MOTIVATING AND EXCITING METHODS IN MATHEMATICS AND SCIENCE

Glossary of Terms

2007

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GLOSSARY OF TERMS

Active Learning

Active learning, as the name suggests, is a type of instruction which some teachers employ to involve pupils during the learning process. It is associated with the term "learning by doing".

Most importantly, to be actively involved, students must engage in such higher-order thinking tasks as analysis, synthesis, and evaluation. Within this context, it is proposed that strategies promoting active learning be defined as instructional activities involving students in doing things and thinking about what they are doing.

Examples of "active" activities include:

- class discussion
- small group discussion
- debate
- posing questions to the class
- think-pair-share activities
- short written exercises

Reference:

Goodlad, J. (1983) *A Place Called School: Prospects For The Future.* 1st edn. Hightstown, NJ: McGraw Hill.

Assessment for Learning

Assessment **for** learning is the process of using classroom assessment to improve learning, whereas assessment **of** learning is the measurement of what students can do, usually done at the end of a learning sequence.

In assessment for learning:

- teachers share learning targets with students
- students know and recognise the goals for which they should aim
- there is feedback that leads students to identify what they should do next in order to improve

- it is assumed that every student can improve
- students review and reflect on their performance and progress with teachers and they develop skills in peer and self-assessment.

Assessment for learning is one of the most powerful ways of improving learning and raising standards. Actively involving all students in their own learning, providing opportunities for students to assess themselves and understand how they are learning and progressing, can boost motivation and confidence.

Assessment for learning should be part of effective planning of teaching and learning strategies that address the diverse needs of different groups of learners, and should acknowledge the barriers to learning that some of them encounter.

Reference:

QCA Characteristics of AfL– Available at
http://www.qca.org.uk/qca_4337.aspx (Accessed : 13.11.2007)

Brainstorming

Brainstorming is a group creativity method designed to generate a large number of ideas for the solution of or making progress on a problem.

All participants should produce ideas without restrictions, following these four basic rules in brainstorming:

- Focus on quantity
- No criticism
- Unusual ideas are welcome
- Combine and improve ideas

Brainstorming is normally followed by all ideas being read, evaluated and sorted by the team members. This includes only some thematic sorting and the removal of ideas that are deemed too far away from the original problem.
The purpose of brainstorming can include:

- Advanced organisation
- Addressing misconceptions

References:

Osborn, A. F. (1963): *Applied imagination: Principles and procedures of creative problem solving*. (Third Revised Edition). New York, NY: Charles Scribner's Sons.

Hutchison Clark. C, (1989): *Brainstorming: How to Create Successful Ideas.* Wilshire Book Company.

Case Studies

In education, case studies are student-centred activities based on topics that demonstrate theoretical concepts in an applied setting. This definition of a case study covers the variety of different teaching structures used, ranging from short individual case studies to longer group-based activities. They can be used to:

- Allow the application of theoretical concepts to be demonstrated, thus bridging the gap between theory and practice
- Encourage active learning
- Provide an opportunity for the development of key skills such as communication, group working and problem solving
- Increase the students' enjoyment of the topic and hence the desire to learn

A case study can recount a new or unusual condition or event, but more normally it would be a description of a classic situation that can be used as a model or exemplar.

Reference:

UK Centre for Materials Education *Working with you to enhance the student experience.*Available at
http://www.materials.ac.uk/guides/casestudies.asp (Accessed : 15.11.07)

Collaborative Learning

Collaborative learning is an umbrella term for a variety of educational approaches involving joint intellectual effort by students, or students and teachers together. Usually students are working in groups of two or more, mutually

searching for understanding, solutions or meanings, or creating a product. Collaborative learning activities are based in student discussion and active work.

Collaborative learning may incorporate:

- Positive interdependence
- Social skills
- Individual and group accountability
- Face to face interaction

Reference:

Sharan, S. (1994) *Cooperative learning methods*. 1st edn. Wesport: Praeger Publishers.

Computer Aided Learning (CAL)

Computer Aided Learning describes an educational environment where a computer program is used to assist the user in learning a particular subject. The goal is to learn mathematics or science rather than computer skills. The key issue is the word assist which means that the program is not alone in this aim and that there are other methods involved.

