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## A collaborative approach to school community engagement with a local CCS project

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### Abstract

The future of Carbon Capture and Storage (CCS) deployment requires research on geological, technical, economic, community and educational fronts. A program that has been running since 2009, CSIRO's Sustainable Futures – CarbonKids, is an education program that combines the latest in climate science with education in sustainability, with a strong focus on carbon.

In 2012 the Global Carbon Capture and Storage Institute (GCCSI) funded the CSIRO to develop and deliver 'carbon capture and storage' educational materials to be imbedded into wider sustainability educational resources under the banner of CarbonKids, now Sustainable Futures - CarbonKids. Resources include a wealth of cross-curricular activities to support the teaching of sustainability and the environment in the classroom, school and community.

The Western Australian Department of Mines and Petroleum (WA DMP) is conducting the pre-feasibility phase of the South West Hub CCS Project (SW Hub) in the South West region of Western Australia. CSIRO Sustainable Futures – CarbonKids program partnered with WA DMP in 2013 to implement an innovative and unique approach to educating teachers, students and the community in the science and understanding of the carbon cycle and CCS. This partnership provides schools registered with Sustainable Futures – CarbonKids a suite of educational resources including carbon and CCS activities. Access to the program also provides opportunities for teachers and students to meet and learn from representatives of WA DMP, and research scientists from WA DMP's research partner the National Geosequestration Laboratory (NGL), who work collaboratively on the SW Hub. This brings real life science into the classroom; providing students and teachers with examples of local scientific knowledge being used to solve problems and enhancing their understanding of the effects of their personal actions relating to energy and carbon, which is an important learning requirement within school curricula. The aim of the collaboration with the SW Hub is to provide

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information and the opportunity for learning from a real world case (the SW Hub CCS project) which will increase awareness of carbon and the environment in schools, and improve students' understanding of activities relating to carbon, energy and low carbon technology CCS research.

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## 1. Introduction

The development of educational resources for sustainability in general and for Carbon Capture and Storage (CCS) specifically began at a national level, with a recognition of the need for such resources in 2009 and continues with on-going program development and delivery in 2016 (Figure 1). A roadmap for CCS communication activities was developed in 2009 by Ashworth and others<sup>[1]</sup> following a series of community surveys. The roadmap outlined the need to provide materials to improve understanding of new and advanced technologies relating to energy generation. The authors observed that policy makers around the world saw the need for strategies to aid in the development of materials that would both provide education and raise awareness of the changing face of the energy industry. Teachers and students were amongst those identified as having a lack of awareness and understanding of CCS<sup>[2]</sup>.

In 2012 GCCSI collaborated with CSIRO to produce CCS educational resources for schools. The project comprised three stages: 1) evaluation of current CCS education materials; 2) develop, review and trial new CCS materials, addressing gaps identified in stage one, and 3) test the resources and activities with a wider sample size<sup>[2]</sup>.

The development and trial of the CCS educational resources soon after showed great promise for creating educational and societal awareness and improving understanding of emission reduction technologies. The partnership of CSIRO and GCCSI sought to widen the dissemination and implementation of the CCS resources, which were subsequently embedded into the CSIRO's existing climate science and sustainability educational program CarbonKids, which is now called Sustainable Futures - CarbonKids.

The focus of Sustainable Futures – CarbonKids is to provide the latest factual information on climate science, with an emphasis on education in sustainability. The CarbonKids program was initially developed by CSIRO, and piloted in 2009 with the support of Shell. During 2012, the GCCSI funded CSIRO to develop and deliver CCS materials specifically to encourage students to learn about low carbon emission technologies and the role these technologies play in reducing climate change.

Following a successful pilot program, the Sustainable Futures – CarbonKids is available to schools which choose to register with the program. The Sustainable Futures – CarbonKids program is sponsored in Western Australia (WA) by WA DMP; and nationally by Bayer; managed by CSIRO and delivered in partnership with Scitech which is WA's major science education outreach body.

The program has been running for seven years with 81 schools registered in WA and more than 450 schools registered nationally. There are two areas of focus in WA; the South West region where the SW Hub CCS investigation is being carried out and the North West and Kimberley regions which are major energy and minerals resources hubs.

