School gardening as a potential activity for improving science learning in primary schools.

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Abstract

There is current interest in the potential for gardening to facilitate understanding in school science and, increasingly, some evidence of gardening experiences developing science knowledge, process skills and, perhaps, achievement. This paper discusses the effect of *growit*, the Royal Horticultural Society's (RHS) strand of Open Futures – a skills-based learning programme, which prioritises enquiry and community involvement (http://www.openfutures.info/index.htm), on science learning and attainment in primary schools.

As the Open Futures project progresses, we are finding evidence in several schools of an impact on science learning. This includes interview responses from children and teachers as well as better test results for life science units of work, compared to other areas of science, for classes of children involved in *growit*. This paper reports these findings but also seeks to develop understanding of how and why *growit* might be effective. This will be achieved through considering these findings in light of school-based observations, the views of the teachers and RHS project officers, and the results of other research in this area. This will allow us to suggest how gardening might be most productively used by primary schools to improve learning in science.

Introduction

The underlying theme in many theories of child development, including Piaget's, is an increasing abstraction away from the actual to the possible. For example, Donaldson (1978) discusses 'de-centring', while Bruner argues that a "benchmark of intellectual growth" is "increasing independence of response from the immediate environment" (1968, p.17-18). Vygotsky argues (1986) that early reasoning uses 'complexes', not concepts, because the child is not able to abstract and generalise a property away from its embodiment in a particular item. This abstraction clearly makes possible more powerful thought, and must be important for understanding the abstractions of many school subjects including science. Yet children, and perhaps learners more generally, frequently struggle with abstraction.

The work of Adey and Shayer (e.g.1990) in developing CASE demonstrated that many students in the early years of secondary school had not developed their thinking to the Piagetian levels required for them to understand the concepts developed by the secondary science curriculum. Within primary school science children are required to think beyond the immediate situation, considering why things occur and pondering how ideas can be tested logically (DfEE, 1999, p.16 & p.21). It seems likely that these abstractions from the here and now will be facilitated by experiential activities which bridge the gap from particular experiences in a more familiar setting to the more distant or generalising perspective needed by science. Such reasoning underpins the British National Curriculum and experiential learning is considered important by teachers and researchers in this area (Bowker & Tearle, 2007; Mabie & Baker, 1996). Many educationalists would trace it back to Dewey's ideas about experiential education (Dewey, 1938).

Such recurring interest in 'hands-on' experience for learners sometimes shades into, or is sometimes explicitly related to, the understanding of science which prioritises the practices of scientists and the processes of scientific enquiry. So, for example, Mabie and Baker open by proposing the benefits of learning in authentic contexts, but then move onto describing how their initiative emphasised the practices of science:

> Each unit was used as an opportunity to have students practice their science process skills. A heavy emphasis was placed on observation of each project as it progressed, recording observations, making prediction, and discussing outcomes (Mabie & Baker, 1996: 3)

Whilst acknowledging that these can usefully work together in some contexts, we would question whether this is necessarily the case; some very practical activities may nevertheless sit less comfortably with scientific objectives.

A third, potentially separable, perspective on science learning links to a more general inquiry based approach to learning, which is also frequently traced back to Dewey (1938). This issue of inquiry-based learning overlaps, in the practices of education, with the ideas discussed above of providing a familiar setting and hands-on experiences. Sometimes, studies which centre on inquiry, or describe inquiry as the pedagogical approach they are investigating, also make conscious use of situations where learners possess background knowledge. For example Samarapungavan and colleagues describe how the content for their science inquiry with Kindergarten children was chosen partly because young children will "have access to many biological phenomena through everyday experiences with plants and animals" (Samarapungavan et al., 2008: 872). This is undoubtedly good teaching practice, but it makes it more difficult to unpick the relative importance of inquiry over learning situated in a familiar setting.

It can seen then that although it is possible to identify three differing emphases within the active approaches to science learning recommended by educationalists, there is theoretical overlap between these perspectives and, in the classroom, elements from all are used. For all these viewpoints, however, there is potentially a problem for school science of authenticity. It is important that the context for the investigation and the questions being asked are genuine, as well as the science process skills being realistic. Despite traditional classroom experiments being practical and possibly relevant to children's everyday experiences, they are fundamentally contrived and so might seem false to the learners. If so, they will probably fail to use them to connect the generalisations and methods of science with their real life, producing fragmentation in their understanding and failing to capitalise on any existing understandings that they have from their everyday lives.

This begins to suggest the benefit of using separate, genuine, everyday activities as a way into science. An obvious possibility for an activity that could fulfil this role is gardening. Studies have shown the benefits of such "different frameworks of learning around scientific experience" through gardening at home (Ruby et al., 2007, p.141) or in out-of-school projects (Rahm, 2002). To ensure these benefits are available to all, however, gardening in school as a curricular activity might be advised and a recent review of related literature notes the history and expected benefits of school gardening (Dillon et al., 2003). There is some evidence that the knowledge children gain from such activities in UK schools may be rather shallow (Bowker & Tearle, 2007), which does not bode well for using gardening to facilitate science understanding. Some research with American children of primary age, however, suggests that if the children are better directed links can be made between gardening and science. A study found that carefully designed gardening activities improved scientific skills and reasoning, which were tested through an unrelated hands-on assessment (Mabie & Baker, 1996).

Currently there are many gardening initiatives in UK schools, some of which seem to be fairly ephemeral, encouraging some gardening to be provided as an add-on to school provision. It seems unlikely that such approaches would have much impact on general learning or science, though they may be enjoyable and worthwhile in themselves. The Royal Horticultural Society (RHS) are involved in a number of the more structured and sustained projects and approaches, which aim to impact more completely, including effects on home, life and school curriculum. It is aimed that

> through gardening children can find the confidence to see new opportunities to shape their own future. This may take the form of improved teamwork, a love of art and natural forms, a better appreciation of science or even the desire to take up gardening as a career" (www.openfutures.info/partners_rhs-flourishwhite.htm).

It is this understanding of the potential of gardening that informs the *growit* strand of the Open Futures initiative, though the aims of the project as a whole are considerably more general. As their website describes:

> Open Futures is an education initiative for Primary Schools funded and directed by The Helen Hamlyn Trust. Its purpose is to help children discover and develop practical skills, personal interests and values which will contribute to their education and enhance their adult lives (www.openfutures.info/index.htm).

