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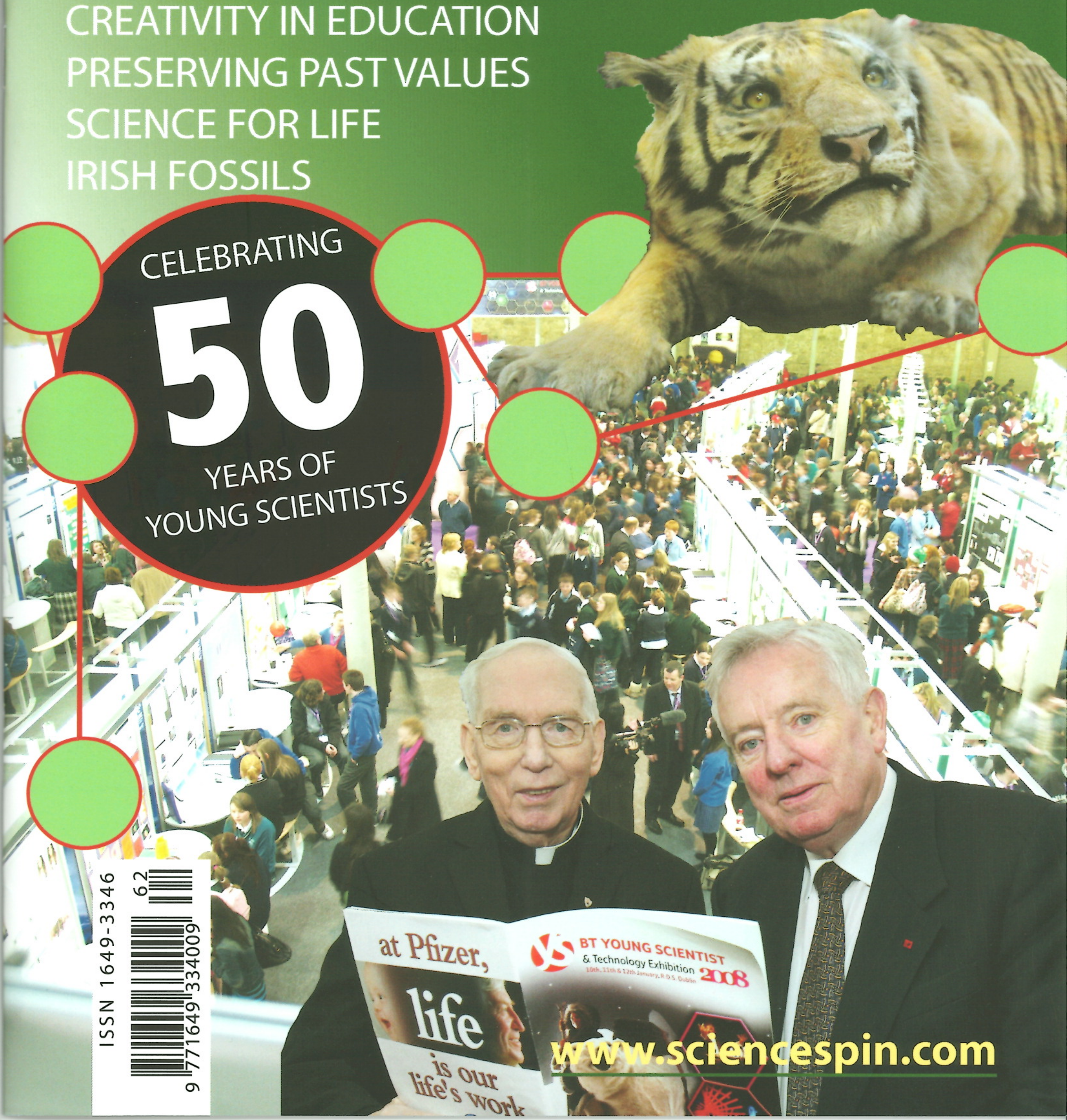

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RE-CREATING SCIENCE

A creativity philosophy for science teaching and learning

Dr Michael Wride writes that we need to be more creative in making sense of what we learn about science

"The fairest thing we can experience is the mysterious. It is the fundamental emotion, which stands at the cradle of true art and true science. He who knows it not and can no longer wonder, no longer feel amazement, is as good as dead, a snuffed-out candle."

