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Ideas for enhancing primary and high school science education

Did you Know?

Velcro

After taking a hike, George de Mestral, a Swiss engineer, found burrs stuck to his socks. Closer examination showed that the burrs had tiny hooks that had latched into loops in the fibres of the socks. In 1951, and as a result of applying this principle, he invented Velcro.

Me and My Body (MAMBO): An Interactive Science Education Programme for Primary Schools

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Abstract

This paper describes a novel science education initiative developed for 8- to 12-year-old children by the Biomedical Diagnostics Institute at Dublin City University, Ireland. Me and My Body (MAMBO) is an interactive, multi-faceted programme that enables children to explore and understand the dynamic physiological parameters of the human body using simple sensing and diagnostic devices. The programme consists of a number of complementary elements comprising a colourfully animated website, a classroom-based series of lessons taught by a visiting educator, a curriculum-linked resource CD for teachers, and an out-of-school workshop. Topics investigated by the children include the blood, immune system, heart, and healthy living. The introduction of the programme into Irish primary schools has been met with enthusiastic responses from both students and teachers.

An early introduction to science is found to have a strong, long-term impact and is highly beneficial in improving children's attitudes towards science and helping them to obtain accurate scientific views of their world (Harlen, 1985; Rocard, 2007). A novel science education initiative for children aged 8 to 12 years, developed at the Biomedical Diagnostics Institute (BDI) at Dublin City University, Dublin, Ireland, is described. The programme was developed and piloted in Irish primary schools in 2006, with over 1000 students taking part in Me and My Body (MAMBO)-related activities.

MAMBO is an interactive, multi-faceted programme that enables children to explore and understand the dynamic physiological parameters of the human body using simple sensing and diagnostic devices. The programme consists of a number of complementary elements comprising a colourfully animated website, a classroom-based series of lessons taught by a visiting educator (a member of the BDI education team or a postgraduate student of the institute), a resource CD for teachers, and an out-of-school workshop (Table 1).

Table 1
Elements of MAMBO

Programme element	Description
Classroom lessons	Series of 1-hour lessons titled The Blood, The Immune System, The Heart, and Healthy Living designed to assist teachers in the classroom setting in the teaching of science.
Website (Me and My Body, n.d.)	Information on the above topics is presented in a child-friendly format. Teacher resource material, word searches, and additional activity ideas are available.
Teacher resource CD	Contains lessons plans, lesson content, and worksheets on the above topics.
Workshop	Diagnostics Through the Ages: A 1-hour, hands-on, out-of-school workshop where children are challenged to use different medical techniques to diagnose a virtual patient.

MAMBO was developed in response to the current science education situation in Ireland. Science was reintroduced into the Irish primary school curriculum in 2003, after an absence of nearly 70 years, in response to declining numbers of students taking science subjects at Leaving Certificate Level (Irish final secondary school examinations for students of generally 18 years of age) and the subsequent low level of science and engineering degree uptake at Third Level (Irish Council for Science, Technology, and Innovation [ICSTI], 1998; Task Force on the Physical Sciences, 2002). As Ireland moves towards a knowledge economy, a continuing supply of graduates in science and engineering is vital (Department of Enterprise, Trade, and Employment, 2006).

The MAMBO programme has four principal objectives:

- To convey the excitement of science to 8- to 12-year-olds, promoting an enduring interest in science and technology;
- To build on students' current knowledge of science and nurture their natural curiosity about their own body;
- To bring science to life using real-life examples, easily identifiable to this age-group, demonstrating that science is "all around us";
- To assist primary school teachers with the delivery of the primary science curriculum by providing useful learning aids.

Science has long been seen as a valuable medium to enhance children's general learning (Palmer, 2001) and scientific literacy is increasingly important in today's society, where so much of our

daily living depends on science, technology, and engineering. MAMBO adopts the hands-on/minds-on approach of inquiry-based science education. This teaching method transfers the experience of learning from a passive one to one where the child is actively engaged. A sense of ownership is placed on activities when children get the opportunity to investigate their own ideas, which in turn leads to "greater motivation [and] a stronger sense of purpose" (Whyte, 2000, p. 42), capitalising on the predominantly positive attitude children of this age have towards science (Whyte, 2000).

