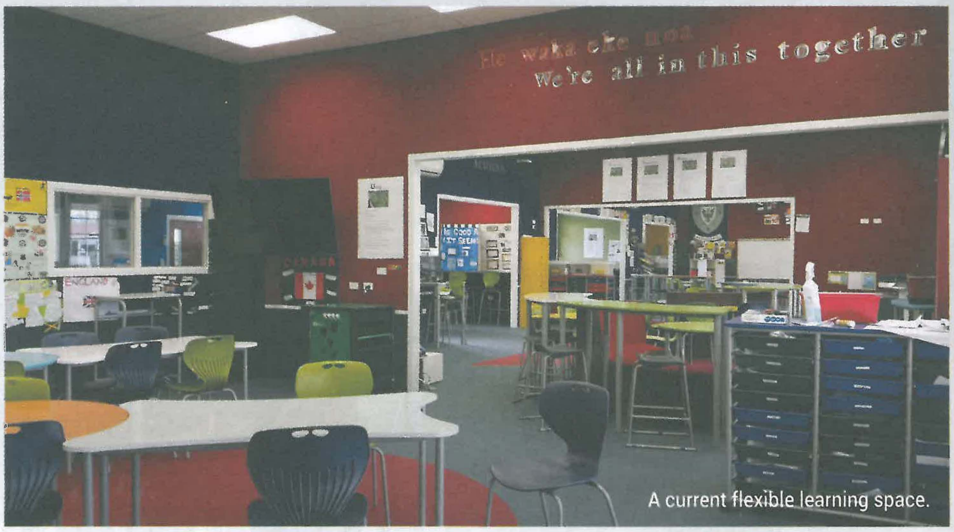
The Sprout:

EXPLORING A CULTURE OF CO-OPERATION AND CO-CONSTRUCTION IN YEAR 9 SCIENCE

Flexible learning spaces create new opportunities for science teachers and students, writes Simon Taylor of Waikato University.



A current flexible learning space.

This article explores opportunities in year 9 science classes, where teaching strategies of student co-operation and co-construction are considered. The term co-operation describes students sharing a task together, and having the opportunity to work and interact with their teacher and peers. Co-operation depends on students knowing when it is appropriate to listen and when to speak, knowing how to show respect for cultural difference, and how to be open-minded to different ideas.

By contrast, the essence of 'co-construction' is the creation of knowledge with others - a kind of knowledge building. Both co-operation and co-construction require a group of learners to take responsibility for creating something together. With these approaches in mind, the Ministry of Education is encouraging schools to move toward more flexible learning spaces and teaching strategies that augment such environments.

'The Sprout' is the name I have given to a year-long exploration involving five secondary science teachers at different schools in the central North Island region, who have initiated science programmes where students have more opportunity to be co-operative and co-constructive. The science faculties in this study have made changes to their physical settings: they have created large open rooms where 60 or more students can work, and adjoining rooms with practical science workbenches, as well as smaller break out rooms. While the teachers' experiences are contextual and unique to their specific situation and community, the study provides a representation of teaching practices that other science teachers might look at enacting. Data to inform the case study came from recorded teacher workshops, teacher interviews, a student questionnaire, and classroom observations. It is titled 'The Sprout' to symbolise a rising opportunity to further understand the complexities of adopting this trend.

The study sought to identify successful classroom strategies that are making a positive difference to student engagement, and are supporting teachers to frame a co-constructive science lesson model, and synchronously seek teacher voice to inform the collaborative liaison.

Several challenges confront teachers looking to incorporate cooperative and co-constructive pedagogy into their science lessons: the difficulty in choosing from among numerous teaching strategies; time constraints; negotiating student tasks with appropriate physical spaces; and ensuring students are engaged in authentic science investigation. Alterator and Deed (2013) claim that teachers and students who utilise multiple physical spaces, as opposed to the traditional one-cell classroom environment, find that adapting to the model can be challenging.

Why pursue this?

The Ministry of Education (MOE) 2016 rather optimistically advocates innovative learning environments (ILE), where schools are required to upgrade their buildings in line with a five year funding plan agreement which integrates flexible physical classroom spaces (Ministry of Education, 2016). The initiative appears to promote not just changes in physical space, but the enhancement of pedagogical practices committed to educational outcomes.

There is a tool provided on the website that assesses learning spaces against ILE criteria, and it is claimed that overwhelming support exists among parents, teachers, and boards of trustees for a learning studio pilot programme.