WA DMP sponsorship of the Sustainable Futures - CarbonKids program was officially launched in August 2013. A strong and growing relationship with schools has been nurtured in the South West and supported by the ongoing development of educational resources. Rolling changes to the national curriculum presented an opportunity for the Sustainable Futures – CarbonKids unit resources to be reviewed for content and updated to align with the new curriculum, including the CCS unit resource. In 2016 the program is strongly visible, with many schools participating and opportunities for inter-school collaborative learning.

# CCS Education Resources Development

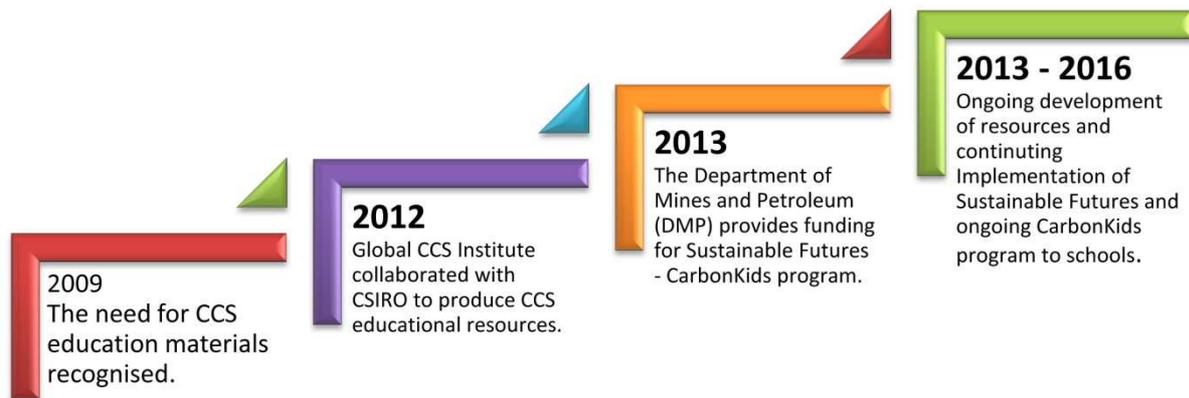


Figure 1 Timeline of development of CCS educational resources.

## 2. Sustainable Futures – CarbonKids aims and target groups

The Sustainable Futures – CarbonKids program is a broadly based, science focussed program targeted at students in Year 3 - Year 9 that aims to:

- Encourage students to develop skills in the process of inquiry, literature research, experimental investigation and critical thinking,
- Facilitate collaborative learning,
- Promote a critical and an action based approach to problem solving,
- Be teacher- and student-friendly, and,
- Promote collaboration between schools.

The program supports schools to achieve these aims through the provision of:

- Integrated curriculum units for years 3 to 9,
- Cross-curricular activities supporting the teaching of sustainability and the environment,
- School visits for professional learning and classroom collaboration around the activity resources to assist in the program's implementation,
- Opportunities and activities for classes and individuals that lead to staff and students taking action to lower their carbon footprint at school and at home,
- Opportunities for students to develop leadership, presentation and communication skills, and,
- Opportunities to interact with scientists.

Examples of some of these activities are shown in Figure 2.



Figure 2 Children conduct experiments as part of the Sustainable Futures – CarbonKids program, investigating rock permeability and capturing carbon dioxide in balloons.

### 3. South West Hub

The SW Hub is a staged project that involves collecting and analysing data and samples from the formation known as the Lesueur Sandstone, to test its feasibility as a CO<sub>2</sub> storage reservoir. The Lesueur study area lies in the southern part of the Perth Basin and is the type of saline aquifer identified by scientists around the world as a potential CO<sub>2</sub> storage reservoir<sup>[3]</sup>.

The SW Hub's research into geosequestration is being funded by the Australian Government through the Department of Industry Innovation and Science and the Western Australian Government through WA DMP. With initiation of each stage of the project's data collection and analysis dependent on a positive outcome from the previous stage, the SW Hub is progressing through a series of data acquisition, processing and modelling stages which to date have all supported the Triassic age Lesueur Formation as a potential storage interval. The SW Hub is working with research partners CSIRO, The University of Western Australia and Curtin University through the National Geosequestration Laboratory which is based in Perth.

