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CREATIVE EXPLORATION: Doing science in a primary school context

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This paper identifies the rationale for developing Creative Explorations, a co-constructivist teaching and learning approach for primary science that addresses issues associated with the decline in primary students' attitudes towards science, and the need for all students to develop a level of scientific literacy. Theoretical positions associated with the interrelationships between aesthetic experiences, the exploration and the explanation of natural phenomena when developing and communicating science understanding, children's science and the nature of science are identified and discussed. Tentative connections between some aspects of the rationale and recent literature on the role of imagination in education have been identified. A narrative of a school based case study centred on the material world/ rates of change and the investigative aspect of the nature of science, identifying and testing variables is used to exemplify elements of Creative Exploration in action.

Introduction

This paper identifies the rationale for developing Creative Explorations, a co-constructivist teaching and learning approach for primary science that addresses issues associated with the decline in primary student's attitudes towards science, and the need for all students to develop a level of scientific literacy. Theoretical positions associated with the interrelationships between aesthetic experiences, the exploration and the explanation of natural phenomena when developing and communicating science understanding, children's science and the nature of science are explored. Connections between some aspects of creative exploration and relevant recent literature on the role of imagination in education are identified.

Significance

The lack of status of science teaching and learning in a crowded curriculum and the decline in students' attitudes towards further learning in science education are two areas of challenge to primary science educators. Despite the availability of many quality teaching and learning resources, science as a curriculum area in primary schools is generally perceived of as low priority. As well as the lost status of science amongst teachers, there is also concern that the decline of secondary school students interest in being involved in further science is becoming increasingly evident in students in primary school (Crooks & Flockton, 2003). The ever increasing call for "scientific literacy for all", as encapsulated in the OECD,(2006) PISA project and Tytler's, (2007) "contention that science education needs to diversify its emphasis beyond focussing on canonical abstract ideas, and place an emphasis on the nature of science and the way it operates" , (p.31) identify the affective domain as an insight to a way forward for primary science educators. For most young children experiences of natural phenomena promote a sense of curiosity and wonder. This natural curiosity and interest that motivates young learners to be engaged to seek explanations needs to be enhanced and recognised as an essential element of science programmes in primary schools (Fried, 2001; Bell,2001). The challenge for primary school science teachers and educators is to develop teaching and learning approaches that showcases science education in such a manner that will firstly appeal to teachers and their students as being significant and worthwhile, and secondly counter the decline in attitudes towards science being expressed by children.

Creative Exploration: A Sequential and Cyclic Model of Exploring for Understanding in Children's Science.

Introducing the model

This teaching and learning approach is based on the assumption that children naturally seek explanations for experiences that have some affect on their feelings, attitudes and the manner in which they think about or view natural phenomena. Children will often construct creative explanations when seeking to understand and explain these aesthetic experiences. Rich aesthetic experiences can lead to the development of a sense of fascination that in turn leads to a greater degree of engagement in the learning process. The outcome of this engagement is a greater depth of understanding, especially if the learner involved has communicated and justified their ideas with others. In a teaching and learning situation children participating in rich aesthetic experiences of natural phenomena can be guided by informed facilitation towards a greater depth of personal understanding. This authentic process of enquiry not only leads to the development of personal conceptual understanding but also to the development of procedural knowledge and skills and a tentative appreciation of the nature of science. Although the approach is presented here in a linear fashion, it should be viewed as cyclic in nature. The cycle can follow the whole process or it may only complete parts of the process. The more elements of the process used deepens the depth of engagement and subsequent understanding.

Creative Exploration		
Explore	a problem, situation, phenomenon, artefact, model, event, story.	**Wonder**
Observe	What is happening? What changes happened? What materials are involved? What are the main parts? What are the key aspects? What do these parts/structure do?	**Wonder about**
Identify evidence	What is the cause and effect of changes? What is the function? What parts are interacting with other parts? What are the outcomes of these interactions? What trends and patterns keep occurring?	
Create explanations	Personal explanations supported by evidence are created and processes to test them are planned	**Wonder at**
Investigate	Find out, measure, compare, verify, test, clarify identify	
Evaluation	A self evaluation of these investigations may lead to, new or modified explanations, doubts about existing ideas or tentative conclusions. These tentative explanations need to be communicated to others for peer evaluation and feedback	
Further investigation	Evaluated explanations can lead to: re-exploration, seeking further explanation, leading to further investigation	**Wonder whether**

Table 1 Sequential elements of Creative Exploration model for developing personal understanding in primary science

