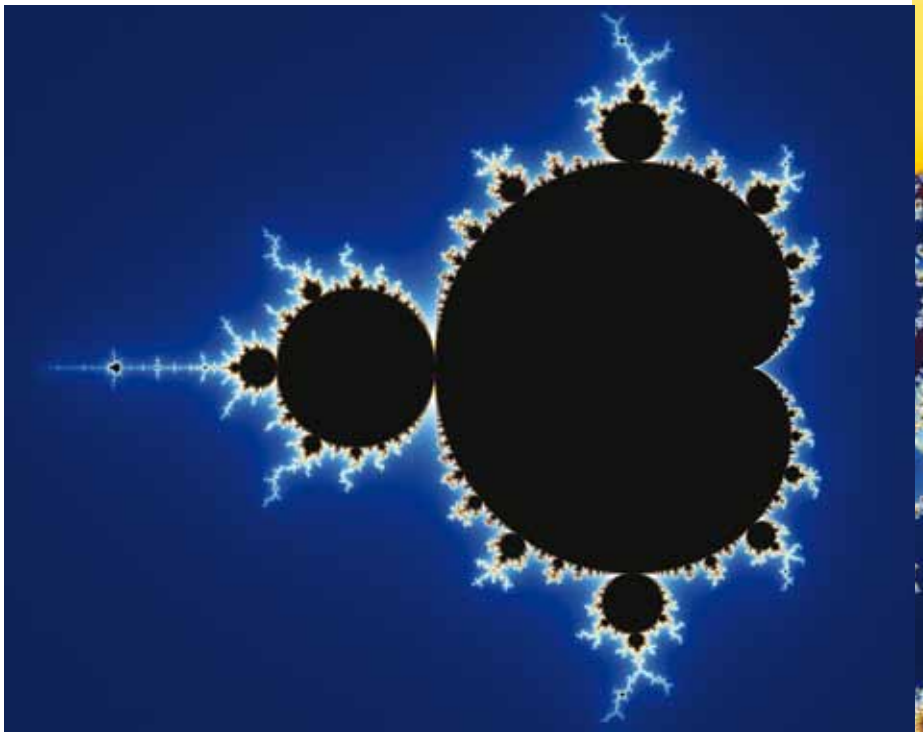
Complexity and Emergence

by Randall Williams

An experienced climber, paddler or skier will recognise the feeling of flow [1] – when action and awareness merge in a state of mind which is wholly absorbed and engrossed in the activity. In such a state, there is no feeling of struggle - hours of practice have led to a state of unconscious competence in which movement is simple and natural. Yet underlying the smooth and apparently effortless movement is a hugely complex set of perceptions and muscular responses that allow a skilled performer to respond to a constantly changing environment. In that process, a simple and satisfying sequence of movements emerges from the complexity.

This article describes another, completely different situation in the outdoors in which simple outcomes emerge from complexity – in an adventure-based residential experience. It argues that the learning that takes place during what is commonly called a residential is the product of complex interactions between the different aspects of the experience, but that those interactions give rise to a simple and satisfying product –the step change in self-confidence that is so often seen.

Findings described are the result of research carried out with primary schools in 2010-2011. It was deliberately a mixture of qualitative and quantitative research. Much research on outdoor learning carried out in the UK is qualitative – understandably, since it can provide an in-depth, rich description of what is happening. However, that is not sufficient – it is clear that, in order to get our message across to decision makers, some quantitative evidence is essential. My research therefore used mixed methods and this article explains both the qualitative and the quantitative findings in an attempt to encourage greater use of mixed methods in outdoor research.