The Research Centre for Learning and Teaching, based at Newcastle University (http://www.ncl.ac.uk/cflat/), has been evaluating the pilot stages of this innovation and so we have had the opportunity to observe how such an approach to gardening, in the context of a wider project in a range of different schools, has developed. *Growit* involves expert gardeners from the RHS working with children and teachers in primary schools to develop school gardens and, through growing fruit and vegetables, learn more about plants, wildlife and the environment. Although the gardening is provided as a separate, intrinsically motivating activity, teachers and RHS project officers are aware of potential links between the gardening and, in particular, life science topics, which they try to enhance. It is this possibility that involvement in *growit* might affect children's appreciation and understanding of science that is explored in this paper.

Method

Evidence for *growit* having an impact on science learning arose through our personal and continued involvement with a more general evaluation of the Open Futures initiative, which has been taking place since September 2006. This investigation of the strand as part of the evaluation of the bigger project has necessarily meant that we have not had much opportunity to design or chose methods specifically intended to investigate pupils' learning in science. Instead we have made use of a range of data collection tools, mostly originating with our evaluation but some of which were produced by the schools as part of in-house evaluations of responses to the project in their schools. Through this eclectic range of methods, we have collected various information from pupils, teachers, parents and project officers. The evaluation as a whole has inevitably produced a vast amount of varied data , only some of which is relevant to this paper, and this has led to challenges in terms of methodological rigour. It is important to emphasise, however, that as we did not set out to look at science learning, we were not here trying to prove a theory, but rather reporting on an understanding that has naturally emerged from the data.

Initially 20 schools were part of the project, ten of which are located across five neighbouring local authorities in the south of England and ten of which are situated in two local authorities in the north of England. These were joined, in 2007, by another eleven 'associate' schools linked to four of the southern schools, and, in 2008, by approximately 20 new schools linked to five of the existing northern schools. The evidence presented in this paper is drawn mainly from the 20 schools with the longer involvement in the project, since it is here that the learners and teachers have had most experience of *growit*. We will look at the following evidence in turn and discuss what, if any, conclusions can be drawn:

Informal comments made by teachers during visits and meetings.

Over the course of the evaluation, we have made visits to the schools involved, where we have talked to teachers and teaching assistants (TAs) who are active in the project, as well as usually meeting the headteacher.

Informal comments made by project officers during visits and meetings.

We have talked to RHS project officers when they are in school providing support and training. We also interviewed a number of officers by telephone in the earlier stages of the project (in spring 2007), mainly to gauge general reactions in school, and met two project officers in summer 2008 to discuss our exploration of science learning.

Interviews with pupils.

Semi-structured interviews were carried out with small groups of children in four schools (two in the southern area, two in the north) in autumn 2007 about their experience of Open Futures up to that point. These learners ranged in age from a Y1/Reception group to groups of Y6 children. We asked in turn about each of the Open Futures strands which the pupils had experienced, using the following schedule:

What have the 'lessons' in *growit*
cookit
filmit
(*askit* [if appropriate])…..been like?

How do they compare to 'normal' lessons?

What do you think you are learning? (probe for ideas about content and process)

Questionnaires completed by pupils and parents.

Over the course of the initiative, many of the schools have used rating scales or questionnaires to allow children and parents to evaluate the Open Futures strands. In two schools, this method became particularly developed and below we report comments made by pupils and parents at these schools in relation to their experience of *growit* in 2006-07 and 2007-08.

Science concept maps completed by pupils.

These concept maps were created by pupils at three of our Open Futures schools in the summer term 2009. They were completed under the guidance of one of the researchers as part of a more general visit to the school as part of evaluation of the project. Unusually for our methods, however, they were targeted specifically to investigate the understanding the learners had of science and probe for any links they might make between science topics and other learning, perhaps including gardening. Schools were asked to select pupils who had had at least one year's experience of *growit*. The schools were asked not to introduce the researcher as part of the Open Futures project, but to explain that that she had come to talk to them about science. This was designed to help prevent leading the pupils into making links between science and *growit*; it was not felt that it misled the children in any way and all participants gave their permission to take part in the exercise. Groups completing the templates were between three and four pupils, and the meetings were held away from the classroom. Pupils were from years 3, 4 and 6.

Pupil science test results.

Reacting to comments made by the Open Futures co-ordinator in one school, who taught a Y2/3 class, we analysed science test results for a group of her learners. These tests were completed over the years 2006-07 and 2007-08, and the school makes use of a science assessment pack based on

QCA units (Windmill Press). The analysis compared their performance on units of life sciences work to their performance on tests of science units less immediately linked to gardening experiences. A similar analysis was carried out for school-produced end of year tests results for Y3 pupils in another Open Futures school in summer 2008.

At all times the researchers worked to BERA's code of ethics, using the Association's *Revised Ethical Guidelines for Educational Researchers* (see: http://www.bera.ac.uk/files/2008/09/ethica1.pdf)

Findings

Informal meetings: teachers

During a routine meeting at School A in 2007-08, the very experienced teacher mentioned her perception that the plant-related units of science work were easier to teach since her class of Y2 and Y3 pupils had become involved in gardening. She remarked that this seemed to be because the children had better background knowledge and understanding than she had come to expect. In School B, the teacher made related points about how *growit* was providing an authentic, practical context for the more abstract scientific ideas which she was trying to convey in lessons. She talked about drawing on practical understanding and experiential knowledge when teaching science, but also mentioned how the more abstract scientific knowledge could enhance the *growit* experience. The teacher's example of how *growit* might relate to understanding in life science involved a child who talked to the RHS officer about ladybirds eating aphids, which in turn eat plants, and suddenly recognised that he was describing a 'food chain'. This was in addition, the teacher pointed out, to her being able to use examples drawn from the children's gardening experience when she wished to illustrate a concept, such as that of food chains. Since the relationship of the practical setting and the more abstract knowledge, understood in this way, is essentially two-way, it might be argued that *growit* is providing a bridge between the abstract and the practical, in this area of science, which appears to be very useful for learning.

If the potential for gardening to enrich science teaching and learning is recognised by schools, this has implications for staffing. In one of the schools, the headteacher explained how she had arranged for a specialist science teacher to cover PPA time in her school, with this teacher also leading lots of Open Futures activities. This organisational linking of science with *growit*, and the other strands, had been judged to work so well that when the teacher retired, the head specifically appointed a new teacher who also had a science background.

It must be noted, however, that such links between gardening and science were not routinely reported by teachers, and perhaps did not seem evident to all. This is reflected both in their comments about the impact of *growit* and the links they choose to make through their teaching practice between gardening and other school subjects. For example, at one of the newer associate schools, when the Open Futures co-ordinator, who was also the school's science co-ordinator, talked about integrating the Open Futures activities into the wider curriculum he particularly mentioned the use of gardening journals to develop literacy skills.