Theoretical justification of the teaching and learning model

Creative Exploration is a co-constructivist approach that incorporates many aspects of the following four elements associated with socio-cultural views of learning identified by Tytler 2007 as offering insights into the conditions needed for engaging learning programmes in science education. These elements include:

- the active role of the teacher in providing opportunities for students to engage with and explore phenomena
- the support for students to engage with meaningful contexts
- the negotiation of meaning implied in the teacher's guidance of students towards the scientific views
- the meta-cognitive implications of making ideas explicit, and extending and evaluating these

Creative Exploration evolved as a teaching and learning approach through the development of the science assessment exemplars (Ministry of Education, 2004). The exemplars identified the demonstration of awe, wonder and interest in science as a key aspect of learning for the goal of "Developing interest and relating science learning to the wider world" (Arcus, 2003; Ministry of Education, 2004). The project developers identified the following set of dispositional indicators that science education fosters student's ability to do at all levels.

- Display curiosity about the world around them
- Demonstrate enthusiasm and excitement about how science works
- Take an interest in a particular science topic
- Become absorbed in a science related activity
- Pursue science interests without prompting, outside the formal learning environment
- Display initiative and commitment when seeking answers to their questions
- Express awe and wonder and enthusiasm about an observation, experience or idea/explanation
- Develop and declare an interest in some aspect of science or the environment
- Persevere to solve problems and overcome difficulties while pursuing their own interest in science

The Creative Exploration approach has similar features to the Primary Connections learning model (Hackling & Prain, 2005) that elaborates on the 5 E's model developed by Bybee (1997)of engage, explore, explain, elaborate and evaluate. In particular, Creative Exploration as an approach places an emphasis on the exploration of aesthetic experiences and the subsequent desire by the learners to make sense of, or explain, the natural phenomena involved. The underpinning philosophy of the approach is also strongly influenced by the interactive approach (Biddulph & Osborne, 1984) that resulted from the Learning in Science Project, and the notion of children's science (Osborne & Freyberg's, 1985).

Children's science

If science can be defined as the current acceptable explanation of natural phenomena and the process by which the evidence underpinning this explanation is generated then children's science can be defined in much the same way. Children's thinking can be classified as being scientific if their explanations of phenomena and change include the identification of the evidence they used when constructing their explanations and this evidence is subsequently tested. Children generating new thinking to explain the phenomena they are exploring are being creative. Creativity is defined by the National Advisory Committee on Creativity and Culture in Education as "imaginative activity fashioned so as to produce outcomes that are both original and of value, (NACCCE, 1999, p. 29 cited in Feasey 2006)" A person acting creatively is "thinking or behaving imaginatively in the process of trying to solve a problem or answer a question, (Feasy, 2005 p.6)" It could be argued that this is a rather broad use of the notion of behaving imaginatively, Takaya (2007) identifies a distinction between behaving imaginatively and behaving creatively, she contends that creativity is more closely associated with the creation of an idea or product whilst imagination is more closely associated with the disposition of the person involved in the process. She suggest "being imaginative suggest being in pursuit of ideas driven by curiosity and fascination about the subject or task, (pg 39)". These affective aspects identified by Takaya are significant elements of this co-constructivist teaching and learning approach that has children creating, communicating and evaluating their own and others' explanations for the phenomena they experience. Taking children's ideas seriously in science was identified by Harlen (2001) as one of the two most significant developments in the past 100 years of primary science education. She suggests that any explanation that is supported by a positive response to the question, "What made you think that?" must be considered as having an impact on further learning. The significance of intuitive ideas on further learning in science was recognised by the learning in science project (LISP) conducted at University of Waikato during the 1980's and further explored during the SPACE project in the UK (Harlen, 2001). Explanations developed by children as they interact with natural phenomena become the foundation blocks on which further and more sophisticated explanations are developed. A knowledge of these ideas and how they were constructed is vital for a teacher when facilitating deeper understanding and guiding the children's learning in science. From and imaginative educators perspective Egan (2001) cautions the unabridged acceptance of Ausubel's (1968) decreed "The most important single factor influencing learning is what the learner knows. Ascertain this and teach him accordingly". Egan's contention that young children are able to imaginatively generate explanations not linked to lived experience offers a subtle reminder about the importance of having an open mind when interacting with the ideas children share. If the learning environment is conducive, children's expressed imaginations may well provide a much fuller account of their understanding and thinking about the phenomena being explored. To be able to capitalise on and effectively use these ideas will require the teacher to approach their teaching in an interactive manner.