Computer Aided Learning is particularly useful in:

- Simulations
- Micro-computer based labs
- Datalogging
- Modelling

Reference*:*

Oliver, A. (2001) *What is Computer Aided Learning*. Available at: http://www.herts.ac.uk/ltdu/learning/whatiscal.pdf (Accessed: 12 November 2007).

Concept Mapping

A technique to allow students to visually represent and inter-relate connections and/or relationships between concepts, ideas or information, drawing on existing and newly introduced knowledge. It is hoped that when students are asked to draw a concept map linking graphically the relationships between concepts in a particular field, they externalise their understanding and put it in a form that can be read and interpreted by their teacher and peers.

″A concept map is a diagram showing the relationships between concepts. They consist of nodes (points/vertices) and links (arcs/edges). Nodes represent concepts and links represent the relations between concepts. Concepts are connected with labelled arrows, and can be arranged in a hierarchical structure. The relationship between concepts is articulated in linking phrases, e.g., "gives rise to", "results in", "is required by," or "contributes to".

A mind map consists of a central word or concept, around the central word the student draws the 5 to 10 main ideas that relate to that word. They then take each of those words and again draw the 5 to 10 main ideas that relate to each of those words."

The difference between concept maps and mind maps is that a mind map has only one main concept, while a concept map may have several. This comes down to the point that a mind map can be represented as a tree, while a concept map may need a network representation.

***References**:*

Buzan, T. (1995) *The MindMap book.* 2 edn. London: BBC Books.

Jonassen, D.H., Beissner, K., & Yacci, M.A. (1993) *Structural knowledge: Techniques for conveying, assessing, and acquiring structural knowledge*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Lawson, M. J. (1994) Concept Mapping, in T. Husén & T. N. Postlethwaite (Eds.). *The international encyclopedia of education.* 2nd edn.. Oxford: Elsevier Science.

Novak, J.D. (1991) Clarify with concept maps: A tool for students and teachers alike. *The Science Teacher, 58*(7), 45-49.

Novak, J. D. (1993). How do we learn our lesson? : Taking students through the process. *The Science Teacher, 60*(3), 50-55.

Discussion and Debate

A mathematical or scientific discussion is a process of talking about a topic in a group in a conversational way. Contributions to the conversation are accepted from anyone involved in the discussion and ideas can emerge and evolve in ways which have not been predetermined by the teacher. The teacher has a role of guidance in the sense that:

- he/she "inserts" a particular discussion in the flow of the activity of the class
- he/she influences the discussion in a conclusive way, inserting himself/herself with interventions planned in his/her preparation.

Debate is the division of a class or individuals into groups to represent particular points of view (most commonly 'for and against') on a controversial topic. Each group works to develop an argument to support its allocated point of view. Students could be invited to argue a view they don't endorse, engage in the debate in character or through role plays.

***References**:*

Italian Ministry Programs (2001) Available at: http://umi.dm.unibo.it/italiano/Matematica2001/matematica2001.html (Accessed: 11 2007)

Scimone, A & Spagnolo, F (2006), *Argomentare e Congetturare*, Palermo: Editore Palumbo.

Demonstrations in mathematics and science

A demonstration is the practical presentation of a process or procedure or skills which is designed to illustrate theoretical principles. Demonstrations require careful sequencing, oral and visual explanations, appropriate illustrations and opportunities for students to pose questions and clarify problems.

The teaching of mathematics and science may be enhanced by the use of demonstrations. Visual examples of abstract concepts aid immeasurably in developing understanding. In science education they also provide an opportunity to illustrate the scientific method and to teach the student to relate experimental observation to scientific theory. Experiments represent the means by which scientific knowledge has advanced so rapidly in modern times.

scientific knowledge has advanced so rapidly in modern times. Finally, not to be underestimated, the use of demonstrations makes the learning of mathematics and science more enjoyable!

References:

Boud, D., Dunn, J. & Hegarty-Hazel, E. (1986). *Teaching in laboratories*. Surrey, UK: The Society for Research into Higher Education & NFER-Nelson.

Forster, F., Hounsell, D. & Thompson, S. (Eds.) (1995). *Tutoring and demonstrating: A handbook*. Edinburgh: Centre for Teaching, Learning and Assessment.

Ladyshewsky, R. (1995). *Clinical teaching*. HERDSA Green Guide Number 1. Canberra: HERDSA.