Informal meetings: project officers

As discussed above, some teachers talked about drawing on practical understanding and experiential knowledge when teaching science, but also mentioned how the more abstract scientific knowledge could enhance the *growit* experience. This is the perspective, we have discovered, that the RHS project officers tend to take. It leads them to deal quite explicitly with scientific issues or questions when they arise, particularly if this involves correcting a scientific misunderstanding. They gave the example of explaining that the large earthworms, referred to by some children as 'bloodsuckers' did not suck blood.

In some ways the RHS officers were also trying to initiate a more scientific approach to *growit*. This involved some wet day activities which explicitly linked growing to aspects of life science and general scientific method, which the children would have met in school science. In developing these, the officers had made use of the KS1 and KS2 National Curriculum for science. During a school visit one of the researchers observed a project officer exploring the garden with a small group of pupils, lifting up stones and discussing what was found, encouraging close observation and identification.

Project officers broadly felt that there is lots of potential for using the garden space to support scientific and number-based school learning. However, it was commented that teachers did not always realise this potential and perhaps needed support to do this at times. It was suggested that for teachers to make these links with the wider curriculum they needed more gardening experience themselves and that more teachers should accompany their classes into the garden for their *growit* sessions. There was also some speculation that activities, such as they used with the children on wet days, could be shared with the teachers.

Interviews with pupils

During our evaluation of Open Futures, children's enjoyment of the *growit* activities has been emphasised by the adults involved. Direct responses from pupils generally confirm this impression. An example is provided by this Y6 pupil from School C:

> I really enjoyed it – it was new. It was fun we did the work and Miss X was fun, she really encouraged us. You could not do it wrong even if you mixed the seeds up, it did not matter. It was nice to learn about what you eat… We grew the pumpkins (you can see) in the entrance hall. Before we did the garden it (gesticulating out of the window) was just weeds, now it is brilliant, it even has a pond.

This was the view from a Y4 pupil from School C:

> It's very different. You get experience … you're free and its fun and you collaborate. In class you write on your own, and you're not free, but in this you go out and get muddy and have fun.

A few pupils did not enjoy gardening, but only a total of 5 in two classes in School D who were asked this question. Their reasons were related to not liking getting dirty or physical work and feeling cold.

Generally children involved with *growit* experience it as different to other school lessons and activities, and this interpretation seems to be more pronounced with the older children. Interviews provided detail on this viewpoint. These are the views of four pupils from School C:

> Pupil 1: In literacy and maths you are sitting down and told what to do. You have more choice and more variety in *growit* and *cookit*.
>
> Pupil 2: It is relaxing – in maths and literacy I have to get everything right and I even think - I have to get a 4C. In *growit* and *cookit* you can learn from your mistakes. It is the experience that is important.
>
> Pupil 3: In English and maths you can do the same (meaning similar) thing for days. In *growit* and cooking you do things that are different every time. In English and maths you have to do something in a certain amount of time.
>
> Pupil 4: Like (names 2 other pupils) in maths you have to do the work and you might have to stay in to do it. In *growit* you are eager to keep going. You say to yourself: 'Oh no, the hour is nearly over, I want to stay longer.' Time whizzes by. There was no hanging around, it would be 2 minutes of talking and listening and then she gets you going and learn the way to do things. Time goes more slowly in lessons, you look at your watch a lot.

In School D pupils had the following views:

> Pupil 1: I like using my hands, I like fiddling and I can get into trouble in maths and literacy. I like digging in gardening and I like building and making things
>
> Pupil 2: You can talk, but you have to be careful too. We know what we are doing and we get the work done. In English you can't write and talk or you miss your break.

Pupils interviewed have also provided specific comments about what they are learning in *growit* sessions:

I know lots of vegetables now, tomatoes, pumpkins, lettuce, garlic (and a further 7)

We know about planting at the right time with the moon and we know a lot about organic gardening, we don't use pesticides, because they are harmful. We use compost stuff to make our plants grow, because it provides all the food that plants need and it means they need less water as well. Everyone puts their fruit bits in the bins in their class and they are collected up by a monitor and put in the compost bins – you should see the fruit flies when you open the lid.

Across the pupils of various ages and at the four schools visited, the interviews suggested that a wide range of knowledge had been gained. The vegetables grown were listed with evident enthusiasm. Their responses also revealed that specific skills were learned through gardening, as they talked about learning to use the tools correctly, "how to harvest properly" (Y5 pupil School E) and the gardening tasks they had completed. While it is notable that they saw this learning mainly in terms of particular gardening skills and knowledge, there were also some suggestions of increasing knowledge and understanding of the natural world. They described how plants need daylight, watering and weeding, and it was also clear that through constructing 'wildlife towers', they had developed their knowledge of garden wildlife. The fact that these towers were mentioned in all the interviews about *growit* conducted in one school (School F), and provoked recall of the many creatures the children had observed, suggests the importance pupils attached to this particular activity.

Questionnaires: pupil responses

Enjoyment

Over the course of the initiative, many of the schools have used rating scales to allow children to rate their enjoyment of the Open Futures strands together with other subject areas. Generally the gardening activities are enjoyed, usually preferred to English and maths, especially by older primary pupils. These evaluations add to the growing picture of very positive pupil response to Open Futures, especially in the later years of primary school, and provide further evidence that as children progress through the school years they increasingly appreciate Open Futures activities as being more different from 'normal' school.

In two schools, pupils of various ages completed questionnaires written by the schools that asked, in different ways, about general enjoyment of the Open Futures activities they had experienced. In all cases, a clear majority of the children respond positively to the question of enjoyment, even when they are given a more neutral choice of 'OK'. Where children were less enthusiastic about *growit*, the comments they made reveal that they relate their lack of enthusiasm to the weather and to the more practical, outdoor aspects of gardening:

Well I liked it but I only did it for a short time. And most of the time it was gloomy

Because I don't really like getting dirty or I'm digging and kill a snail

Because I like to be inside best
(Responses by Y3 children at School B, summer 2008, who had indicated that they found gardening 'OK', to the question 'Why?')

It must be noted, however, that it is this outdoor aspect of *growit* that many pupils particularly enjoy, and some children link this to experiencing the natural world:

It gave me chance to enjoy fresh air

Because you can see nature and caterpillars

Because I enjoy being outside and see the wildlife
(Responses by Y3 children at School B, summer 2008, who had indicated that they found gardening 'good', to the question 'Why?')