Albert Einstein (1949) *The World as I See It* [1].

The creativity of the embryo

As a developmental biologist of over 20 years, I am still filled with a sense of awe and wonder when studying embryos. The gradual appearance of form of a zebrafish embryo for example is astounding. The fertilized egg begins to cleave and the first cells are formed, wrapping around the yolk sac that will provide all the food the embryo needs.

The cells move and divide in an intricate dance of creative exuberance over the ensuing several days. It is the astounding ability that the cells within the embryo have to communicate with each other that always amazes me. This is a dance and dances require co-operation and the ability of the partners to hear the rhythms in the music, creating intricate, interweaving patterns that are beautiful to behold.

To me, the process of embryo development is mysterious and amazing. It always seems to me there is a fundamental creative spark, a kind of ever-changing enthusiasm that the cells have to sculpt themselves into form in time and space. Ultimately, how can we explain the development of such perfect form? The individual cells are constantly and instantaneously communicating with each other so that they are essentially united in one dynamic and indivisible whole.

Sure, great strides have been made in breaking the system down to isolated individual units, whether they be cells or molecules, to try and explain the process, but then all we have are separate fragments whose connections still need to be explained. The emergent properties associated with these relationship and processes still await true understanding.

We need to move away from the idea that creativity is only associated with art and music, rather than science

Aristotle pointed out that, unlike inert things, organisms are 'self-movers' or 'self-changers' in that they have what might be termed an 'inner agency'. Later, Immanuel Kant in his *Critique of Judgment* (1790) pointed out that, useful as they are, linear mechanical approaches using analytical thought can only take us so far in understanding living creatures, because the relationships between the whole and the parts mean that causes become effects and effects become causes. Kant felt it *"absurd ....to hope that another Newton will arise in the future"* who would make any inroads into unravelling these complexities. And so the task of biology was to study the physico-chemical properties of the parts using analytical thought alone [2].

There is even a case to be made that the accepted scientific method actually goes so far as to actively discourage thought! The British biologist Peter Medawar said in his book *Induction and Intuition in Scientific Thought* that the best experiments avoid the need for thinking entirely: *"...a 'good' experiment is precisely that which spares us the exertion of thinking: the better it is, the less we have to worry about it interpretation, about what it 'really' means"* (p14-15)[3].

Such a sentiment echoes the thoughts of the philosopher Martin Heidegger, a long-term critic of science, who pointed out that *"science does not think"*.

An artist's eye?

So, in order to understand embryonic development, is it just a case of explaining the material interactions between the molecules and cells or is there something more at work here, something perhaps even more wondrous? Can we remind ourselves occasionally to just step back, perhaps with an artist's eye, and admire the beauty of the process as it is, while also gaining deeper understanding? Is there a way of actually developing our thought processes to gain direct insights about the phenomena of study? Can we consciously develop 'new organs of perception'?

Surely this is the way that science really works? The most successful and creative scientists have always been able to move beyond the 'official' scientific method into the realm of intuition, imagination and inspiration to gain their creative insights. As Einstein said: *"problems cannot be solved from the same level of consciousness that created them"*. And let's face it, we have many problems requiring creative solutions in the world at the moment.

