Science Education European Platform

European innovative approaches and methodologies in science education and career guidance at secondary level

Research Report

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Theoretical Framework on Effective Teaching

The emphasis on effective teaching, as Good and Brophy (2000) argue, involves those attitudes, skills and abilities needed to guide students.' learning as the ultimate goal of education. Teaching is a complicated profession and requires attention to several components, such as providing students with opportunities to think and to share their thoughts with others, helping students develop values, creating a secure emotional atmosphere to facilitate learning and so on (Blair 1988). Researchers have identified an array of traits that are important to the success of teachers. First, it is generally agreed that the teachers.' first priority should be the creation of a teacher – student relationship that is conducive to learning (Good and Brophy 2000; Tomlinson 2005). Towards this direction, as Sachs (2004) states, effective and ineffective teachers may utilize their attributes in different ways. For example, effective teachers may use their attributes to positively affect their teaching, whereas ineffective teachers may use their

attributes to become resilient and survive in the school environment. The quality of classroom environment is a significant determinant of student learning (Fraser 1998), and especially students.' views of the classroom environment and the educational process and the teachers are strongly related to their educational outcomes (den Brok et al. 2006).

According to Smith (2007), effective teachers know the subject, engage students in instructional activities, care about students and their success and demonstrate enthusiasm for teaching. Chen and Hoshower (2003) in their study found that students generally consider an improvement in teaching to be the most attractive outcome of a teaching evaluation system. Second, helpfulness has been noted as another important characteristic for teachers to have. Helpfulness can come in many forms from providing assistance to encouraging independent work, and it was found as the most important teachers' characteristic (Peterson 2000). Third, enthusiasm is also identified as a very important characteristic of an outstanding teacher (Check 1999). Patrick, Hilsey, and Kempler (2000) noted, 'When a teacher exhibits greater evidence of enthusiasm students are more likely to be interested, energetic, curious, and excited about learning.'

(p. 15).

Along these lines, Neill (1991) considers learning a voluntary activity, and that teachers must 'sell' the concepts being taught by using interesting approaches; or put otherwise, the importance of a subject is established by the teacher's enthusiasm. A relevant consideration is that enthusiasm or lack of enthusiasm is demonstrated with nonverbal cues, which expose the teacher's likes and dislikes about the subject matter and even about the students. Other researchers also discussed various characteristics of teachers.' effectiveness. Wesley (1998) argued that effective teachers also have to be fair and non-judgmental. This is because teachers are viewed as role models, and hence they are constantly being scrutinized by students for tolerance and fairness. Another characteristic to consider when evaluating a teacher is related to their teaching styles (Check 1999). The effectiveness of such characteristics has been documented in several studies (Kubow and Kinney 2000). A study by Kubow and Kinney (2000) provided evidence that the democratic style is likely to promote a positive attitude towards learning, whereas an autocratic style has the potential to enhance productivity (Xohellis 2007). According to Check (1999) it is important that teachers

understand their students and their problems – this perhaps falls within the general ability of a teacher to communicate with the students. Similarly, Monganett (1995) argued that to improve the teacher – student relationship, teachers should have a friendly interest in their students, clarify their doubts and attempt to be aware of their socio-educational backgrounds. It is also important that teachers show an interest in the emotional well-being of the students (Foote et al. 2000). Other studies have focused on the characteristics of effective teaching that lead to student achievement. Burden (2000) suggested that academic achievement is enhanced when teachers maintain effective classroom control, maximize the use of classroom time, use a variety of materials to teach and differentiate their instruction according to students' needs.

In a recent study conducted by Cirino et al. (2007), it was found that teacher quality was related positively to student and classroom performance, whereas, surprisingly, content knowledge was consistently not related to student outcomes. Moreover, the ability of a teacher to manage effectively his/her classroom has been identified as an important factor of teacher quality (Garrahy, Kothran, and Kulinna 2005). As described by Rink (2002),

effective classroom management relates to arranging of the environment for learning and maintaining and developing student-appropriate behaviour and engagement in the content. A related study was carried out by den Brok, Fisher, and Scott (2005), which examined the factors that influence Californian students.' perceptions of their learning environment. Data for this study were collected from 665 US middle school science students in 11 Californian schools. The findings of this study illustrated three main things: (a) girls perceive their learning environment more positively than do boys in the same science classes; (b) there was a positive association between the number of ethnic groups in the classroom and their perception of student cohesiveness and, (c) class size was positively related to investigation, which describes the extent to which there is emphasis on skills and inquiry.