Learning, skills and knowledge

A questionnaire completed by a sample Y2 and Y3 children in School G near the beginning and at the end of one academic year (2006-7) asked a number of questions relating to knowledge about fruit, vegetables, gardening and growing food. This revealed a very clear increase in the numbers of vegetables that respondents could name and reported having tried. The following year, a similar questionnaire was administered at the end of the year to all the children of this age who had been involved in *growit*. Again the answers were comprehensive, with for example, all children in both these year groups being able to respond appropriately to 'In the garden we are growing…'. The Y3 pupils were asked to name fruit and vegetables. All of them could name at least four fruits and vegetables, with most able to name between eight and ten. Unfortunately, since for this second questionnaire, we do not have a measure of this knowledge before the Open Futures activities began, this does not tell us exactly what they are adding. However, looking across the two questionnaires, it seems fair to conclude that the *growit* strand had been developing content knowledge, which is clearly relevant to gardening, and perhaps also to life sciences.

Clues to the process knowledge and skills that these children consider they have learned are provided by their responses to the prompt 'This is what I have learnt about gardening...'. Their answers refer to various gardening skills such as digging, watering, how and when to plant seeds, sometimes including detail which suggests the knowledge and understanding that they are developing as they learn the skills. For example:

> To not put the seeds too close to each other
>
> you need to water them to help them grow
> (Responses by Y3 children at School G, summer 2008)

This second response clearly suggests the sort of knowledge that could support further learning in life science. The child, who was at this point nearing the end of Y3, might be suggesting their awareness of a link back to science work of the previous school year when children of this age generally experiment with germinating beans. It must be noted, though, that most children did not make such comments, tending to report understanding that is much more closely linked to gardening, which is not surprising, given the phrasing of the question that was asked. Many clearly understood this in terms of skills rather than background knowledge, including one child who responded "I have learnt all the skills".

Although the question about learning that was asked by the School B questionnaire was phrased more openly, asking 'What do you think you have learned?', responses from the Y3 children were very similar, again reporting various gardening skills. There were some responses, however, that talked of increased knowledge of the natural world, some of which parallel the pupil interview comments reported above:

> how to identify aphids and types of plants
>
> new names of fruit the names of seeds
> (Responses by Y3 children at School G, summer 2008)

In an attempt to establish an overview of what children think is important about *growit* activities, including why they like them and how they think they are benefiting, the questionnaire responses made by children in these two Y3 classes at School B were categorised. These were answers to the questions 'Why?' (…did you give that rating) and 'What do you think you have learned?'. The categories used for the children's answers had previously been developed to analyse adult responses to questions relating to pupil outcomes and benefits on the questionnaires completed by staff at the pilot and associate school after two terms of the Open Futures initiatives. The intention was to look for similarities and differences in adult and child views of the characteristics and benefits of Open Futures, but for present purposes the following table is revealing of learner understanding of *growit*:

Table 1: Child responses (from 69 questionnaires completed by Y3 children) to questions relating to pupil outcomes of *growit*

Affective	**Frequency**	**Learning Experience**	**Frequency**
Helps shy, underachieving pupils, gives confidence	0	Practical outdoor approach, first hand approach	13
Interest, enthusiasm, motivation	3	Relevance/meaningful context	0
Enjoyment/fun	3	Real outcome/authentic learning	5
Lifelong Learning/Life Skills	0	Improving lifestyle	0
Nurturing/taking care	0	Multi-sensory learning	0
Inclusive	0	New/different	1
Pride	0	Total	19
Links to home interest	1	**Relationships**	
Total	7	Builds relationships between teacher and pupils	0
Skills			
Develops speaking and listening, talk, discussion	0	Builds relationships/social skills between pupils	0
Asking questions/Questioning	0	Total	0
Develops cooperative/ teamwork skills	0	**Knowledge**	
Initiative/creativity	0	Knowledge of where food comes from	0
Improved writing/Writing skills	0	Healthy diets	0
Personal and social education	0	Improved knowledge of the world	1
Fine motor skills	0	Develops environmental/ ecological awareness	1
Record keeping	0	Making connections	1
Signing skills	0	Helps learning	0
Thinking skills	0	Safety/hygiene awareness	2
Skills (generally)	0	Vocabulary	0
Concentration	0	Identify plants/animals/food	11
Gardening skills	17	Total	16
Total	17		

In general, as suggested by the quotations reported above, the children tended to emphasise knowledge and skills, together with what we have termed the learning experience, over affective or relationship benefits. Considering the finer categories, it is clear that some of the ideas suggested by the adults, on which the categories are based, do not entirely match up with the understandings the learners have, or at least which they are able to produce in the context of a short questionnaire response. In particular, adults involved with Open Futures suggested a range of skills that the children might be learning, but these Y3 pupils only see themselves as gaining 'gardening skills'. This difference is probably partly due to differing interpretations of the same learning: it is notable that many of the children's comments categorised as gardening skills specifically referred to garden jobs such as harvesting and watering, which might be interpreted by an adult as involving listening or cooperative skills. Nonetheless, it does seem possible to conclude that the children were more inclined than the adults to interpret their learning in terms of gaining specific skills. The value they place on this opportunity and their appreciation of the expertise of the RHS project officers is suggested by this comment:

> the people who teach us teach us properly so we don't harm the plants
> (Response by Y3 child at School B, summer 2008, to the question 'Why?')

These questionnaire responses also show that the children perceive that they are gaining various sorts of knowledge from their involvement with *growit*. This is mostly to do with identifying plants and animals, which, as has been discussed above, might indicate some content knowledge links which the child has made, or which could be developed, between gardening and biology.

Questionnaires: parent responses

The two schools which administered pupil questionnaires about Open Futures also sent home questionnaires asking related questions of parents. While the style of these questions, and the answers given, is heavily influenced by the relationship between the schools and their parents, they provide some suggestion of what parents perceive the impact of *growit* to be. The parents' questionnaire administered by School B in the summer of 2007, asked whether they now did more growing 'as a family' and whether their children would now 'try more new food'. These questions provoked insistence from some parents that they already did these things, but, in general, the answers were quite mixed. On average, reactions to the questions about trying food were slightly positive while answers to the question about gardening at home were slightly negative. However, this assessment hides a wide range of responses, including some from people who clearly had been inspired by *growit* to grow food and enthusiastically list the vegetables and herbs they are growing.