As mentioned previously, Creative Exploration as an approach draws heavily on the assumptions underpinning the interactive approach in particular the exploratory stage and the need to negotiate common explanations for the phenomena being explored. This negotiation includes the clarification of the terms and their meanings used when communicating about the phenomena and contexts involved. It is important that teachers use active listening strategies when teaching in an interactive style. An interaction can be described as an interchange of communications in a context where there is a genuine desire by the facilitator to understand the student's point of view (Rivers, 1987). The recent call for more dialogic teaching and learning in the UK (Alexander 2006) highlights the significance of the need for quality communication to truly understand the students current ideas about the phenomena in question. The valuing of children's thinking by the teachers involved can substantially influenced the student's attitudes towards further engagement and learning in science.

Importance of affective attitudes on developing explanations.

The decline in attitudes towards being involved in learning in science has resulted in the call by some science educators to promote the development of affective attitudes like curiosity, awe, wonder and interest as an essential goal of science education (Millar & Osborne, 1998; Arcus, 2003). Similarly others, Dahlin, (2001), Girod and Wong (2002) and Wickman,(2006, p.38 cited in Tytler, 2007) claim that a more phenomenological - aesthetic approach is required. That is an approach to teaching and learning in science that stresses the importance of aesthetic experiences of natural phenomena that leads to the development of a sense of fascination by the learners involved. Girod and Wong (2002) contend that Dewey's notion of educated experiences, or fulfilled experiences of phenomena over time, could be described as aesthetic experiences that can have a significant influence on learning in elementary school science. Similarly, Dahlin (2001) also contends that there needs to be a greater "emphasis on the aesthetic dimension of knowledge formation" (p. 130). He defines aesthetic as "a point of view which cultivates a careful and exact attention to all the qualities inherent in sense experience …. an approach to natural phenomena would not merely be to appreciate their beauty but also understand them" (p. 130). Learners involved in aesthetic experiences of nature can develop a sense of fascination (Godlovitch, 1998) that can generate a sense of anticipation which can in turn lead them to a depth of engagement and learning (Girod & Wong, 2002). It could be argued that the contention that the affective elements associated with aesthetic experiences may strongly influence how children approach their learning is supported by Egan (2007), proposal "Whatever content is to be dealt with needs to be attached to students emotions in some way… and need to be part of what is dealt with in the class" (p.19). A feature of Creative Exploration is the significance of exploratory activities that, with teacher direction and input, provide aesthetic experiences of natural phenomena that will promote a sense of wonder leading to a desire for understanding and explanation of the phenomena for the learners involved.

Wonder and its relationship with aesthetic experiences

The links between awe and wonder, and aesthetics and fascination are inherent in Goodwin's work (1994; 2001) where he contends that there are three aspects of wonder that directly relate to the teaching and learning of science: "Wonder about", "Wonder at" and "Wonder whether". Goodwin's suggestion that "Wonder about" pertains to questions relating to: How does it work? What would happen if? Why? When? What next? is similar to the notion of anticipation that Girod and Wong contend evolves from initial fascination. The notion "Wonder at" pertaining to the exclamations like: wonderful! wow! how interesting! how exciting! how beautiful!, relates to the appreciation phase of an aesthetic experience of nature (Dahlin 2001). The third aspect; "Wondering whether" includes a value aspect and involves value laden questions pertaining to: Should I do this? Must I do this? Would this be better than that? Is it right? Why is this significant /important? Goodwin (2001) includes a need to provide a greater emphasis on the process and value dimensions affecting teaching and learning in science. Goodwin argues that if the goal is to develop enjoyment of and a commitment to learning in science then there are serious value judgments implicit here that only pupils can make. Goodwin's reference to value judgement can be used not only to clarify our understanding of the relationship between awe and wonder and fascination and anticipation but also link the use of wonder when investigating scientific related issues from a nature of science perspective.

Nature of Science

The increasing demand for science education programmes to present science in relevant context for all students highlights the importance of including aspects of the nature of science into the classroom work in an overt manner. Recent curriculum developments in the United Kingdom "Twenty First Century Science" and in New Zealand the introduction of the overarching Nature of Science Strand in the 2006 National Curriculum draft are both examples of attempts to develop science education programmes that will result in scientifically literate students who will be able to participate in making informed decisions about scientific issues that may impact on them as they go about their daily lives. PISA (2006) identifies scientific literacy as "A willingness to engage in science-related issues and with the ideas of science as a reflective citizen."(Prenzel, 2006) The Nature of Science strand in the New Zealand curriculum identifies four aspects that include;

- Understanding about science
- Investigating in science
- Communicating in science
- Participating and contributing (Ministry of Ed, 2007).