At the heart of the MAMBO programme is the direct involvement and participation of children through a variety of hands-on activities. Therefore, it was important that the activities included in the programme were feasible in a classroom setting and could be used by teachers without the involvement of a MAMBO facilitator. Research by Appleton (2002) on this topic was helpful in informing the design and choice of activities. He has identified the following six criteria for "activities that work," all of which are evident in MAMBO activities:

- They are hands-on; children should be engaged in the activity,
- They are interesting and motivating for the children; some teachers look for a gimmick to grab the children's attention. If a child is particularly taken with an activity they may be motivated to go home and explore it further for themselves,
- They are manageable in the classroom, which is aided by most primary teachers' knowledge of general pedagogy,
- They have a clear outcome or result. Teachers' are often hindered by their limited scientific knowledge to "diagnose how or why an activity may not perform as expected" (p. 402),
- They use readily-available equipment, reducing the amount of organizing required before class, and
- They lend themselves to cross-curricular integration (i.e., where a theme is taught across a number of different curricular subjects).

An important aspect of the MAMBO programme is its links with the new Irish primary science curriculum. Through our interactions with teachers, it is apparent that activities related to the curriculum are highly attractive for use in the classroom. This informed the development of the programme and each topic and activity has specific, listed, curriculum links and learning outcomes. Additionally, there is significant scope for integration with other areas of the curriculum, such as English, Mathematics, and Art. Our collaboration with science teacher education specialists at St. Patrick's College of Education, Drumcondra, Dublin (St. Patrick's College, 2006) ensured that all elements of the programme are appropriate for both teachers and students.

Since its introduction in the autumn of 2006, MAMBO has been introduced in over twenty Irish classrooms and approximately 1000 students have taken part in MAMBO-related activities. The four elements of MAMBO will now be described.

Classroom Lessons

The four, 1-hour classroom lessons are titled The Blood, The Immune System, The Heart, and Healthy Living. These lessons are intended to be a novel starting point to support teachers' own lessons on the topics. As such, it is worth noting that limited time is dedicated to written exercises during the 1-hour lessons and the focus is upon practical activities and discussions.

Lesson One: The Blood. In the first lesson, the children are invited to examine the network of veins on the inside of their wrists and are introduced to the concept that their bodies have many more of these veins, and arteries, throughout their bodies to carry their blood around. In addition, the children learn that blood is made up of four main parts--red and white blood cells, platelets, and plasma--and the role each part plays in their body. The main activity in the first lesson is the construction of a class model of the blood using playdough (Figure 1) to help visualise the microscopic blood cells and develop the children's science skills of designing and making.

Figure 1. A playdough blood model.

Lesson Two: The Immune System. The second lesson begins with an activity to show how a disease or infection can be spread through contact. All children put on surgical gloves and a blob of paint is squirted onto the glove of 1 or 2 children. The class then shake hands with one another and observe how the paint spreads to everyone in the class. The class then discuss other ways that infections can be spread and what causes them; that is, viruses and "bad" bacteria. They then consider the body's various means of protection against infection and disease; the immune system. The role of the white blood cell is discussed in more detail and the role of antibodies in the immune system is introduced.

Children also experiment with forehead and ear thermometers to discover normal body temperature and compare the two methods of measuring (Figure 2). This activity encourages children to develop their observing, questioning, and analysing skills.

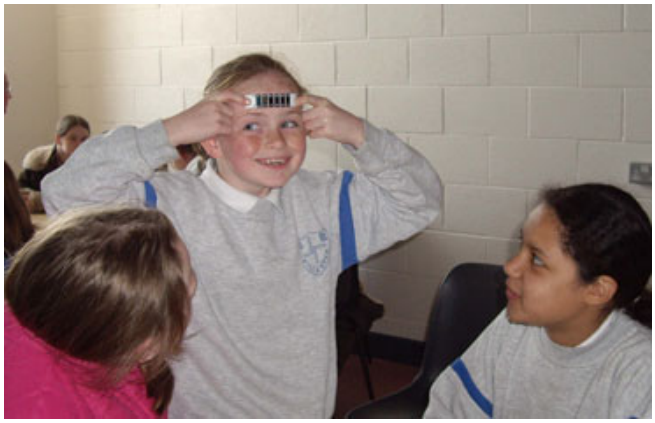

Figure 2. Using forehead thermometers to investigate normal body temperature.

Lesson Three: The Heart. In the third lesson, the class discuss the function of the heart, linking back to what they learned about their blood. Stethoscopes are passed around and children work in pairs to listen to their heartbeat. Pulse rate is introduced and heart rate monitors are passed around. The class then practices locating and counting their pulse on their wrist or their neck.