Experiential learning/experience-based learning

This is an approach to teaching and learning that is based on the presumption that every experience has the potential to be an opportunity for learning. Students are placed in contexts or environments where they can assimilate information and develop skills from being personally involved. Experiential learning strategies include role plays, games and simulations, case studies, problem-based learning, fieldwork and work-based education.

Experiential learning is an expressive and/or implicit set of relationships established between a student or a group of students, some element of the teaching resource (tools or materials are included), and the teacher, with the purpose to allow the students to learn - that is: to reconstruct - some knowledge. The situations are specific to such knowledge, but are frequently non-formal.

References:

Boud, D., Cohen, R., Walker, D. (1993). *Using experience for learning*. Buckingham, UK: The Society for Research into Higher Education & Open University Press.

Brousseau G. (1997), *Theory of Didactical situations in mathematics*. Kluwer Academic Publishers.

Hutchings, P. & Wutzdorff, A. (Eds) (1988). *Knowing and doing: Learning through experience*. SanFrancisco:Jossey-BassInc.

Exposition

A statement or rhetorical discourse intended to give information about or an explanation of difficult material.

Exposition can be used to convey large amounts of information in a short time frame. It is also used to explain concepts at the start or end of a lesson. Exposition with interaction teaching includes a questioning session.

Exposition allows the teacher:

- to present background information ;
- to create a frame of reference for a unit of study;
- to summarize an activity, a lesson, or a unit.

Exposition to be effective must be well planned and carefully timed. The younger and/or less motivated the student, the shorter the exposition portion of the lesson should be. The remainder of the lesson should include other techniques: discussion, demonstration, guided practice, peer-teaching, group work.

Reference:

Exposition Teaching. Available at
http://spectrum.troy.edu/~mjparker/exposition.htm (Accessed:11.07)

Fieldwork

Fieldwork involves work out of the classroom. It may involve work in the school grounds, in the area immediately surrounding the school, or further afield. It can vary in duration - part of a lesson, a half day or a whole day, or a residential fieldwork course of more than a day. It involves live collection of primary data from external References by means of surveys, observation and experiment.

Fieldwork should be seen as an essential part of science education, because it actively engages students in science. Fieldwork provides a real world context whether the topic studied is biology and food chains or physics and gravity. This helps enthuse students about science.

Reference:

National curriculum in Action, *Glossary of terms*. Available in http://www.ncaction.org.uk/subjects/geog/glossary.htm (Accessed: 14.11.2007)

Homework

Teachers assign homework for a variety of reasons: to help students review, apply and integrate what has been learned in class; to help them prepare for the next class session; to extend students' exploration of topics more fully than class time permits; or to help students gain skills in self-directed learning and using resources such as libraries and reference material. Homework can also help students:

- develop mastery by practising what they have learned
- acquire effective habits of self-discipline and time management
- learn to work independently
- gain a sense of personal responsibility for learning
- develop research skills such as locating, organising and condensing information
- make connections between school and everyday life

Homework is intended to be a positive experience that encourages children to learn.

Reference:

Kidsource . Available at http://www.kidsource.com/education/sciencemath.html (Accessed: 13.11.2007)

Independent Learning

Independent learning is a method whereby a learner acquires knowledge by his or her own efforts which may be facilitated by the teacher. It is learning that fulfils the following conditions:

- learning at the learners' own pace;
- at times and places of their own choosing;
- often with other people around, especially fellow-learners;
- when they feel in control of their learning

References:

Candy P (1991): *Self-direction for lifelong learning*. Jossey-Bass Higher and Adult Education Series San Francisco, California.

Race P (1994): *The Open Learning Handbook* (2nd Edition) Kogan Page, London.

Inquiry

Inquiry based learning describes a range of philosophical, curricular and pedagogical approaches to teaching. Its core premises include the requirement that learning should be based around student questions. Pedagogy and curriculum requires students to solve problems requiring a holistic range of skills. Teachers use their knowledge to guide the student inquiry.

The inquiry method starts with summarizing current knowledge pertaining to a topic. Next, questions are formulated to focus the inquiry. Working together and individually, students discover solutions via various methods.

The inquiry process invites students to experience the world's richness, empowers them to ask their own questions, seek their own answers and challenges them to understand complexities.