A feature of Creative Exploration is the overt manner in which the nature of science is featured in learning intentions The children are made aware that they are doing science and the Nature of Science aspect involved in the scientific activity is made explicit to the learners.

As highlighted already communication plays a central role in the Creative Exploration approach. Firstly, the learners are encouraged to think and talk to themselves before sharing their ideas with others. The learners are encouraged to work in a meta cognitive manner as they share their ideas with their peers and teachers. They evaluate their and others ideas and in the process further negotiate their understanding and subsequent explanations. A wide variety of communicative strategies can be used when sharing ideas in science. A feature of the early work in exploring this approach is the use of drama and role play to model the phenomena being explored. Initial anecdotal evidence suggest that children creating explanations communicated by models or drama not only increases the engagement of the learners involved but also lifts the level of understanding of the phenomena being explored.

Teachers' actions in promoting engagement and learning.

The quality of teachers' actions and responses when interacting with students can have a significant formative influence on students' attitudes towards science (Osborne and Collins, 2000). The quality of these behaviours is dependent on the attributes, skills, and dispositions that the teacher brings to his or her work with learners. Osborne and Freyberg (1985) identified five aspects of the motivational role that the teacher must play if they are to capitalize on the pupil's intrinsic control over their attention to the learning activity in hand. They suggest that the teacher must;

- "explicitly state the intent of the lesson or activity so that pupils can reconstruct for themselves the problems to be solved or the learning task"
- "encourage pupils to ask themselves, and each other questions which will focus attention and initiate generative learning,
- encourage pupils to take responsibility for, and to direct, their own learning,
- choose situations of demonstrable interest to the pupils whenever possible,
- and encourage pupils to reflect on their own ideas and ideas of others" (p. 92)

These aspects presented by Osborne and Freyberg over twenty years ago are still very relevant today, not only for science education but education in general. They could be described as a set of guiding principles which teachers could apply to their interactions with the learners they are working with as they explore, seek and create explanations. These principles focus the attention on the learners and the control individuals have on their learning as they make sense of, communicate and evaluate ideas associated with the phenomena being explored in a scientific manner.

Ice Hands

A context for exploring Creative Exploration based around the material world -melting / rates of change and the investigative aspect of Nature of Science, identifying and testing variables.

Recently I was invited to assist a group of junior class teachers to plan and teach a material world unit based around kitchen chemistry with the key idea being identifying changes that occur when preparing food. There was a school focus on lifting the level of investigative skills in science. The following narrative describes an example of creative exploration in action. I was asked by a teacher to model the identification and testing of variables with five year old children. The key science understanding involved was change in the form of melting and the context used was water?

The introductory stage of the lesson was spent revisiting the children's understanding of melting. There had been some prior exploratory activity and experiences of changes in material when heated. Firstly the children were asked to share their understanding of melting in a general way. To support this process the children sat around an electric fry pan and were asked to predict what would happen when a range of materials were placed firstly on the cold pan and then if the pan was heated. In the process of testing the materials we established the idea that some form of heat energy was required for materials to melt. The children also noted that some things melted whilst others did not, they only got hotter. Several children were asked to touch the cold pan and hold their hands above the hot pan to establish that there was temperature change between the two.

The children were then introduced to an ice hand made out of frozen water and red dye and asked to predict what would happen to the red frozen hand. The children enthusiastically responded *"it will melt."* The children were then asked *"I wonder what part would complete melting first?"* The most common response was *"the pinkie (the little finger) would melt first"*. When asked why they thought this? One student suggested that the pinkie would melt first *"because it was smaller than the other parts of the frozen hand"*. A short discussion with the children established the shared theory***, "the size of the piece of ice will effect how long it will take to melt".*** As a class we set out to test this theory. Working in pairs the children were each given three different sized pieces of ice and a dish to test the theory out. In the process we established the idea that the only thing that was different was the size of the ice cubes. In their pairs the children found spots around the classroom to observe the melting process. At this stage the teacher visited each group, discussed the progress of their investigation and had the children identify the relationships between the different size ice cubes and the different parts of the ice hand.