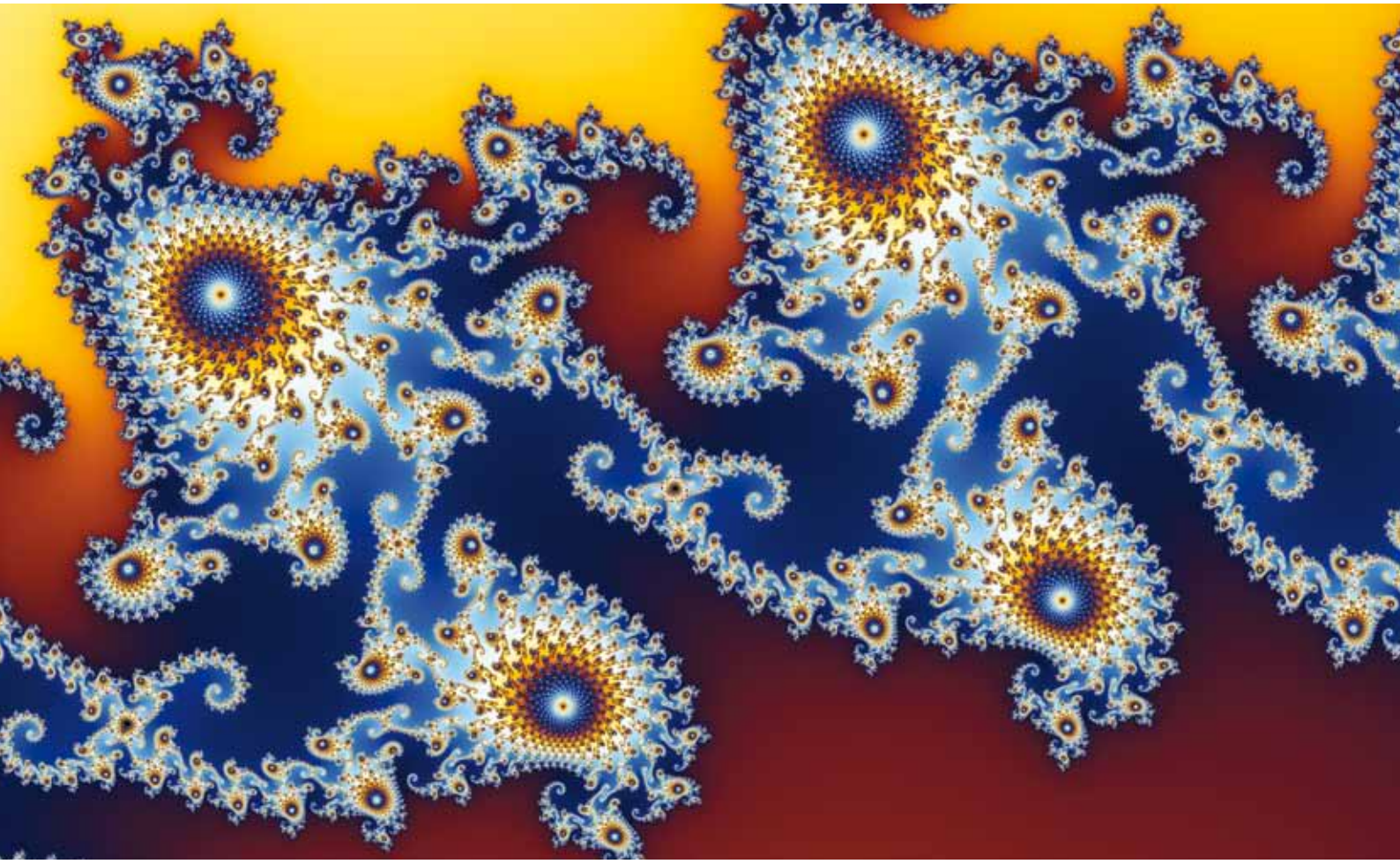


Complexity theory

To understand the way in which the complex environment of a residential gives rise to simple outcomes, it is helpful to get a feel for some key ideas from complexity theory. Complex behaviour can arise in two quite different ways - one is described by chaos theory, the other by complexity theory. In chaos theory, the best known example is the suggestion that the beat of a butterfly's wings in one continent can trigger destructive weather systems in another. A second example is the beautifully intricate Mandelbrot set shown in the illustrations accompanying this article – which is the result of a remarkably simple mathematical process. In both cases, the resulting chaos is deterministic – the outcomes are massively complex but those outcomes are a result of a chain of causes and effects which are, at least in theory, predictable. Chaos theory is about simple inputs leading to complex outcomes.

In contrast, complexity theory is about complex inputs which give rise to simple outcomes. Unlike chaos theory, it is non-deterministic –a complex system consists of a large number of elements interacting with each other, in which it is impossible to describe the outcomes in terms of cause and effect. Such a system has some unexpected characteristics – one is that changes that take place are often non-linear, meaning that outcomes do not vary smoothly with the inputs – instead, small inputs can provoke large changes. Unpredictability and step changes are typical of non-linear systems. A second, particularly exciting characteristic of a complex system is emergence - new behaviour which emerges naturally and spontaneously simply as a result of the complex interactions within the system, rather than in response to specific causal factors.