The parents' responses to the questionnaires suggest that they perceive the *growit* strands to be developing relevant knowledge. As these examples show, however, this knowledge is generally understood as relating to the life skills of gardening and eating well:

> My child has always had a keen interest in good / healthy food. Gardening and recycling is a way of life to us, however it has re-enforced our beliefs and increased and supported the importance of it.
> (Parent questionnaire School G summer 2008)
>
> I think that the *growit – cookit* project has been very educational for my child. Learning about different foods and where they come from and what is healthy and what is not.
> (Parent questionnaire School G summer 2008)
>
> This has been brilliant and has affected us all as a family. Although we only have a small garden, we have managed to grow the above. Next job – composter!
> (Parent questionnaire School B summer 2007)

Pupil science concept maps

Concept maps were created by pupils at three schools. As discussed above, the aim was to investigate learners' understanding of science, and any links they might make to gardening, but we did not introduce ourselves as being there to hear about *growit*. However, in at least one school the researcher was aware that the pupils had been told that she was from Open Futures; in this case the researcher emphasised that she was from Newcastle University and that she was interested in what they could tell her about the whole of science.

In all cases pupils were asked to design a concept map about science, making links with any areas they felt were connected, and to include science they had done at school, both inside and outside of the classroom, and at home. All children were broadly familiar with the idea of concept maps and so did not require any further explanation as to what one looked like. Pupils were reassured that there were no right or wrong answers, that the finished maps would not be handed over to the school but would be taken back to the University to show colleagues what the children had been doing in science and that they may be used as part of a report and/or article. The conversations that arose in the groups as the concepts maps were being designed were not recorded, but the researcher encouraged the pupils to write down relevant comments that they made and made occasional notes herself.

School A - (Year 3/4)

One group of four pupils and another of three, all from a mixed Year 3/4 class, took part in the activity. The pupils began by placing 'science' at the centre of their map and then listed topics and activities which they felt were incorporated within science as a whole; topics were often those explored by the curriculum, for example 'electricity', 'bulbs and circuits', 'temperature' and 'looking after animals', but also included Open Futures either as a collective or in terms of the four strands (*growit*, *cookit*, *filmit* and *askit*) and more frequently specifically the gardening activities (*growit*). Many of the children wrote about a current competition, known by the researcher to be part of Open Futures, for who can grow the best vegetable and linked this to information about how to look after vegetables 'water it', 'weed it' etc. In a few cases this was further linked to growing activities at home, which tended to centre around helping a relative with growing flowers, and in some cases links were made to more traditional science experiments carried out in class such as growing cress and beans in a variety of conditions, this is displayed in figure 1 below.

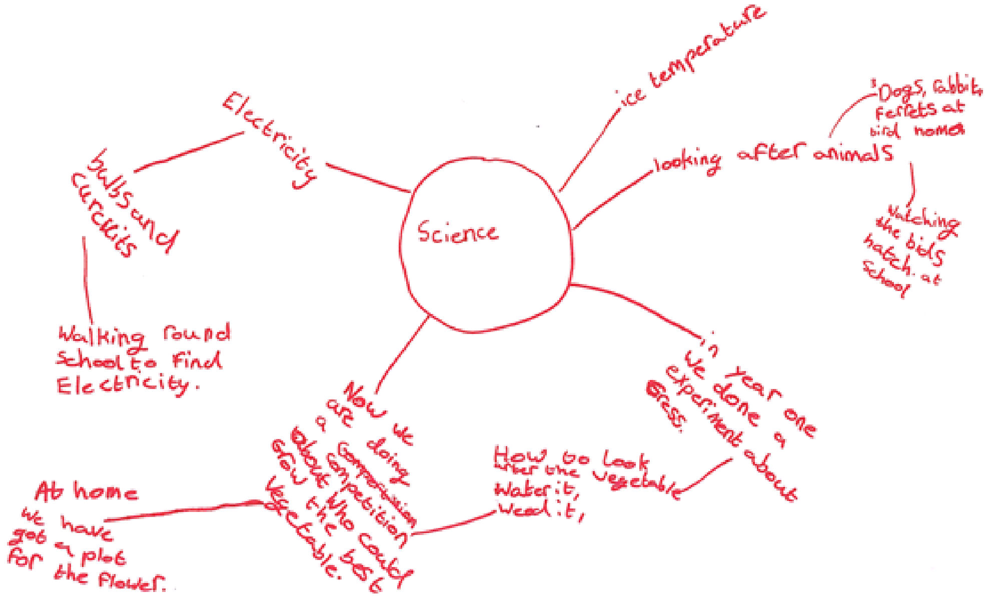

Figure 1: concept map produced by pupil in School A

A further link that pupils in this school often made was between *growit* activity and mini beasts, in particular the spotting of a newt and centipede that evidently happened during a gardening session. In one case a pupil was able to link this to work in class on baby animals, although the majority did not.

School H - (Year 6)
A group of four Year 6 pupils in this school were asked about scientific experiences and learning, including but not necessarily confined to science lessons. Pupils readily wrote about cooking, gardening and art as well as more traditional areas such as electricity, magnets, gravity, motion and friction. Some links were made between the more traditional areas, for example electricity and magnets and motion and gravity, but in relation to gardening the only link made was that between growing vegetables and cooking, which all four of the children made.

School I - (Years 3 and 4)
In this school two groups were interviewed, the first included four pupils from a Year 3 class. In this group pupils listed various areas they felt were incorporated within science such as ‘float and sink’, ‘teeth’, ‘healthy food’, ‘weather’ and ‘rocks and soil’. Whilst individual areas were then explored, for example one child linked ‘rocks and soil’ to ‘beach’ and then ‘diamonds, rubys, pearl, sapphire’, very few links were made between areas. One exception did link ‘plants’ to ‘gardening’ and subsequently to ‘rocks and soils’, but this was not representative and was one of only two mentions to any kind of gardening, the other linking ‘rocks and soil’ to ‘flowers and jewellery’.

The second group of four were from a Year 4 class and the concept maps produced here were much more likely to list things that they had done rather than actual topics. Some examples include ‘made some gooy glue’, ‘what have bones and what the scientific word is’ and ‘science fair’. Again some pupils were able to explore links between certain areas, particularly areas that were linked in their activities, for example different aspects of the science fair, but this was not always the case and unfortunately pupils did not explore *growit* or gardening more generally in their concept maps. The nearest indication was one pupil who linked ‘we learned about every living thing and compared them to each other’ to habitats and the life cycle of a tree, to an incident at home when he had spilt some sugar and the ants had come and carried it off. Nevertheless none of these descriptions indicate activity known to the researchers as part of *growit*.

Figure 2: concept map produced by pupil at School I

Overall, the pupil concept maps produce rather a mixed picture. Whilst in School A links were made between *growit*, the science curriculum and/or home activities related to science, this was not replicated in either School H or School I.