Perhaps, we need a new renaissance of thought that can somehow meld the feelings, intuitions, imagination and inspiration of the artist with the current rational and analytical scientific method. One pioneer we might look to in this area is the German polymath Johann Wolfgang von Goethe (1749-1832). Goethe was famous as a politician as well as an artist, poet and novelist (the author of *Faust*). He also developed a unique method of science, a phenomenological approach, which he called a 'delicate empiricism' in which the scientist actively engages with the phenomenon of study using the intuitive mode of consciousness to gain creative insights about the phenomenon under study[4]. Using this approach, for example, Goethe was able to develop his 'new organs of perception' and intuit the developmental relationship between leaves and flowers long before plant geneticists had realized the same thing [5].

A creative philosophy at the heart of science education?

Therefore, an emphasis on creativity is particularly important in science teaching and learning. How can science teachers be empowered and freed to take themselves outside of the 'box' in order to develop the approaches to maximise engagement in and excitement about science in their students? How do educators engage students in balancing scientific rigour with an open mind capable of recognising the need for creativity for scientific progress? How can students be enabled to explore and expand upon the latest concepts in a given field? Should we always rely on textbooks that are out of date as soon as they are written? It has recently been argued that textbooks are actually counter-productive to creative learning, since they fail to stimulate the process by which educational experience unfolds as lived meaning and instead contribute towards a kind of 'deadening' of the study material for both the students and the teacher[6].

Therefore, the challenge becomes how to engage and re-energise both teachers and students: to develop the means to teach science creatively and to engender creative thinking in students. We need to do a much better job of embedding the concept of creativity as a fundamental underlying principle in the science curriculum and to highlight creativity in nature during teaching. We need to move away from the idea that creativity is only associated with art and music, rather than science[7].

I would like to suggest here that there is a need to develop a science with creativity at its heart and to provide science teachers with the space and resources to develop a creativity philosophy as the basis of their approaches to teaching and learning; a science that sees the relationships between the parts; a science that effortlessly derives new solutions for seemingly paradoxical and incompatible situations; a science that integrates rather than fragments; a science that inspires students and unleashes their imaginations and creativity. We need a science that sees the big picture as well as the parts, a science that understands its own history and philosophy. We need a science where wisdom, creativity and purpose are valued; a science that is integrated with philosophy again, so that deep thinking is encouraged and facilitated. We need to encourage students to question their preconceived ideas about what science is, to move beyond the notion of science as simply problem solving.

How are students to realise that there are very few if any absolute truths in science, thus opening the door to the presence of hitherto unseen possibilities – the essence of creativity? We need to encourage science students to become active participants in their own education and not passive consumers of unchanging 'facts'. We should emphasise that scientific research and learning are two sides of the same coin: research is learning and learning is research (again, the causes flow into the effects and the effects flow into the causes).

There also needs to be more time in the currently busy curricula for science students and teachers to reflect on the topics of study and on their own learning and teaching processes. Silence and reflection are necessary to develop the kind of meditative thinking that expands the imagination and which allows the insights and intuitions that are essential for creative science learning and teaching to 'bubble up' to the surface[8]. Thus, curricula will become more flexible, more like scaffolding than a rigid structure (perhaps just like the way the cytoskeleton remodels continuously within the cells of our developing zebrafish embryo). We will still have clear ideas about the topic of study and 'learning outcomes' will not be disappearing any time soon, but the teachers and the students will co-create their teaching and learning experiences together as a group by utilising and playing with the knowledge, which is literally at our fingertips, for example, from the information technology revolution.

Today's students belong to the 'facebook generation' having grown up interacting extensively with information technology. These students are used to active learning, 'dynamic sources of knowledge' and connectivity and look to be engaged actively by the content they are studying. Their natural learning processes themselves are highly creative and this will only increase further with the future generations of students.

Indeed, it is recognised that there is currently a battle for creativity at the frontiers of both science and science education[9] and that the pursuit of creativity should be at the heart of biology[10]. But, it still remains the case that science is not perceived as a creative endeavour[11]. As Seán Duke recently pointed out in *Science Spin*, current educational structures focusing on outcomes and results, which are detrimental to real learning and independent thinking, are still prevalent, particularly at secondary school level here in Ireland[12].