That 'bottom up', self-organised emergence is well documented in many different scenarios, including the evolution of language, the inner workings of the brain, the growth of



cities and even the emergence of self-replicating molecules in a chemical 'soup'. Closer to the world of outdoor learning, it has been used to describe the emergence of self-esteem, the behaviour of organisations and aspects of classroom education [2].

One factor that encourages non-linear changes and emergence is the presence of positive feedback loops. Feedback is not limited to verbal comments from one person to another – it includes self-perceptions and objective considerations such as success or failure in a task. There are two types of feedback – positive and negative. Negative feedback is commonly used to keep a process on track – imagine paddling a canoe which begins to veer to one side – sensing this immediately leads to a correction to reduce the divergence and bring the process back under control. In negative feedback, the feedback acts as a stabilising influence on the system to return it to a desired state.

In contrast, positive feedback increases or amplifies the effect of any divergence and can have a destabilising effect. This is clearly not helpful when trying to paddle a canoe but it can lead to very interesting new behaviours within a complex system - it helps to create the conditions within which emergence can take place.

A second factor that encourages non-linear changes and emergence is the input of energy to create a degree of disequilibrium – to increase the instability which gives rise to emergence. Interestingly, the potential for non-linear change is greatest when an input of energy pushes the system into a state which is far from equilibrium – the optimum state for emergence of new behaviour to take place is 'on the edge of chaos' [3].

What's that got to do with Residentials?

Residentials contain all the elements necessary to create a complex system. The qualitative part of the research consisted of interviews with parents and headteachers, which suggested that the following factors contribute to the impact of a residential:

- many different influences, creating the potential for complex interactions,
- new experiences, including new activities and living with others 24 hours a day,
- excitation – an increase in energy levels caused particularly by two key energising influences
  - the element of challenge
  - the social dimension,
- a catalytic effect caused by the affective or emotional nature of the experience,
- a cementing effect caused by the memorable nature of the experience,
- the fact that the reward is intrinsic – personal satisfaction has a self-motivating effect,
- the way in which all these elements act together in a holistic way.

To explain how these elements interact to create a complex system, imagine a typical course. Pupils are excited by the new activities. By offering a succession of new experiences, the instructor injects energy into the mix. Being with other pupils in a situation where interactions are

>>

encouraged helps to reinforce the excitation. This creates a 'far from equilibrium' situation which is precisely the condition for the emergence of new behaviour.

That's not all. There is a wonderful degree of mutual support and encouragement between pupils who are attempting challenging activities. Positive feedback from peers as well as from instructors and teachers abounds. Moreover, the fact that overcoming a challenge has an emotional impact creates a snowball effect in which the affective reinforces the cognitive. In other words, rather than simply thinking abstractly that success in one activity might increase the likelihood of success elsewhere, the emotional connotations mean that pupils know, viscerally, that they can succeed.

There is a lot of debate as to how much transfer of learning takes place between a residential and everyday life. However, there was clear evidence from the interviews that the effects are seen in the classroom. This is helped both by the memorable nature of the experience and the fact that pupils experience a degree of intrinsic satisfaction that is deeper than their response to extrinsic reward. Evidence suggests that this leads to a greater degree of self-motivation back in the classroom.

But the most interesting aspect from the complexity perspective is the way that the elements interact to produce non-linear, emergent changes. The rich interactive environment of a residential adventure course, its constantly changing, open-ended nature and the positive feedback that is an integral part of the experience not only allow non-linear change to occur but make it inevitable that it will occur. To illustrate one possible set of interactions:

The new environment and its energising influence creates an openness to new experiences. Working in small groups, pupils want to do well in the eyes of their peers and are therefore persuaded to have a go at something difficult. Support from fellow pupils contributes to success. The emotional impact of overcoming fear creates an obvious sense of achievement. That raises the aspiration of those who might be dubious and gives them the confidence to try. They succeed in turn and the effect is a self-sustaining process of raising achievement within the group.