However, on closer investigation there are several striking assumptions made regarding motivations behind changing a learning environment. Perhaps more importantly, the resulting teacher/student pedagogical challenges posed by a new physical learning space are not explored.

In addition to these new challenges, previous research measuring student perception of science lessons has revealed that year 9 and 10 students were keen to share greater control with their science teacher (Taylor, 2014). Students preferred a more collaborative and participatory science lesson than they were used to. Furthermore, historical research on the effects of socio-negotiation has shown positive achievement outcomes in New Zealand science classrooms (Lowe, 2004), and an effect size (d=0.59) in 774 studies worldwide measuring co-operative versus individualistic efforts (Hattie, 2005). These earlier findings prompt deeper investigation of co-operative learning environments.

By contrast, particular difficulty is encountered when attempting to assess the impact of changing physical spaces on student performance. Hattie (2009) reports that, from an analysis of meta-studies, there was little or no impact from open plan environments. As was argued in many of these studies, often room re-design had indeed opened up learning spaces, but there was no accompanying adaptation of teaching practice.

Opening up the science classroom

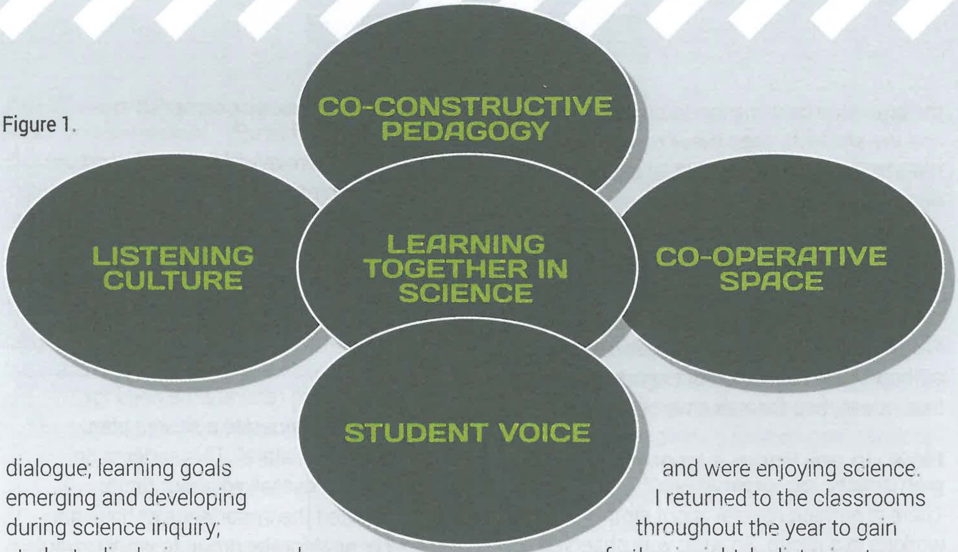
Roseth, Fang, Johnson and Johnson (2006) claim: "If you want to increase student achievement, give each student a friend".

As I worked with teachers during my study, this quote really challenged us. It just seemed too simple, and raised lots of questions about the scope of pedagogy we wanted to see happen in new learning spaces. We were aware that the level of shared pedagogical control between teacher and student in science lessons has been historically low in traditional single-cell settings. With the introduction of flexible learning spaces, teachers were committed to change but lots of idea sharing needed to take place in order to establish optimal group size and student positioning.

We wanted to explore student/teacher and student/student power sharing, and wondered how best to form and manage groups of students in these settings. We also found we needed to select topics of work and their design quite carefully, in order to excite engagement. We were challenged around providing activities that promoted group autonomy while retaining teacher guidance.

From initial meetings with teachers, it was recognised that the interpersonal relations between teacher-student and student-student were paramount in flexible learning spaces. The main aspects that the teachers noticed after opening classroom environments were: adaptability of physical spaces; interpersonal knowledge; and visibility and condition of student learning progress checks. Teacher discussions centred on increased student autonomy, greater student movement in the room/s, and more emphasis on collaboration. A model of co-constructive pedagogy illustrated in Figure 1 was designed with the teachers to support the thinking, with discussion on integrated concepts of listening culture, student voice, and cooperative space.

Figure 1.



Co-construction, cooperation, and flexible learning spaces - what's the link?