Noting the challenges associated with public acceptance of major projects, community engagement has been a strong focus since its inception of the project in the mid-2000s<sup>[4]</sup>. As CCS projects are long term propositions, the SW Hub is nurturing a strong relationship with the South West community, particularly in the Harvey–Waroona area<sup>[5,6]</sup>. Informative displays are regularly presented at agricultural shows in Harvey, Brunswick and Waroona. Information sessions are held in the Harvey–Waroona area. These open sessions are advertised in the local press and provide an opportunity for people to offer input, ask questions and find out about project activities<sup>[5]</sup>. A consultative committee, the Lesueur Community Consultative Committee meet regularly with WA DMP, researchers and contractors engaged on developing information on the project site to share information and provide regular updates.

Working together, the Sustainable Futures – CarbonKids program and the SW Hub achieve a common objective, which is to provide the community with access to, awareness of and understanding about the latest science research being conducted. The program encourages teachers and students to engage in learning about climate science and

sustainability: The SW Hub provides a real life example of scientific investigation that is helping to build a clean energy future and taking place in the school’s local area.

#### 4. Collaborative approach to school community engagement of a local science research project

Carbon and our environment is a key theme running through Sustainable Futures - CarbonKids resources. Stakeholders including teachers, students and the broader community tend to have a minimal understanding of carbon interaction in our environment (Figure 4).

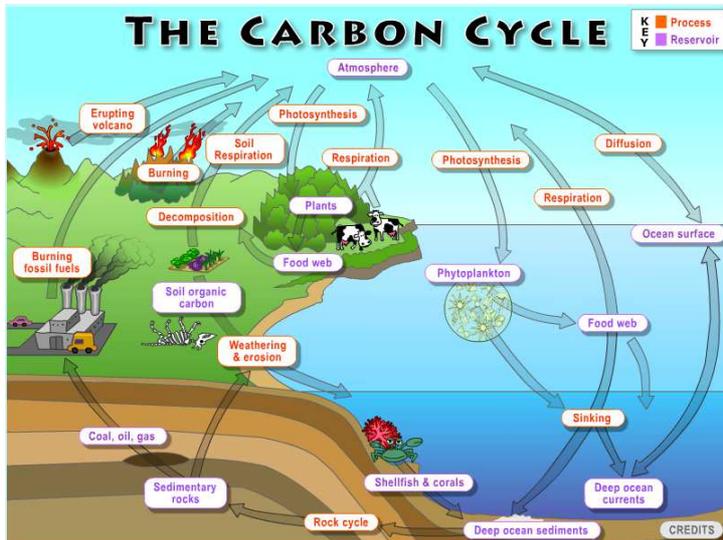


Figure 3 The Carbon Cycle. Source: [http://d32ogoqmya1dw8.cloudfront.net/images/eslabs/carbon/global\\_carbon\\_cycle\\_1427132279.jpg](http://d32ogoqmya1dw8.cloudfront.net/images/eslabs/carbon/global_carbon_cycle_1427132279.jpg)

Teachers are required to teach meaningful content that assists students to meet learning goals in the context of education activities within a structured curricular framework, while addressing the needs of diverse learners. To assist teachers to impart knowledge education materials should address teacher learning as well as the education of students, as shown in the new unit contents<sup>[7]</sup>.

The Sustainable Futures - CarbonKids program supports teachers and students in understanding the science of carbon and our environment, introducing them to carbon dioxide and investigating its chemical and physical properties. The activities investigate carbon in natural systems and the human use of carbon, including the use of fossil fuels and future implications due to increased levels of carbon dioxide in the atmosphere, and consequently advances in low carbon emission technology solutions, including CCS. Throughout the program, schools are provided with real life learning opportunities to meet and engage with research scientists and representatives from the CSIRO and SW Hub CCS project. This is complemented by activities on carbon in agriculture (supported by Bayer), and in the activities in the NW of WA, on marine carbon or “blue carbon” information.

Schools are provided with a range of resources as well as on-going support and development opportunities to create an environment where the outcomes of the program can be achieved (Figure 4).

Resources provided to schools for the Sustainable Futures - CarbonKids program include:

- Integrated curriculum units including ‘Carbon Concerns’ and ‘Investigating carbon capture and storage’,
- Consultation, professional learning and classroom collaboration, and,
- DIY kits containing materials and equipment.

Support provided to Sustainable Futures – CarbonKids schools enable:

- Teachers and students to continue to use program resources to meet their needs, with consultation, professional learning and classroom collaboration visits available,
- Teachers and students to work on collaborative tasks to present at an annual school cluster workshop,
- Teachers and students to attend an annual school cluster workshop, and,
- Learning support through phone and email correspondence and school visits provided.