That is emergence – what one headteacher called "a whole shifting of the peer group". To take these interactions into account in the traditional theoretical model of the process of adventure education would not be easy – it would add a substantial degree of intricacy and would still not explain the step change in self-confidence that we so often observe.

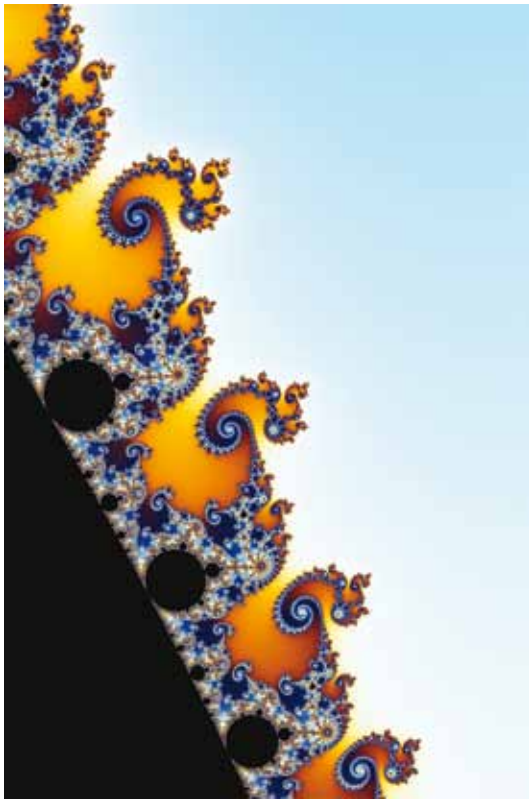
However, if we change perspective and look at the process through the lens of complexity theory, the power of adventure education can be understood very simply:

- Residential adventure education is a complex system,
- Therefore emergence takes place, leading naturally and, for some, inevitably to a transformative, non-linear step change in self-confidence.

Quantitative findings

There is insufficient space in this article to go into any detail on the methods used – it is therefore limited to quoting the results. However, full details of the methodology and statistics are available online [4]. Two sets of numerical data were gathered. The first was simply used to set the scene. This was a simple survey of 260 English primary schools, with the sample chosen in a way that allows generalisation to all English primary schools.

Surprisingly, 95% of English primary schools offered at least one residential experience to their pupils who moved on to secondary school in 2011. (The statistical uncertainty in that figure is plus or minus 5%). This is considerably higher than the most recent reliable figure of 86% in 2004/5. Unsurprisingly, there was a significant correlation between the extent of residentials offered and the proportion of free school meals – the poorer the school's catchment area, the fewer residentials were offered.

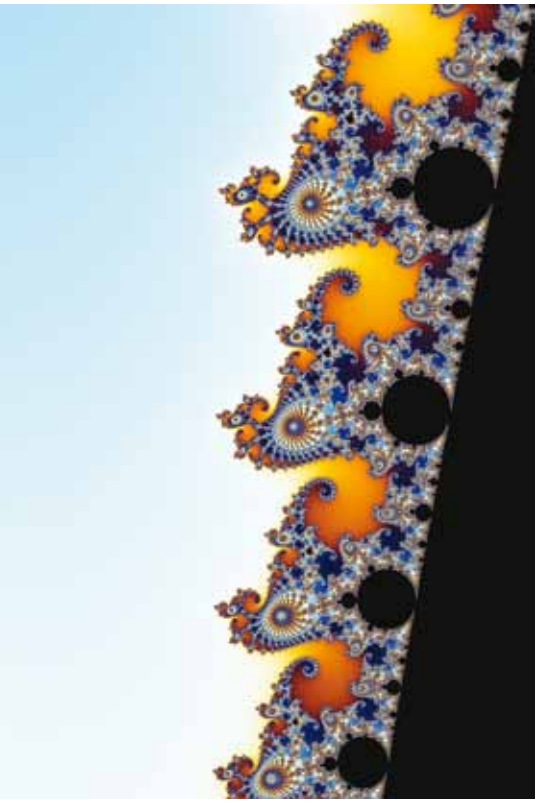


This is a very helpful finding from the perspective of lobbying for greater opportunity for all young people to experience the benefits.