The class considers the effect exercise has on their pulse and investigates their ideas by measuring and recording their pulse at rest and after a few minutes running around the school yard. The students conclude that exercise increases their heart rate and discuss the reason why. This activity also builds the skills of observing, questioning, and analysing.

Lesson Four: Healthy Living. In the previous lessons, children develop their knowledge of the human body, its systems, organs, and defence mechanism. Although our bodies are very good at protecting us from illness, it is obviously better to keep our bodies healthy. In this lesson, students have the opportunity to explore the long-term benefits of healthy living by eating a balanced diet, maintaining good dental hygiene, and being physically active. The class investigate the food pyramid to learn about the types of food we eat and how much of each type we should be eating.

They also discuss the role of each food group in keeping their body healthy. The children then look at their teeth and learn the names and role of all the different types of teeth, and discuss how to keep their teeth healthy.

The final classroom activity investigates pH and introduces acids and bases. The children use universal indicator paper to test water, orange juice, and cola to find out if any is acidic. This highlights the benefit of water in protecting teeth from decay. At the end of the series, all children are presented with MAMBO certificates (Figure 3).

Figure 3. Children with MAMBO certificates.

Website

The MAMBO website (Me and My Body, n.d.) uses a highly graphical, child-friendly flash interface to illustrate the four classroom lessons. In addition, The Digestive System, The Cell, and Diagnostics are introduced for further learning. Two cartoon characters, Ryan and Róisín (Figure 4), go on a journey of discovery where they meet red and white blood cells, antibodies, and other characters who answer the questions they have about their bodies. It is suitable for use both in a classroom setting and at home. There is also a selection of games, including word searches containing new words learnt in each section to help build vocabulary.

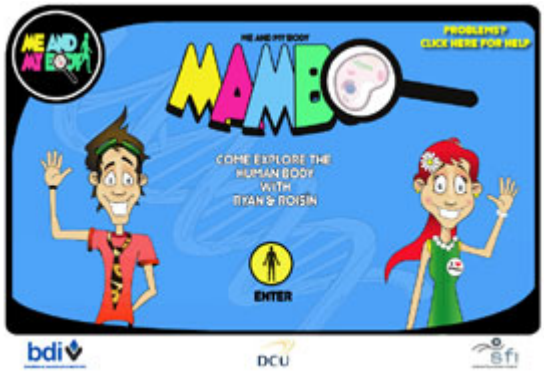

Figure 4. The MAMBO website homepage.

Compact Disc (CD)

The MAMBO resource CD was specifically designed for teachers and assists in developing lesson plans, activities, and worksheets for students. Teachers are free to use the CD to present the lessons in the same way the visiting educator would, or to take elements of it to use as they wish. A list of materials needed for each activity is also provided.

Each topic is presented in a teacher-friendly manner through an interactive desktop window. The topics include lesson plans, lesson content, and worksheets. Currently, over 100 teachers have received this CD free of charge and we aim to send a copy to every primary school in Ireland by the end of 2008.

Workshop

A 1-hour Diagnostics Through the Ages workshop has been developed for delivery at science fairs and events, such as the Irish National Science Week. It contains a condensed form of many of the hands-on activities carried out during the classroom lessons. Children explore the history of medicine in ancient Greece and Egypt and use a variety of simple diagnostic techniques to diagnose a virtual patient and learn about healthy bodies (Figure 5). In addition to using thermometers, stethoscopes, and heart rate monitors, the children test the pH of fake urine samples (made of yellow-coloured water) using universal indicator paper and also test for the presence of glucose using Clinistix. After detecting glucose in the sample, the children then analyse a fake blood sample with a glucometer. Diabetes is found to be the diagnosis of the virtual patient and the children are asked what they know about diabetes and its causes. The need to live healthy lives by exercising regularly and eating well is one of the main take-home messages from the workshop, along with the appreciation of how different diagnostic techniques reveal different bits of information that can be used to build up a complete picture of what may be causing a person's illness.

Figure 5. MAMBO workshop in action.

MAMBO on the Move

MAMBO on the Move is a travelling version of the Diagnostics Through the Ages workshop. It is housed on the Science Bus (Figure 6), a coach converted into a mobile laboratory that visits schools throughout Ireland.

Figure 6. MAMBO on the Move on the Science Bus.