After the consultation with each group had taken place the children and teacher returned to the fry pan and the investigation was redone using the heated fry pan. Sets of different sized ice blocks were tested and the prediction that the smaller sizes would melt first was confirmed. The slowly melting hand was placed on the hot pan and the children observed the melting process. The children were spellbound and the engagement was intense. At the conclusion of the melting process the children revisited their theory and decided that their observations from the investigation had confirmed their explanation. To further aid their understanding the children were then asked to role play what had happened to the ice blocks. Each child was asked to pretend they were a very cold ice block. The children then stood tall and erect and then acted out the melting process until they were spread out on the floor. Selected children were asked to model the process in front of the class, the observing class members then explained the process that was being modelled. The whole teaching and learning sequence took approximately 35 minutes and the children were completely enthralled and engaged throughout. There was an emphasis throughout on working with the children ideas, prompting and challenging their thinking, and introducing them to the key idea that science is about developing explanations that can be supported by evidence. Throughout the process the classroom teacher was taking digital photographs which were later used in literacy time to develop a record and account of the activity and to revisit later as the experiences were relived as a power point presentation.

Summary

Although Creative Exploration is still in a developmental stage, it does identify significant practices that could be beneficial for teachers when reviewing their practices. It stresses the importance of making the learner realise that exploration is part of science and, through close observation and wondering, patterns and trends can be identified. The testing and further investigation of these tentative observations and evidence through systematic inquiry can lead to validated explanations that are able to be communicated to others. In short they are using scientific processes to create explanations that are new to the individuals involved. They are doing science.

References

Alexander, R. (2006). *Towards dialogic Teaching: Rethinking classroom talk.* Cambridge: Dialogos, UK

Arcus, C. (2003). Developing a sense of wonder and awe-antarctic (and other) science New directions for science curriculum development. *New Zealand Science Teacher, 104.*

Biddulph, F., & Osborne, R. (1984). *Making sense of our world: an interactive teaching approach.* Hamilton, NZ: Centre for Science and Mathematics Education Research, University of Waikato.

Crooks, T., & Flockton, L. (2003). *Science assessment results 2003*(National Education Monitoring Unit report 29). Dunedin: Ministry of Education.

Egan, K. (2001). *Start with what the students knows or with what the student can imagine?* Paper presented at AERA 2001 retrieved from www.educ.stu.ca/kergan/

Egan, K. (2007) Imagination, past and present. In K Egan, M Stout & K Takaya (Eds), *Teaching and learning outside the box Inspiring imagination across the curriculum* New York: Teachers College Press.

Dahlin, B. (2001). The primacy of cognition- or of perception? A phenomenological critique of the theoretical bases of science education. In F. Bevilacqua, E. Giannetto & M. Mathews (Eds), *Science education and culture* (pp.129-151). London: Kluwer Academic Publishers.

Feasey, R . (2005). *Creative science Achieving the wow factor with 5 – 11 year olds.* London: David Fulton

Feasey, R. (2006). Creativity in teaching and learning science. In W. Harlen (Ed) *ASE Guide to Primary Science Education* (pp. 207 – 215). Herts: Association for Science Education

Girod , M., & D, Wong, (2002). An aesthetic (Deweyan) perspective on science learning: Case studies of three fourth graders. *The Elementary School Journal, 102*(3), pp 199-226.

Goodwin, A. (2001). Wonder in science teaching and learning: an update. *School Science Review, 83*(302), 69-73.

Harlen, W. (2001). Taking children's ideas seriously- influences and trends. *Primary Science Review, 67*, 14-17.

Hackling, M., & Prain, V. ((2005).*Primary Connections Stage 2 Trial: Research report.* Australian Academy of Science

Millar, R., & Osborne, J. (1998). *Beyond 2000: Science Education for the Future*. London: King's College.

Ministry of Education, (2004). *The New Zealand curriculum exemplars science.* Wellington: Learning Media.

Ministry of Education. (2007). *The New Zealand curriculum.* Wellington: Learning Media.

Osborne, J., & Collin, S. (2000). Pupils' views of the role and value of the science curriculum: a focus-group study. *International Journal of Science Education, 23* (5), 441-467.

Osborne, R., & Freyberg, P. (1985). *Learning in Science The implications of children's science*. Auckland: Heinemann.

Prenzel, M. (2006). *Scientific Literacy in PISA* British Council International Seminar on *Scientific Literacy and its implications for schools.* September 2006 York.

Rivers, W. (1987). *Interactive language teaching.* Cambridgeshire: Cambridge University Press

Takaya, K. (2007), Imagination in the context of modern educational thought In K Egan, M Stout & K Takaya (Eds), *Teaching and learning outside the box Inspiring imagination across the curriculum* New York: Teachers College Press.

Tytler, R. (2007). *Re-imagining science education: Engaging students in science for Australia's future.* Australian Education Review Victoria ACER