Outcomes are achieved through meeting the goals and aims of the program and partnering organisations and include:

- Teachers and students gain an improved awareness and understanding of carbon and their environment as a result of working through integrated curriculum units, the DIY kits and cluster school workshops,
- Facilitation of collaborative learning within schools and between schools, and,
- Opportunities to raise community awareness.

## Sustainable Future - CarbonKids Program implementation and delivery in Western Australia

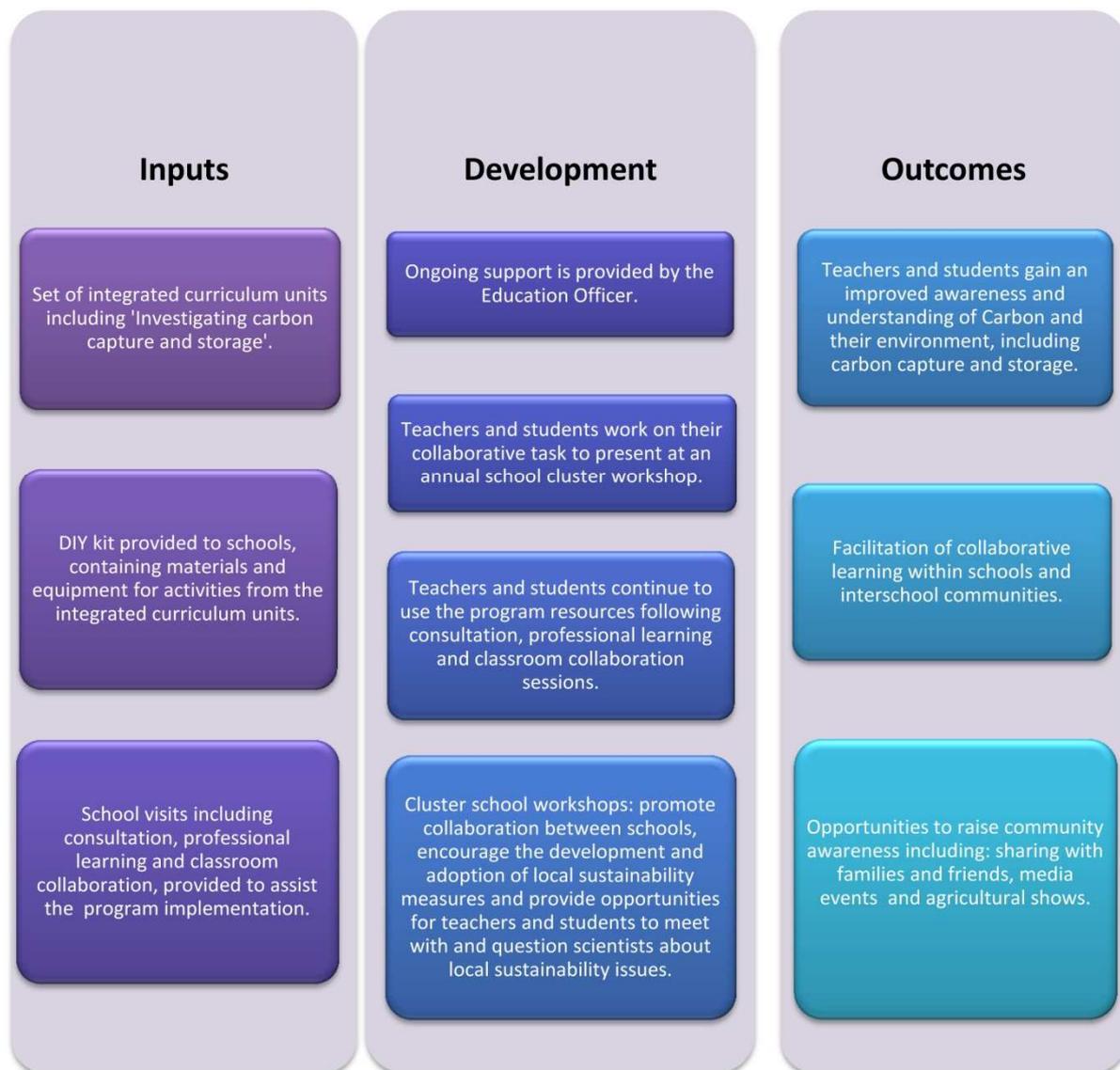


Figure 4 Sustainable Futures – CarbonKids flow chart

### 5. Sustainable Futures – CarbonKids resources and support for schools

Teachers registered with Sustainable Futures – CarbonKids are provided with a set of integrated curriculum units for the program and access to consultation, professional development and classroom collaboration provided by the CSIRO Sustainable Futures - CarbonKids Officer (Figure 5). The resources, materials and support offered to teachers ensures they have the knowledge, skills and confidence to integrate the program, which fulfills a cross-curriculum priority area of sustainability, into teaching and learning programs.