Evaluation

Formative evaluation was carried out during the pilot phase of the MAMBO programme to garner feedback from participants. Teachers and students taking part in the classroom-based lessons were asked to complete a short questionnaire. Verbal feedback received from teachers was very important to help fine-tune the programme for maximum impact and benefit. The questionnaires were reviewed, using the Generic Learning Outcomes (GLO) model (Museums Libraries Archives Council, 2004), to assess the types of learning gained by users of the MAMBO programme. GLOs look at learning under five general themes: Knowledge and Understanding; Skills; Attitudes and Values; Enjoyment, Inspiration, and Creativity; and Activity, Behaviour and Progression. We felt that these themes were a suitable measure of our objectives, which are not limited to increasing children's knowledge on a topic, but also include the development of skills and attitudes.

We found that questionnaire responses fell predominantly into the Knowledge and Understanding category for all age groups. The older classes (11- & 12-year-olds) also responded with positive comments that were categorised under Enjoyment, Inspiration, and Creativity and Attitudes and Values. All ages responded with statements about skills development, incorporating science skills such as experimentation, questioning and communicating. A smaller number of statements could be categorised under Activity, Behaviour, and Progression. All five types of learning, as classified by the GLOs, are evident in MAMBO.

Examples of the responses of participants include the following:

- "The whole course was very good. I hope to do it again next year!" (*Teacher*)
- "We learned that blood is pumped around the body by the heart and is made up of four different parts. . . . We need blood clotting so we don't bleed too much from the simplest of cuts. . . . We made a model of our blood out of play-dough. It was a lot of fun learning about blood and I can't wait until the next session." (*Student*)
- "My favourite part of MAMBO was everything. It was excellent. I loved it!" (*Student*)

MAMBO will be introduced to additional schools during 2008/2009. A more detailed, longitudinal programme evaluation is underway, involving both qualitative and quantitative studies, and will look at issues such as skills development in more depth.

Conclusion

The Me and My Body programme developed by the Biomedical Diagnostics Institute (BDI) Education & Outreach team has been well-received by its target audience of 8- to 12-year-old Irish schoolchildren and their teachers. Most of the programme is available to a wider audience through an interactive website (Me and My Body, n.d.) and a teacher resource CD available from the BDI. Please find contact information at Biomedical Diagnostics Institute (BDI) (n.d.). We hope that aspects of this programme will be of use in science classes further afield!

Note

The Biomedical Diagnostics Institute (n.d.) is an industry-academic-clinical partnership based at Dublin City University. The Institute carries out cutting-edge research focused on the development of next-generation biomedical diagnostic devices. These accurate and reliable diagnostics devices, measuring disease indicators in the home or at the point-of-care, will enable the detection of life-threatening events long before a critical stage is reached. The institute is funded by Science Foundation Ireland (SFI) (2002). SFI administers Ireland's Technology Foresight Fund and provides awards to support scientists and engineers working in biotechnology and information and communications technology development.

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Teaching Ideas

Science stories, teaching techniques, demonstrations, activities, and other ideas

Resistance to Reformed Teaching

The teacher operating a reformed classroom based on interactive engagement and classroom discourse may encounter resistance, especially when this style conflicts with school culture. Among the advice Reif (2008) offers for implementing reform and dealing with resistance are the following:

- Ensure that your first class with a new group of students reflects the features of your reformed classroom (e.g., use the learning cycle, think-pair-share, or student whiteboard presentations). It is the behaviours displayed, rather than the content of the activity, that is important.
- Sincerely reward positive behaviours (e.g., put an Einstein action figure on a student's desk or pass out candy (e.g., Smarties) or stickers.
- Help create a positive, respectful, and less threatening atmosphere by adopting the following simple rule for student presentations: The audience (including the teacher) may only ask questions (as opposed to correcting the presenter).
- Seek the support of like-minded colleagues, locally and/or online.
- Periodically survey the thinking and feelings of students about your class and discuss any differences in expectations. However, avoid allowing any one or more students to object for any extended period. Rather, after providing a brief forum, choose to further this discussion outside class time.

Source: Reif, M. (2008). Dealing with resistance to reform. *The Physics Teacher*, *46*, 381-382.

Critical Incident

An Invitation

Readers are invited to send, to the Editor at editor@ScienceEducationReview.com , a summary of a critical incident in which you have been involved. A critical incident is an event, or situation, that marks a significant turning point, or change, for a teacher. The majority of critical incidents are not dramatic or obvious, but are rendered critical through the analysis of the teacher (see Volume 3, p. 13 for further detail). You might describe the educational context and the incident