In early March a workshop was held, where the teachers and I worked to find out what determined a co-constructive climate. This exercise was challenging: juggling theory with classroom reality fuelled our dialogue. However, the discussions proved invaluable in that we could see a way forward, we were able to assimilate ideas and importantly, we established links between co-construction, cooperation and flexible learning environments.

Teachers saw that it was easy to get lost in day-to-day organisation of science lessons, and not take into account the importance of the theoretical fundamentals of changing practice. We arrived at an agreed framework, as illustrated in Figure 1.

Examination of this framework shows the interaction of four overlapping concepts around a central focus on *learning together in science*. The teachers interpreted the features of co-constructive pedagogy as including: students helping each other to learn through dialogue; learning goals emerging and developing during science inquiry; students displaying communal responsibility, including control of the classroom; students operating together to access products outside the class community, and evaluating how they learn best . It was evident to these teachers that their students had a range of cognitive process needs, across the various skills involved in collaborative investigation. Among these requirement were, for example, students using their understanding of cause and effect to plan a sequence of actions, or to reconstruct conceptual understanding of a problem in search of new solutions. The meaning of co-construction that we negotiated could perhaps be interpreted as knowledge building, a term currently used by Hesse, Care, Buder, Sassenburg and Griffin (2015), where learner-centred cognitive understanding builds through collaborative problem solving action.

Creating a *listening culture* was another aspect that came out of teacher conversations, a concept linked with *student voice* and the ability for students to feel that they are valued members of the science lesson. The flexible learning spaces did not guarantee a listening culture in the science lesson. Fostering a listening culture posed a challenge to ensure lesson design had opportunity for students to feedback their ideas, and that they were given authority and agency as active learners. It could involve assigning roles to students in their investigations or that they design and adopt these roles themselves.

The concept of *cooperative space* encompassed physical and collaborative interactions between students, and student use of specific social skills in maintaining an inquiry. Drawing on specific skills of conflict resolution, participatory awareness and perspective taking required careful teaching instruction. The teachers believed that these skills could be taught, and this became an emerging teaching role in the flexible learning spaces. Teachers could not avoid or assume these types of collaborative skills. It was critical that they explained them to all their students.

Initial observations

My initial classroom observations indicated positive levels of student engagement: students were on-task, followed instructions and were enjoying science.

I returned to the classrooms throughout the year to gain further insight, by listening to teachers and students. Analysis from an early student questionnaire showed 37 per cent of the students across the five classes said science was their favourite subject – a figure considered high, compared with other class averages. A factor in their enjoyment of science was that they appreciated working on projects in groups. Students said they had more time to talk about ideas and had more to take on different viewpoints. The students felt they were posed learning opportunities that linked with real contexts in everyday life. Working as a team to present their findings was seen as a rewarding experience.

Co-operation and the scientific café

I was struck by the thought that the classes created a climate similar to a 'scientific café'. I began to use this term to describe scenes that I observed.

Teachers still generally decided on topics, but the topics included a choice of tasks within the inquiry, for students to select. Topic examples used were: climate change; human body systems; energy sustainability; a local ecosystem and chemical reactions. Activities in the lessons were recorded as: guessing-judging-predicting; planning; categorising; problem solving; manipulating; making a model, and debating. Groups were made up of two to five students sharing materials, books, laptops and equipment.

I observed that flexible learning spaces gave opportunity for students to move to areas and rooms in which there was more chance to talk and discuss, so potentially social. Nuthall (2007) has described peer learning as powerful, whether conducted cooperatively or competitively. He has claimed that much of the feedback students receive comes from their peers. Classmates are a significant part of the student learning world, and their experience in lessons is shaped by what they say and do *together*.

Lessons were designed to include opportunities for students to see other ideas, and hear different opinions. There was also opportunity to negotiate ideas. On several occasions groups of students used a breakout room to conduct a brainstorm session on multiple whiteboards. Photos were taken of the brainstorms using ipads/chrome books and the students used these to add to their reports. One teacher described the group discussions:

"It's a shared thinking space where students can grab new ideas, knowing that their peers are hearing their voice: they can combine their ideas or go with just one."

From this combination of increased student autonomy and opportunity to grapple with fresh ideas, two themes emerged.

How do we know a group is genuinely co-operative?

There is nothing special about simply working in a group. So what was observed that was perceived as genuine cooperation in science lessons?