A related research area is the one examining gender bias in students.' evaluations. Centra and Gaubatz (2000) used data from 741 college classes in a wide variety of subjects to examine potential bias in student evaluations of their teachers. Aggregating across all classes and all subjects, the researchers found that female students rated their female professors somewhat higher than their male professors and the ratings of male students

also had a (smaller) same-sex bias. The researchers also examined the natural sciences separately and found slightly different results: both female and male students rated female instructors somewhat higher than male instructors. Similar findings were produced by Sidanius and Crane (1989) in a large survey, which included the evaluation of 401 instructors by 9000 students. Zahra Hazari, Tai, and Sadler (2009) examined the bias from student evaluation of their high school science teachers. The findings of this study showed that male professors were rated significantly higher than female faculty with respect to their overall teachers.' effectiveness and academic competence by both male and female students. The evaluation of high school biology, chemistry and physics teachers by their students is examined according to the gender of the student and the gender of the teacher. Female teachers are rated significantly lower than male teachers by male students in all three disciplines, whereas female students underrate female teachers only in physics. Interestingly, physics is also the field that suffers the greatest lack of females and has been criticized most for its androcentric culture.

These problems create the need for innovative approaches and

methodologies in science education with the purpose of not only supporting student learning but also for career guiding in science at secondary level, which is in fact, at the heart of the account of this report.

Innovative Approaches

Internationally, science education is seen as a means to

- Insure a competitive economic advantage and all competent persons should contribute.

- Insure a scientifically literate public.

These goals are not necessarily being met.

- Women and certain minorities are under-represented in scientific professions.

- Scientific literacy is not attained across the board.

Why are these goals not being met?

- Science education does not resonate with women.

- Science education assumes women will assimilate into the science that is.

- Science education does not promote scientific literacy.

- Educational philosophies reinforce the science that is.

An innovative approach, proposed by European science educators (e.g., Osborne & Dillon, 2009) to addressing these issues is teaching the social studies of science along with scientific information

- Social studies of science include history, philosophy, sociology of science and feminist analyses.

- These disciplines can make students aware of the norms, attitudes and practices of science that are invisible to scientists.

- These disciplines can make students aware that science is a social activity, whose attributes reflect those of the society in which it is practiced.

Preliminary results of teaching with this transformed pedagogy illustrate positive effects:

- Students learn standard material.

- Students claim the social studies of science help them learn standard content.

- Students gain an appreciation for the social location of science.

- Students increase their self-confidence as scientists.

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Innovative Methodologies

A review of the literature indicates a variety of innovative methodologies, programs and instructional practices, used by teachers to support student learning across Europe. These can be summarized in the following 6 main themes:

- Inquiry-based approaches

    - Engaging students in authentic scientific inquiry investigations (e.g., what is the water quality of a lake, how polluted is the air that we breathe etc)

- Use of technology applications

    - modeling tools

    - virtual reality tools

    - electronic games

    - the use of mobile devices

- School-scientists partnerships

    - Scientists visiting school classrooms

    - Students visiting laboratories

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- The use of narrative in science education

- the use of stories in science

- the use of documentaries

- the use of biographies (e.g., Darwin's biography)

- comics

- Informal learning environments

- Visits to museums, environmental parks, nature trails

- Science Fairs

- Argumentation

- Engaging students in argumentation about socioscientific issues

- Engaging students in argumentation about disputable issues (e.g., the evolution theory, genesis of the world)

Success Factors

Success factors to be kept in mind when applying such innovative approaches and methodologies are the following:

- A clear analysis of the situation;

- A detailed description of the innovative methodology;

- The monitoring and strong support given to teachers and schools;

- A strong cooperation between all the stakeholders based on partnerships

- The awareness that science education based on an inquiry-based approach also enables to acquire various competences and skills, key elements as to lifelong learning;

- The development and use of evaluation tools that notably contribute to constantly improving and/or adapting what is being developed and implemented in the innovative approaches

Conclusions

There is no doubt that the traditional science programs are very useful for the selection of that 1%- 5% of the population that could be the future physicists. However, the question is how to support science learning for the 99%-95% of the secondary science students that are not to become scientists? Many innovative approaches and methodologies across Europe provide powerful platforms for *science education for all.* Yes, these approaches and methodologies alone will not be enough and in addition such

programs should also include the following characteristics:

• Learning in an authentic and relevant context as much as possible.

• Organizing the learning in a sequence that shifts gradually from the concrete to the abstract.

• Adjusting the learning for variant abilities learners.

• Integrating the outdoor environment as an integral and central component of the learning process.

• Focusing on both the cognitive and the emotional aspects of learning.

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