So, to engage science students in creativity, we need to re-instill the sense of wonder about science and the natural world as well as bringing about a creative evolution of the educational structures themselves. This is as a total 're-visioning' or 're-balancing' of science teaching and learning — an emphasis on bringing 'love and passion' back into science in a truly holistic manner.

Left brain-right brain

The psychiatrist Ian McGilchrist argues in his book *The Master and his Emissary* [13] that the modern western world, which has been so influenced by science, has developed the left hemisphere of the brain to the detriment of the right side and its ways of dealing with the world. It is now more vital than ever that we recognise that a re-integration of approaches to understanding the world is required that recognises the importance of both hemispheres of the brain in an expanded view of the scientific method and science education that includes the logical, analytical, reductionist left side as well as well as the imaginative, intuitive and connected right side.

However, this ideal concept of the well-rounded scientist is not always the image that the public at large have about science and scientists or even the image that scientists have about themselves. This is in the context of the prevailing culture within academic science with its focus on hypothesis-driven research, reductionism, absolute objectivity and narrow specialisation, as well as the short-termism associated with the necessity to obtain grant funding and the pressure to 'publish or perish' for promotion.

There is also a fear by academic scientists of being ostracised or of losing funding if their creative insights lead them to venture outside of the 'mainstream' or the accepted thinking of the prevailing dogmas and theories in their fields. This is the idea that scepticism is healthy to good scientific practice. However, in the extreme, scepticism becomes destructive, both for individual scientists, and for science as a whole, because it suppresses open-mindedness and creativity.

Perhaps the most iconic articulation of this scientific 'operational reality' was once again made by Peter Medawar in his books *The Art of the Soluble: Creativity and Originality in Science* [14] and *Advice to a Young Scientist*[15]. Medawar proposed that those wanting to achieve success in science should focus on what became known as 'the Medawar zone' of so-called optimal difficulty. The challenge is to identify a problem that is not too simple or too difficult. Simple problems will bring insufficient rewards and attempting to solve problems that are too difficult will only lead to lack of career progression. Thus, the creative value, quality and originality of the work are not as important as the ability to impress one's peers.

This is a rather bleak view of science, which is still propagated in science education in different guises. This view of science as a safe pursuit of obtainable answers reinforces the idea that science is not a creative endeavour. This is then carried over into teaching and learning, such as an over-emphasis on rote-learning, a rigid and dogmatic adherence to the rules of the discipline and a perception of science as the domain of the elite, with a specific skill set and an incomprehensible and exclusive language[9 11]. We could also extrapolate this 'operational reality' to the current obsession with 'cramming' to pass exams in secondary school for example, rather than encouraging creative thinking in our students. Often, the most creative students are those most penalized by the current situation.

Re-visioning science

Thankfully, there is evidence that there are significant numbers of scientists who rank creativity highly in their pursuit of knowledge. In a study on 're-visioning science', scientists were interviewed about their motivations and every day 'lived experience'[16]. The most all-pervasive theme to emerge was the relationship between science and creativity. The research results clearly demonstrated that privately, if not openly in their professional setting, inspiration from art and relating to art were highly important for scientists in finding inspiration and providing a wider context for their work. The words 'wonder' and 'beauty' were often used by scientists when talking about their work.

So, science teaching should incorporate the links between art, aesthetics and science in order to engage and inspire students about the overall richness of nature. A wonderful quote by one scientist stands out from the work on 're-visioning science': *"If you have science without passion, forget it as far as I'm concerned. If you have science without creativity or without insight, well you don't have science. It's about extracting order out of a chaos of information, some kind of beautiful, simple, elegant theory…"*

Emphasising such approaches can lead to greater levels of motivation and transformative experiences on the part of the students, which in turn lead to much deeper levels of engagement[17]. In order to do this however, it will be necessary that science teachers engage with their students in exploring the fundamental role of creativity and connection in nature in innovative, imaginative and inspiring ways.

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