Pupil science test results

School A

In School A, end of unit test scores had been recorded for a group of children who had (in summer 2008) just completed Year 3 and their second year of participation in *growit*. Two of the science units considered below were followed in Year 2 and two in Year 3. When the test scores were compared with those from other science units, it was found that the children had in general performed considerably better on the plant-related units. This is shown below in box plots of the distribution of the children's scores on the tests of two contrasting science units covered in Year 2 and for another two units covered in Year3:

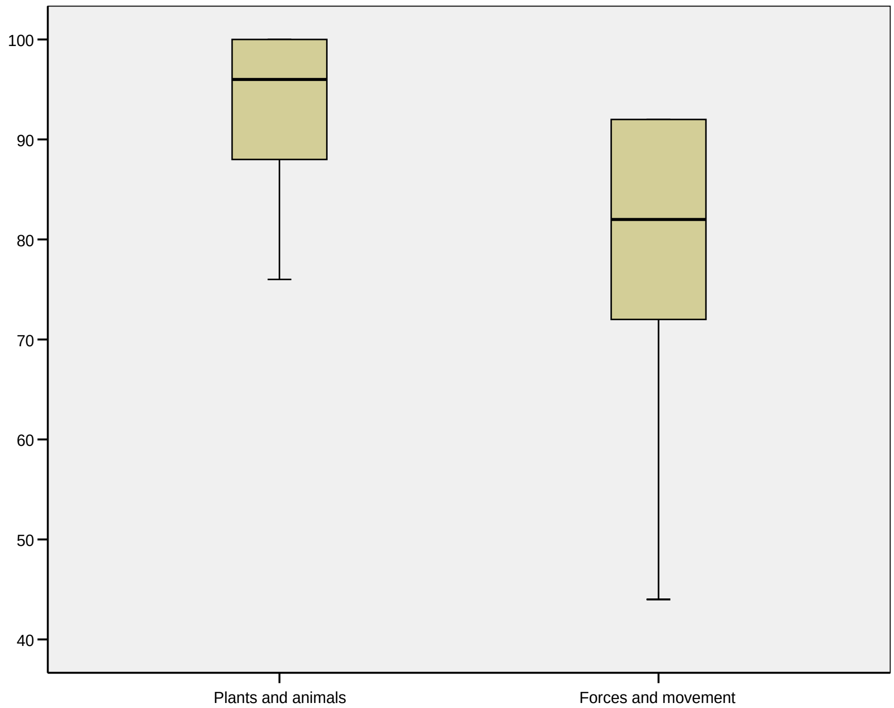

Figure 3: Distribution of test scores for Unit 2B and Unit 2E (School A)

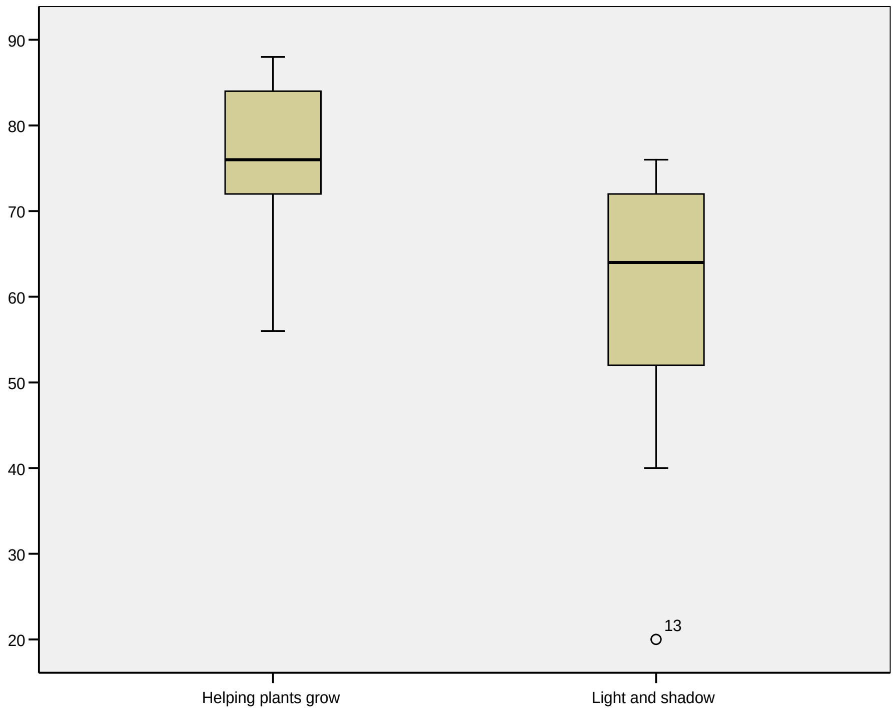

Figure 4: Distribution of test scores for Unit 3B and Unit 3F (School A)

Comparing each child's scores on the Year 2 and Year 3 units using a paired samples t-test reveals that the higher scores on the plant-related unit tests are indeed statistically significant ($p=0.004$ and $p<0.001$ for Y2 and Y3 respectively). These results, together with descriptive statistics for the children's performance on the four tests, are shown in the table below.

Table 2: Science test scores for a class of children involved in *growit* (School A)

		Mean	N	Std. Deviation	Sig. (2-tailed)
Pair 1	Plants and animals	93.00	12	7.652	0.004
	Forces and movement	79.00	12	15.076	
Pair 2	Helping plants grow	74.77	13	10.505	0.000
	Light and shadow	59.38	13	16.800	

School B

In School B, end of year test scores were recorded for two classes of children school who had just completed Year 3. One class, 3JT, were involved in lots of Open Futures activities, since their class teacher is the Open Futures Co-ordinator in the school. Test results were considered for this class of children who had participated in much Open Futures activity. When the scores on the two papers were compared, it was found that the children had in general performed considerably better on the paper testing content related to *growit* (and also *cookit*). This is shown below in box plots of the distribution of the scores on the papers.

