Press.

Lerner, J. (2003). *Learning Disabilities.* Boston: Houghton Mifflin.

Lyons, N. (1990). Dilemmas of knowing: Ethical and epistemological dimensions of teachers' work and development. *Harvard Educational Review*, *60,* 159-180.

Murphy, P. (1991). Assessment and gender. *Cambridge Journal of Education, 21*(2), 203-213.

Murphy, P., Lunn, S., & Jones, H. (2006). The impact of authentic learning on students' engagement with physics. *Curriculum Journal, 17*(3), 229-246.

Murphy, P., & Whitelegg, E. (2006). *Girls in the Physics classroom: A review of the research on the participation of girls in physics.* Institute of Physics Report: Institute of Physics.

National Research Council. (2000). *Inquiry and the National Science Education Standards: A guide for Teaching and Learning.* Washington DC: National Academy Press.

Olson, J.K. (2006). The Myth of catering to Learning Styles. *Science and Children, October 2006,* 56 – 57.

Osbourne, J., & Dillon, J. (2008). *Science Education in Europe: Critical Reflections.* London: Nuffield Foundation.

Parker, L.H., & Rennie, L.J. (2002). Teachers' implementation of gender-inclusive instructional strategies in single-sex and mixed-sex science classrooms. *International Journal of Science Education, 24*(9), 881-897.

Parkinson, J. (2002). *Reflective Teaching of Science 11 – 18.* London: Continuum.

Pashler, H., McDaniel, M., Rohrer, D., Bjork, R. (2008). Learning Styles: Concepts and Evidence. *Psychological Science in the Public Interest,* 9(3), 105 – 119.

Reid, G. (2005). *Learning Styles and Inclusion.* London: Paul Chapman.

Reiner, C. (2010). *Learning Styles: What's being Debunked.* http://www.edweek.org/tm/articles/2010/02/24/learningstyles_riener.html?tkn=VVUDdxk0v0bxCSRVqyhmyxZnW01BLpTpMVi%2B&print=1 Accessed: 9th March 2011.

Riding, R. (2002). *School Learning and Cognitive Styles.* London: David Fulton.

Rogoff, B. (2003). *The Cultural Nature of Human Development.* New York: Oxford University Press.

Santrock, J. (2001). *Educational Psychology.* New York: McGraw Hill.

Schreiner, C. & Sjoberg, S. (2004). *ROSE, The Relevance of Science Education.* University of Oslo: Department of Teacher Education and School Development.

Sjoberg, S., & Shreiner, C. (2010). *The ROSE Project: An overview and key findings.* University of Oslo: Department of Teacher Education and School Development.

Stoll, L., Fink, D., & Earl, L. (2004). *It's About Learning.* London: RoutledgeFalmer.

Vondracek, M. (2009). Teaching with Multiple Methods in Mind. *The Science Teacher, October 2009,* 38 – 41.

Wenger, E. (1999). *Communities of Practice: Learning, Meaning and Identity.* Cambridge: Cambridge University Press.

Wickman, P.O., & Ostman, L. (2002). Learning as a discourse change: A socio-cultural mechanism. *Science Education, 86,* 601 – 623.