When students were asked to work together, they sensed there was purpose to their work. They had input into the selection of their group. They knew that their success depended on the contribution of all the group's members. The roles that they had been assigned were clear and purposeful. They appreciated providing progress updates to the teacher as they advanced through a unit of work. They worked face-to-face at a communal table or at desks placed close together. If they were working outside of the classroom they were physically close to one another. They showed a commitment to each member of the group and the overall success of the group.

What were the successful co-operative factors?

The teachers were asked to identify and describe in their terms the success factors of student co-operation. What were the important elements of group work in their science lessons and how did they construct them? Four dimensions emerged from teacher discussion.

Purpose

Hesse et al (2015) reiterate the need for collaborators to generate a shared plan to achieve a "goal state". This suggestion endorses the most talked about factor. Teachers noted the importance of having a purpose or goal for the group to work towards. A task or activity was clearly stated and each member of the group had a specific role to play in responding to the purpose of the task. The task had an inquiry-orientated purpose. Examples of contexts used in the tasks were:

» Investigate to produce hydrogen-carbon dioxide-oxygen gases and test for them.
» Design and build a model bridge to support a 1kg mass, and investigate associated force.
» Build a model bio-dome to survive a world disaster.
» Make a torch.
» Make a video on the pros and cons of nuclear power in New Zealand.
» Investigate water rockets and how they work.
» Compare properties of aluminium and iron in weapons.
» Investigate health properties of medicinal native plants.
» Explore a sand dune-mangrove forest ecosystem.

Assigning students to groups and group size

Teachers discussed group size, and could see that the smaller the group, the easier it was to identify difficulties students may have had in working together, and the more difficult it was for students to hide and avoid contributing their share of work. The larger the group, the fewer were the interactions among members, which meant there was less cohesion, and more obvious management of roles was

Making torches with foil, plastic and batteries.

LEARNING IN SCIENCE
Authentic Science Education

RUTHERFORD'S DEN

Rutherford's Den – the science learning facility within Christchurch's Arts Centre – re-emerged in August, after sustaining severe damage in the Canterbury earthquakes. It's now bigger, better and more immersive than ever before.

Rutherford's Den is a science learning centre on Christchurch central's Worcester Boulevard, part of the Arts Centre. Students from years 1 to 13 can come to the centre to be immersed in the discoveries that New Zealand's most famous scientist, Ernest, Rutherford, and his peers made possible, including sonar, radio, television, and telephones. And it all takes place in the very buildings where the eminent science heavyweight himself conducted some of his early experimentation.

The buildings that make up the Arts Centre were, until 1978, part of Canterbury College, which moved that year to the suburb of Ilam, where it remains to this day, renamed the University of Canterbury. The buildings vacated by the growing university were held in trust for the people of Canterbury, and are still serving the community today.

Damage to Rutherford's Den as it was prior to the big earthquake of 2011 was so extensive that the building had to be closed. While the shell of the buildings remain, retaining their 'English college' charm, the structure has been considerably strengthened. Arts Centre communications manager Caroline Fenton says that the revitalisation of the building itself provided the perfect opportunity to create entirely new learning programmes too.

This has involved the installation of some of today's needed. However, larger groups invited more discussion and a greater chance of students hearing different opinions. Group size also depended on the activity and resources. If there was a short period of activity then it was better to have smaller sized groups – greater engagement was observed. For longer periods of time, for example in projects, larger sized groups were seen as successful.

All the teachers used self-selection at the beginning of the year when assigning student to groups; however, as the year proceeded, changes were made to groups, with both teacher and student input.

Teachers discussed the importance of random selection at times throughout the year, so students had the opportunity to work with different students. The teachers observed positive outcomes from this.

Teaching social skills

Teaching students how to work co-operatively was seen as an important dimension to practice from a teacher perspective. Teachers said there was emphasis on the negotiation of rules for teamwork at the beginning of the year. This emphasis on the importance of roles and what was expected from students was maintained throughout the year.

Roleplays were acted out, with students demonstrating appropriate and inappropriate behaviour. One teacher wrote a guide describing steps for encouraging participation in the science lab, which included social skills for students to actively use.

Assigning roles to ensure interdependence

The teachers saw specific roles as particularly significant (the names of the roles were described in te teo Māori in some classes):

The *director* (rangatira) was responsible for overall progress and leadership of the team. The director had responsibility for discussing daily team progress with the teacher, and with the class. Some of the directors kept a log of progress in a team clear file.

The *technician* (kaihangarau) was responsible for science equipment: getting and returning laptops for example, handling of apparatus, and measurement of data - this was a particularly important role in field research and in active practical science investigations.