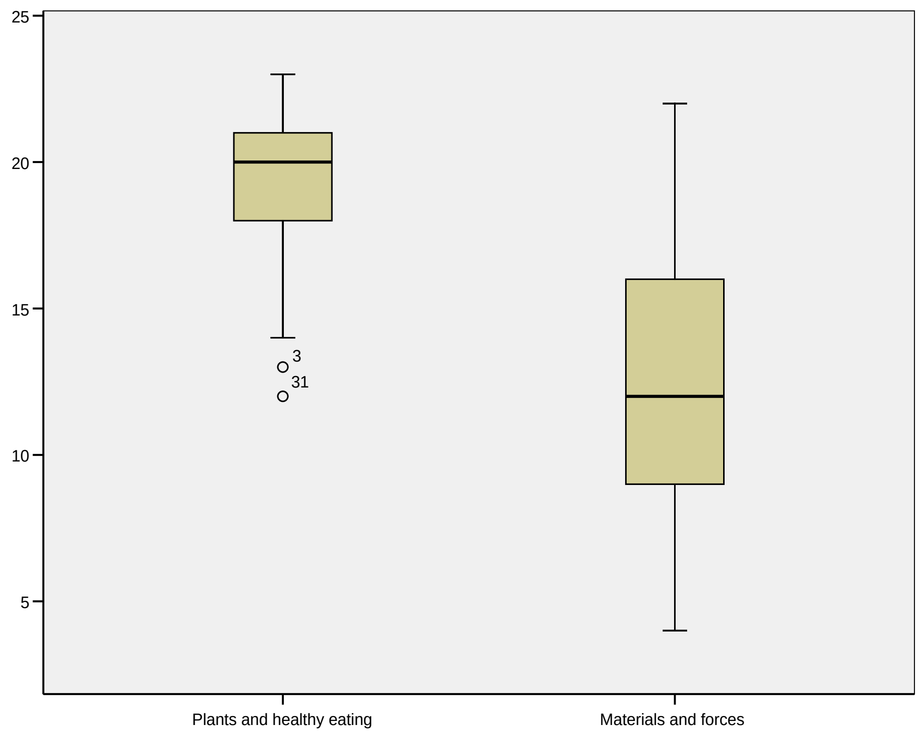

Figure 11: Distribution of 3JT's test scores for two science papers (School B)

Comparing each child's scores on the two science papers reveals that the higher scores on the plants and healthy eating paper are indeed statistically significant ($p<0.001$). The table below shows this result.

Table 3: Science test scores for a class of children involved in *growit* (School B)

	Mean	N	Std. Deviation	Sig. (2-tailed)
Plants and healthy eating	19.27	33	3.003	0.000
Materials and forces	12.36	33	4.801	

Overview

The test results from these two schools indicate that the children have more science knowledge and understanding about life science than they have relating to physical science. It is not possible to judge, however, whether, this difference is due to their involvement in *growit* since they might anyway have found this area more comprehensive due to their previous experiences with living things (see the comment of Samarapungavan et al., 2008, referred to in the introduction to this paper). If, as their teachers suspect, *growit* is having an impact, this would seem to be upon fairly specific content knowledge, rather than on more general understandings of scientific process. This interpretation fits in with the other evidence of impact, which suggest children are developing knowledge of living things while out in the garden, as well as with the finding of improved test scores in biology but not in other areas of science, which we could also expect to be affected if the knowledge gained was more general.

Discussion

Reaching conclusions about overall impact of *growit* on science learning

It is difficult, if not impossible, to draw a valid conclusion about whether *growit* can be said to have had the impact on science learning which we speculated it might have. There are such differences across the Open Futures project in how the various strands have been developed in the different schools, including how they have progressed as individual strands and how they have been related to each other, the wider curriculum and the wider interests of the schools. As will by now be evident, there are also contrasts in the evidence we have been able to assemble. Theoretical ideas, together with the professional understandings of teachers and RHS officers involved, suggest the potential for school gardening to enhance science learning and understanding, and the analysis of science tests results suggested that there might be an impact on attainment. Yet, these test results are suggestive but very limited, while the experience reported by learners does not indicate that they are making many links between gardening and science which would allow us to draw conclusions of direct impact on science understanding. The children involved seem to experience, and appreciate, *growit* as being distinct from other school learning and an opportunity to learn very specific, practical skills, which they rarely related to the knowledge and experiences they recognise as school science.

Rather than asking whether *growit* has in general had an effect on pupils' performance in science, we need to look at where and how *growit* might be able to affect science learning. This involves looking in more detail at the understandings that the learners have of *growit* and of science, and considering the distance between these two conceptions

Learner understanding of *growit*

It is clear from the pupil interview and pupil questionnaire evidence above that learners experience *growit* as very enjoyable. They appreciate the chance to get outdoors and do practical activities, with the children who were interviewed tending to emphasise how different this feels compared to other school lessons. The questionnaire responses from School B convey the importance some children attach to the authenticity they think gardening has: five of the 19 comments about the learning experience of *growit* referred to a real outcome or authentic learning. In terms of the three overlapping perspectives identified in the introduction for understanding active science learning, it can be seen that gardening certainly can fulfil the need identified for experiential learning, where a more familiar or practical setting helps learners to develop a more abstract scientific approach. However, since the learners seem to perceive the garden setting as so very separate and different, this suggests that they might resist or be unable to develop their understanding in this way.

This suggestion is bolstered by the views the learners express about what they are learning in the garden since they tend to emphasise precise, but necessarily limited, gardening skills, which they recognise as being taught to them by professionals with considerable expertise. They would seem to be absorbing many of the practices of gardening, which are genuinely rather different from the practices of science that educationalists perceive to be important in learning science.

Together with this learning of skills, the children also consider that they are increasing their knowledge through *growit*. As discussed above, some of the examples they give of knowledge gained might be termed fairly narrow gardening knowledge and much seems limited to identifying plants and animals. As mentioned above, however, this fairly narrow knowledge could provide the foundations for a more developed understanding or perhaps a scientific investigation with life science. There are limited suggestions from teacher comments and from the pupil questionnaires that for some learners this might have happened.

Moving to the inquiry aspect identified as important in science learning, it would seem that *growit* does not appear to be pursued in this manner, or, if it is, this is not noticed or valued by the learners. This is presumably due to the fact that the gardening sessions are mainly aimed at teaching particular, practical skills and appropriate ways of proceeding in the garden. Conversations with the RHS project officers suggest that the wet day activities they have designed are much more open and investigational, but, as is evident, it is not the indoor, more like school, activities which most children relish. Despite the learner comments generally not being suggestive of classic inquiry learning, however, the children seem to have a distinct sense of agency and control when they are gardening. This is evident from the interview responses, and some of the phrases which are used, such as “more choice” and “you can learn from your mistakes”, begin to suggest active meaning-making. The clearest references, however, to more independent, inquiry-based learning through gardening are the comments of the children in School A about their biggest vegetable competition. These show the possibility of an inquiry approach, perhaps once learner gardeners have reached a certain level of competence, though they do not provide much detail about this.