Reference:

Newel P, (2007), Elementary school students Available at http://www.thefreelibrary.com/ (Accessed : 15th May 2007)

Investigations

A mathematical investigation is an enquiry into an area of mathematics – it is usually open-ended. The purpose is not only to develop mathematical knowledge, but also to develop mathematical skills and processes. It may involve conjecture, testing, generalisation of results, and it may involve different degrees of guidance.

In addition, a mathematical investigation may involve:

- researching outside references

- collecting data
- collaborating with peers
- using multiple strategies to reach conclusions

A scientific investigation is an enquiry into an area of science which draws on scientific methodology. It depends on systematic use and interpretation of data and evidence. It can be open-ended. The purpose is to develop scientific knowledge.

Reference:

Speer, W. et al. (1998) 'Mining mathematics – stake your claim to learning', *Teaching Children Mathematics*, 4(8), pp. 464-468.

Peer teaching/tutoring

Peer tutoring is an approach in which one student instructs another student in material on which the first is an expert and the second is a novice. However, multiple definitions of peer tutoring exist, and they are not all consistent. For example, not all peer tutors are "experts." They are sometimes randomly assigned, same-age classmates or same-aged low achievers. To make matters more confusing, the term "peer tutoring" often subsumes both cross-age and same-age tutoring. Peer tutoring occurs when tutor and tutee are the same age. In cross-age tutoring, the tutor is older than the tutee. However, sometimes the term peer tutoring is used to include both types.

There are three commonly cited benefits of peer and cross-age tutoring: the learning of academic skills, the development of social behaviors and classroom discipline, and the enhancement of peer relations. Researchers have also identified improvements in self-esteem and one of its components--internal locus of control. It is important to note that all such benefits accrue to both tutor and tutee.

Peer teaching can enhance learning by enabling learners to take responsibility for reviewing, organizing, and consolidating existing knowledge and material; understanding its basic structure; filling in the gaps; finding additional meanings; and reformulating knowledge into new conceptual frameworks.

References:

Dueck, G. (1993) *Picture Peer Partner Learning: Students Learning From and With Each Other. Instructional Strategies Series NO. 10.* 1st edn. Saskatoon: Saskatchewan Professional Development Unit.

Farivar, S., Webb, N.M. (1993). Helping an essential skill for learning to solve problems in cooperative groups. *Cooperative Learning* 13, 20-23.

McKeachie, W.J., Pintrich P.R., Yi-Guang Lin and Smith, D.A. (1986) *Teaching and Learning in the College Classroom: A Review of the Research Literature.* 1st edn. Ann Arbor, MI: University of Michigan.

Whitman, N.A. (1998) *Peer Teaching: To Teach Is to Learn Twice*. 2 nd edn. Jossey-Bass: San Francisco.

Problem-based learning

This is a method that challenges students to "learn to learn" to seek solutions to abstract or real world problems. These problems are used to engage students' curiosity and initiate learning the subject matter. PBL prepares students to think critically and analytically, and to find and use appropriate learning resources.

The defining characteristics of PBL are:

- learning is driven by challenging problems;
- students work in a variety of ways individually or otherwise;
- teachers take on the role as "facilitators" of learning.

Reference:

Duch B. Problem based learning .Available at http://www.udel.edu/pbl/ (Accessed: 15.5.2007)

Role play

A role-play is an activity in which learners deliberately adopt roles for a specific learning purpose, defined in learning outcomes. A role play is set as a model of a real situation. It usually involves a development of a situation and characters which is generated by changing behaviour of the characters in the role-play or changes in external conditions to which characters need to respond.

Through addressing the emotional, cognitive and behaviour level, a role play offers ample scope for reflection. A role is adopted when a learner takes on any behaviour, attitude, opinion, and socio-economic characteristic different to his/her own. The most common techniques used within a role play are taken from drama. The theory behind the use of role-play in science teaching and learning – as with 'active', 'experiential' or 'child-centred' learning – is that children are encouraged to be physically and intellectually involved in their lessons to allow them to both express themselves in a scientific context and develop an understanding of difficult concepts.

Reference:

Struder-Hill, I. Role-play as a teaching and learning tool for enterprise education. Available at http://ncge.com/files/biblio1044.pdf
(Accessed :15.11.2007)

Scientific/mathematical writing

Science and mathematics depend on communication both within their own communities and with others. Communication includes writing, literacy, speaking, reading and other forms.