The *researcher* (kaiwhakamahara) had overall responsibility for recording data and information, and they ensured that all written material was collated and designed for presentation impact. Data gathered was tabulated and summarised. The researcher developed their skills in collating facts, summarising ideas, and used skimming and scanning techniques in reading.

Conclusion

This study confirmed that flexible learning in science lessons proved to be a challenging initiative for teachers. There was no guarantee that co-constructive and cooperative learning would transpire in new physical spaces, and these pedagogical techniques required careful design and implementation. However, when a conceptual framework was established, teaching practices identifying successful student co-operation and a documented process of teacher collaborative practice have been recognised. The teachers and researcher have gained valuable knowledge; it has enhanced our understanding of applying new skills meaningfully and creatively in a variety of contexts and situations. This study also signals how changing physical environments such as flexible learning spaces can influence pedagogical change, an area of science education research that has considerable opportunity for further investigation.

Acknowledgements

The study acknowledges the vital support and contributions of the five secondary schools, the science teachers and students. Acknowledgements also go to academic buddy and fellow researcher Dr Paul Lowe for his active support in earlier studies.

Dr Simon Taylor is lecturer and secondary graduate programme coordinator, Te Hononga School of Curriculum and Pedagogy, Faculty of Education, University of Waikato.
Email: simont@waikato.ac.nz

References are available on request.

MORE INFORMATION ON RUTHERFORD'S DEN, INCLUDING HOW TO BOOK A SESSION FOR YOUR CLASS, CAN BE FOUND BY GOING TO:
www.goo.gl/eZKoeg

RE-EMERGES IN CHCH

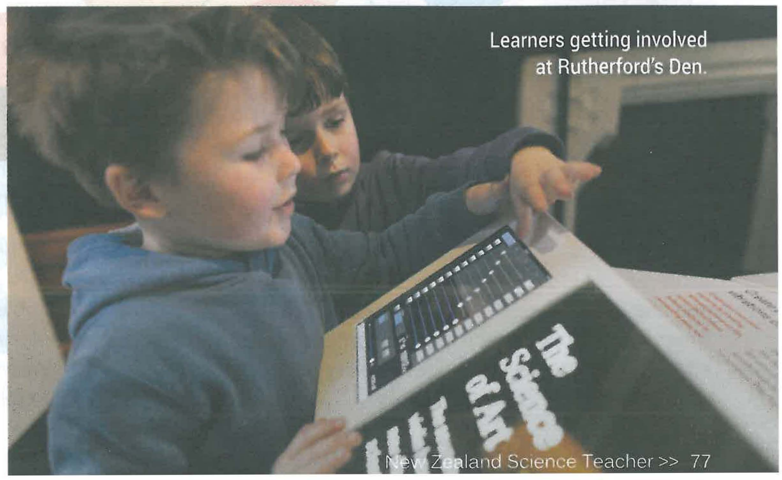
learning technologies that, it could be argued, Lord Rutherford and his contemporaries helped set the evolutionary ball in motion for: digital blackboards and touchscreens now help to create a thoroughly interactive experience for students of 2016, in contrast to those who laboured in dim light, scratching away with paper and ink, when the first Canterbury College students pursued their scientific passions here.

Another of the resources that teachers are able to utilise at Rutherford's Den helps to illuminate the area of science that Rutherford is perhaps best known for: our understanding of atomic structure. The display is one that users are able to 'step into', and uses light projection and sound to create a truly immersive, 3-dimensional experience.

Rutherford's Den employs three teachers, who after the earthquake continued to take the LEOTC learning programme to the students of Canterbury. There are three programmes available, aimed at primary, intermediate and secondary age groups. These encompass several curriculum subjects.

At primary and intermediate level, three learning programmes are available: 'Ernest and other famous New Zealanders' aims to get kids thinking about Kiwi identity, and links to social sciences Levels 2 and 5 at years 5 to 8; 'Arty Atoms' is an introduction to atomic structure and forces, linking to science Levels 2 to 5 for years 7 and 8; and 'Inventions and Innovations' encompasses inventions, changes in writing, and changes in communication and lighting technology.

At secondary level, the main programme on offer – at this stage, as programmes are still being finalised – is 'Radioactivity – from the old to the new'. The programme relates directly to achievement standards, and compares and contrasts different models of the atom, and how they evolved over time, including interactive research on Rutherford's Gold foil experiment.



Learners getting involved at Rutherford's Den.