The integrated curriculum units are teacher friendly and easy to use, encouraging students to collaborate, think critically and learn through inquiry based learning. Each unit of work includes background information for teachers, a table showing curriculum links and a number of activities catering to a diverse choice of teaching methods, and encouraging students to learn about the science behind sustainability.

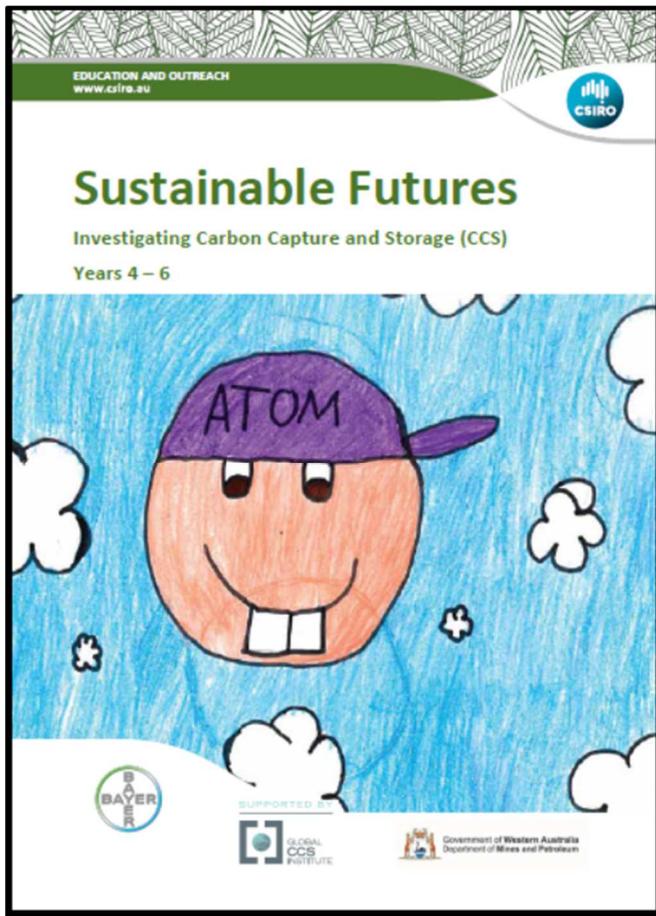


Figure 5 Example of one of the curriculum units developed.

Topics for the structured units include: 'Carbon concerns', 'Sustainable energy for all', 'Biodiversity', 'Sustainable projects' and 'Investigating carbon capture and storage' (Figure 5). The resources encourage students to work collaboratively, think critically and gain knowledge through inquiry-based learning. The unit 'Investigating carbon capture and storage' takes teachers and students on a journey which helps them understand carbon, energy sources, the link between energy use and the level of carbon dioxide in the atmosphere and low carbon emission technologies such as CCS.

It is recognized that each school is unique, so an initial consultation with teachers registering with the program, either by email, phone or face-to-face, has been an important step in successfully meeting the needs of individual schools and ensuring the successful implementation and ongoing use of the program. Professional learning and classroom collaboration sessions are available to introduce the program resources and demonstrate the variety of content in the unit resources. Various methods for delivering the units are explained in an exploration of where and how sustainability is integrated into curriculums.

In 2016, thirteen schools in the South West, North West and Kimberley regions of WA were given a DIY kit containing the materials and equipment required to complete activities from the Sustainable Futures – CarbonKids

integrated curriculum units. For efficiency and ease of use, each of the activities is packed in a separate, labelled container with the corresponding instruction sheet and background information. The consultation, again either face-to-face or by email and phone, was provided by the program's WA Education Officer to assist with implementing the DIY kits. In most cases the consultation coincided with a combination of professional learning for teachers and classroom collaboration sessions.