Learner understanding of science

Moving now to consider the understandings that learners have developed about science, it must be noted that we have much less information about this than we have amassed about their experience of *growit*. We are basing our ideas on our limited knowledge of the National Curriculum and common primary school practice, together with our analysis of the concept diagram produced by a small sample of children in three schools. The original intention of investigating the concepts about science held by children with *growit* experience was to see if they were making the links between science and gardening. This would seem to be a vital part of their gardening experience having an impact on their learning in science, and, as detailed above, this had been suggested by teachers involved in the project. Once these concept maps revealed a paucity of these anticipated links, however, it seemed necessary to consider in more detail the understanding of science which they suggest.

The central conclusion is that the concept maps reveal the children’s understanding of science to be topic-based. The areas they demonstrate knowledge of are quite varied, and many children were able to produce sub-topics, facts and remembered activities associated with each topic. They were, however, generally quite isolated. Even with some encouragement from the researcher, the children were generally reluctant to make connections between topic areas.

The concept maps also tend to emphasise content over process. The children mainly listed the names of entities they had seen rather than processes they had carried out. There were some exceptions to this of course. The children from School A referred in a number of place to processes and activities, but it is notable that it was in this school that the links to *growit* were most developed, and, in fact, many of the processes were primarily gardening activities, such as the actions needed to look after plants. In School I, the older Y4 children were more inclined to include references to what they had done, but these do not generally include scientific practices such as asking questions or making observations. Perhaps such aspects are understood by the children in a more implicit way, but it still seems notable that they are not more explicitly aware of them.

The prospect of bridging between these understandings

It seems clear from the two previous sections that there is considerable distance between the conceptions generally held by learners about science and about their experience of gardening, despite both activities taking place in school. This distance between the two understandings must make it more difficult for the bridges to be developed which should help learning in science. However, the detail of these understandings, and the exceptional cases where there did seem more common ground, might enlighten us about how these important links might be encouraged in the future. As will be argued below, we think that inquiry approaches may be worth pursuing.

What links need to be made?

It might be questioned whether the links we have anticipated, based on previous research in this area and our understanding of science, need to be explicit. We have tended to rely on very explicit views, mainly gained through interview or questionnaire, to establish how learners understand gardening. Learners might have a more nuanced view of *growit* than they can readliy express in interviews and questionnaires, which might better support the links to science. This seems reasonable, but the use of concept maps should have been able to reveal such implicit links between aspects of science and *growit* experiences. Their failure to do this, together with what they suggested about the children's experience of science, does seem to indicate that these links are not as well developed as we might have expected.

How can links be made?

A conclusion which can be drawn from the evidence above is that links between science and gardening will not inevitably be made, and will instead need to be worked on and consciously elaborated. This concurs with evidence from previous research which suggested that knowledge gained through gardening activities may be quite limited (Bowker & Tearle, 2007), and that carefully designed gardening activities involving scientific skills and reasoning might be required if gardening is to facilitate science understanding (Mabie & Baker, 1996).

The pupil concept maps may be useful in addressing how this might be done in the present context. Although in one school links were made between *growit*, the science curriculum and/or home activities related to science, this was not replicated in the other two schools. Whilst links made are certainly encouraging of the possibility that gardening has the potential to develop such links, there is not evidence that this is happening at present across the schools. Of the three schools we visited, it seemed to be happening most clearly and successfully in School A, through initiatives such as their biggest vegetable competition and, perhaps, through the particular approach of the teacher. The nature of this kind of project is that teachers will inevitably develop strands in their own way. Indeed this has been seen as a strength in terms of sustainability, although this also has the affect that pupils are likely to gain differing benefits across schools. Furthermore, teachers will inevitably tweak their practice according to new information and we have been open about our interest in science learning, as it has developed. We have discussed our findings, and possible mechanisms for any impact, in some detail with certain teachers, including the teacher at School A. It seems probable then that, for a number of reasons, the links between *growit* and the science curriculum have been made more explicitly in School A. However, it is also the case that where children are making these links, they appear more likely to make links with non-school activities.

What seems to be emerging here is the importance of intentions. If it is considered useful or necessary for learners to make links between their gardening activities and science, then it will require direction or facilitation for these links to be developed well in most learners.

In practice

This facilitation could take the form of structured activities which encourage the building of these links. As noted in the introduction, some previous projects have achieved this by carrying out scientific procedures quite explicitly in a garden or living things context (Samarapungavan et al., 2008; Mabie & Baker, 1996). Our research would suggest, however, that an inquiry approach, which is less clearly scientific, but which provides the children with the choice and agency that they appear to value, can also succeed in encouraging pupils to see links between gardening and some aspects of school science. This might be a more appropriate, or appealing, approach to take in some schools or for some teachers, and seems justifiable if inquiry is seen as a constituent part of science.

Whatever approach is taken, however, it seems to us that there is a risk of spoiling *growit* through working too hard to entwine it with a scientific, or even a more broadly-based inquiry, approach. As has been shown, children involved with this project really value the way that gardening is different to other school activities. For some children who are less successful in academic subjects, *growit* has provided a very welcome break and a chance to succeed. This is conveyed by the interview comments of Pupil 1 in School D.

This concern also relates to the place of expert gardeners in this and other school gardening projects. The sustained, hands-on involvement of the RHS project officers has been a central part of the *growit* initiative; one which has been valued highly and consistently by teachers, children and other adults involved with the project in schools. The suggestion of using gardening as an entry point for science learning would seem to undervalue the gardening itself and, therefore, the professional expertise and skills of the project officers. Although they currently show enthusiasm and interest in fostering a more scientific approach to gardening, taking this too far would perhaps be asking them to pretend to be experts in science or education, at the expense of their actual expertise in gardening. As they themselves suggest, perhaps the solution here is more involvement of teachers so that the two sets of professionals can develop a more integrated approach.

Finally, it is worth noting that the findings of a limited impact of gardening on science, and the possibilities we have suggested based on our evidence for increasing that impact, have only related to biology. As discussed, we have not found evidence of an impact on understanding of general scientific method or process. Instead there is only evidence of specific background knowledge, which could be categorised as life science knowledge, providing something of a foundation or ongoing support for school biology. This begs the question whether other areas of science could be bridged through particular practical activities if approached appropriately, perhaps with experts visiting the school. It seems possible that other parts of Open Futures could be developed to provide links to other specific areas of the school curriculum. For an initial suggestion of such areas, it is worth noting that the School B teacher discussed the potential links between *cookit* and numeracy, through weighing, measuring and calculating costs. Might there also be the possibility of developing a hands-on experience of electricity, 'Spark It', led by professional electricians to aid understanding in physics? Further research would begin to answer this and the other questions raised by our study.

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