To follow the scene-setting survey, the core of the quantitative part of the study was a survey to gather pupils' perception of the impact the experience had had on them. A total of 232 9-11 year old pupils completed a questionnaire to assess the impact that the residential had on them. Completed questionnaires were analysed using a statistical process that identifies the underlying variables in a set of data. This showed that there were four components to the impact, each of which had a good degree of statistical reliability:

- the impact of living with others
- the impact of challenge
- the impact of developing new relationships with teachers
- the impact of learning about oneself

For some of the pupils, these components of impact were compared with two separate indicators of behaviour change. One was the change in classroom attainment over the period following the course. The other was a measure of social and emotional progress.



Classroom attainment was measured before and after the residential using teachers' formative assessments in reading, writing and maths. Two of the impact components, living with others and teacher relationships, showed a significant correlation with the improvement in pupils' classroom attainment. This is a very exciting finding. However, a correlation does not in itself show that the residential causes the improvement in attainment – to demonstrate that requires more work and the final paragraph of this article invites readers to help with that work.

Social and emotional progress was measured by a self-perception questionnaire. There was a significant correlation between the perceived impact of living with others and the reduction in adverse emotional symptoms. The opportunity was also taken to compare the pre-course and post-course social and emotional indicators. There was a predictably strong and significant improvement in prosocial (co-operative and helpful) behaviour. However, there was also an interesting unpredicted finding - there was a significant reduction in self-perceived hyperactivity. This finding does not of course say anything about causality but it does suggest an interesting area for future research.

Findings from the pupil impact survey corroborate the suggestion that there is a complex interaction between a number of different elements of a residential experience. Drawing together the different parts of the research, there is considerable evidence that the process of personal development through residential adventure education can be seen as a complex system. Moreover, the elements that make the greatest impact were the same in both the qualitative and quantitative parts of the research – the social dimension of living and working closely with others and the impact of challenge.

What does it mean in practice?

To make the most of the potential of complex interactions, an instructor should create the conditions for emergence to happen. Strategies to encourage emergence include:

- Maintain an open-ended approach. Do not 'front-load' an experience with specific learning objectives but allow maximum scope for pupils to develop in different ways as they respond differently to the situation
- Maintain an input of energy, remembering that the energising influences that can provide that energy include both the element of challenge and the social dimension
- Maintain an appropriate degree of disequilibrium by presenting a variety of different challenges, ideally at the level that each pupil will find just achievable.
- Make the most of the way that the different elements of a residential experience interact to catalyse emergence. Recognise the vital contribution of interactions with peers and teachers and make sure there is enough opportunity for these. Create the opportunity for pupils to reflect on their experiences but without leading their thinking down a particular channel.
- Ensure that positive feedback loops exist. Praise effort rather than ability and encourage pupils to believe that they can change their level of achievement by their own efforts.

What next?

Perhaps the most tantalising finding from the research is the correlation between the impact of a course and an improvement in classroom attainment. To establish whether a residential causes that improvement would require an experimental research design with a control group. Because such a finding would be enormously useful in lobbying for greater opportunities for young people, I intend to carry out that research. If you work in a primary school that carries out formative assessments on a termly basis and would be willing to spend a small amount of time getting some data together, or if you think you might be able to put me in touch with such a school, I should love to hear from you – at randall@avius.org. Thank you.

References

1. CSIKSZENTMIHALYI, M. (1990) Flow: the psychology of optimal experience, New York: Harper Collins.
2. DAVIS, B. and SUMARA, D. (2006) Complexity and education: Inquiries into learning, teaching and research, New York: Routledge.
3. KAUFFMAN, S. (1995) At home in the universe: The search for laws of self-organization and complexity, London: Penguin.
4. WILLIAMS, R. (2012) The impact of residential adventure education on primary school pupils. Exeter University: http://hdl.handle.net/10036/3518.
5. THE SCOUT ASSOCIATION, DUKE OF EDINBURGH'S AWARD and DfES (2004) Research into residential opportunities available for young people through schools, London: DVL Smith Ltd.

Author's Notes

Randall Williams. Randall's whole career was spent in outdoor education, starting in Outward Bound and spending the last 30 years as Director of Bowles. He was Chair of the English Outdoor Council from 2003 to 2012. As a retirement project, he has just completed a doctorate on the impact of residential adventure education.

Photographs: With Creative Commons License and by Center for Image in Science and Art _ UL