Using scientific/mathematical writing in class is a means of enhancing scientific/mathematical and general literacy. There are many ways of doing this including:

- giving pupils a piece of scientific/mathematical writing and asking them to summarise it;
- giving pupils a piece of scientific/mathematical writing and asking them questions about it to test their comprehension;
- getting pupils to convert a piece written in scientific/mathematical language into one which is in normal style;
- using scientific/mathematical writing to introduce new concepts, keywords and knowledge that are to be developed using other teaching approaches;
- developing students' skills in writing scientifically/ mathematically.

These methods aim to show pupils that scientists and mathematicians must communicate using linguistic skills as well as through the symbolism that sci-

ence and mathematics often resorts to, and that they should be able to transfer between the two styles.

Reference:

Goper, G D & Swan, J A . The Science of scientific writing. Available at http://www.amstat.org/publications/jcgs/sci.pdf (Accessed :13.11.2007)

Small group work

Small groups are helpful for students to develop their understanding of concepts and to acquire or improve strategies and approaches to problems. To achieve these higher-order thinking and learning activities promoted by small group work, it is helpful for the student to engage in meaningful communication directed towards a goal or set of goals. These higher-order thinking skills (e.g., application of concepts and principles, problem-solving, etc.) are the primary objective of small group sessions. Typically the group size is between 3 and 5.

References:

Gibbs G (1995) *Learning in teams.* 1 st edn. Oxford: Oxford Centre for Staff and Learning Development, Oxford Brookes University.

Heron J (1995) *The facilitator's handbook.* 3rd edn. London: Kogan Page.

Jaques D (1991) *Learning in groups.* 3rd edn. London: Kogan Page.

Johnson D., Johnson F. (1991) *Joining together: group theory and group skills.* 1 st edn. London: Prentice Hall International.

Student presentations

Student presentations mean students presenting pieces of work, that they have contributed to in varying degrees, in front of other people. These presentations might be personal/direct (talks, presentations in a narrow sense) or indirect (poster, movie, multimedia, internet), they might use different media (speech, black- or whiteboard, overhead projector, data projector, paper-and-pencil, graphic representations), they might be in front of different types of audience (peers, teacher, other students, general public), they might be done by one or

more students, present work of only themselves or of a larger group, and they might present work of varying size.

Student presentations are used for instance:

- to introduce new pieces of information in several peer teaching situations;
- to present project work and/or group work done by students;
- to summarize information gained by group or classroom work.

Reference:

Goering, L. Student prentations. Available at http://serc.carleton.edu/introgeo/campusbased/presentation.html (Accessed: 15.11.2007)

Text Based Learning

Traditionally, text has been viewed as the linear connected discourse typified by textbooks, magazines, or newspapers. The process of learning from text depends significantly on the genre, structure, and quality of the messages students encounter in books, in discussions, and online. Among the multiple factors that contribute to text quality and subsequent learning are comprehensibility and text credibility. When students understand the intended message in the text, text-based learning is more likely to take place. Of all the factors relevant to text-based learning, none exerts more influence on what students understand and remember than the knowledge they already possess. This background or prior knowledge serves as a scaffold for obtaining new knowledge.

Meaningful purposes for reading textbooks include:

- background reading for a project
- finding data
- challenging ideas
- researching for forthcoming activities

Reference:

Terms used in qualitative research, Adapted from Answers.com. Available at www.mrs.org.uk/mrindustry/glossary.htm (Accessed :15.11.2007)

Worksheets

A worksheet is a sheet(s) of paper which requires activity by the students.

For a worksheet to be effective, it must be easy to read and easy to understand, visually interesting and interactive. Worksheets should include a clear, simple and short explanation of what needs to be done. The teacher should use appropriate language and grammar for the age group they are teaching. He/she may, where appropriate use bullet points and provide lines or boxes for students to write their answers in. It is advised to use drawings to add visual interest.

Before designing a worksheet, the teacher needs to be clear about what they want the students to learn and how the worksheet will support this. There is a need to consider the age and ability of the students to ensure it is pitched it at the right level. Also there is a need to be clear about what supporting information is needed to provide to help the students complete the worksheets.

Reference:

Friends of the Earth Available at http://www.foe.co.uk/resource/guides/worksheet_design.pdf (Accessed: 10.06.2007)