## 6. Sustainable Futures – CarbonKids program development

In 2015, changes to the Australian National Curriculum prompted a review of the Sustainable Futures – CarbonKids units of work to ensure they aligned with the new changes. This was an opportunity to include new content within the unit of work 'Investigating carbon capture and storage' that had particular relevance to schools in the South West. The unit was updated with the latest in science research from the SW Hub project which is being conducted in their local area, as well as embracing examples of work pieces created by other local students involved in the Sustainable Futures – CarbonKids program.

Teachers continue to use the resources according to their needs, with email and phone support provided by CSIRO and the WA Education Officer. Feedback from teachers has been positive, especially relating to the program's carbon activities which have been repeated with different classes over consecutive years. The integrated curriculum unit 'Investigating carbon capture and storage' contains an activity called 'Capture carbon dioxide' which is often chosen as a favourite by students. The activity requires students to add vinegar to bicarbonate soda in order to release carbon dioxide and then to capture it using balloons provided in the DIY kit.

Capturing carbon dioxide is a popular investigation which enhances science understanding in the area of chemical sciences (solids, liquids and gases). Background information included in this unit resource outlines additional valuable links to cross curriculum priorities such as sustainability and science as a human endeavor. Cross curriculum links with mathematics, English, geography and technology are also encouraged. The background information directs teachers and students to explore further; to find out more about the cause and effects of increasing carbon dioxide in the atmosphere and then to consider what can be done to address the issue. CCS is one of the low carbon emission technology solutions communicated.

Each unit resource provides teachers with a table indicating the Australian National Curriculum science links for each activity. For example, the table suggests the activity 'Capture carbon dioxide' links to the following: chemical sciences; science inquiry skills; science as a human endeavour and sustainability which is a cross-curriculum priority [7].

## 7. Cluster School Workshops

Once a year between four and six schools come together to attend a sustainable Futures - CarbonKids day of activities known as a cluster school workshop. Each school is allocated a collaborative task to present at the workshop. In 2016, schools attending such a workshop were given specific carbon related activities from the unit resource 'Investigating carbon capture and storage' along with DIY kits designed to help students prepare for their important teaching role.

The DIY kits contain:

- Materials and equipment for preparatory carbon-themed activities,
- Background reading, and,
- Materials and equipment for an allocated workshop activity on the day.

To prepare for the workshop presentations, students engage with an interactive carbon-related activity from the integrated curriculum unit resources which they must learn and then communicate to other students. On the day of the workshop students make their presentations with their teachers taking on a facilitation role. This is an excellent opportunity for students to reinforce their learning and understandings, and provides wonderful opportunities for students to develop collaboration and communication skills and to make new friends.

Cluster school workshops are designed to encourage teachers and students to consider some of the sustainability measures they might adopt both personally and within their school communities. Science experts including representatives from CSIRO, WA DMP and Bayer are invited to attend the workshops to discuss the latest scientific research relating to a range of sustainability issues relevant to students and their local communities. Students use the workshop to question the experts about energy, carbon and sustainability, including CCS technology and research projects. Representatives from WA DMP have attended all the cluster school workshops in the South West and demonstrated aspects of carbon storage technology.

Representatives from Bayer have attended each of the workshops in the South West and presented on the topic of crop science, a relevant area of research for students living in a rural agricultural area. Students have worked on experiments investigating the growth of plants such as wheat and lupin in different conditions including an increase in temperature, changes in water availability and increase in carbon dioxide levels. The content of the work and the message also relates to the relationship with carbon.

A Sustainable Futures - CarbonKids event held at St Anne's Primary School in Harvey in 2015 was an example of how science and sustainability learning opportunities that are relevant to teachers and students can be harnessed through engagement with local projects and science experts. St Anne's hosted students from three neighbouring schools who gathered together to view the installation of a new seismometer at the school (Figure 6).

A scientist from the University of Western Australia (UWA) addressed the students, describing what a seismometer is and does, and how seismicity data could be used to assist the local SW Hub CCS project by monitoring background seismicity<sup>[8]</sup>. The seismometer installation in the Harvey school is part of the Australian Seismometers in Schools (AuSIS) network run by the Australian National University. The overarching program aims to raise community awareness of natural seismic events and has piqued students' interest in earth sciences through a range of experiments and activities designed by the AuSIS program<sup>[9]</sup>.

A Broome workshop held in 2016 is another example of collaboration with local projects, when a CSIRO scientist engaged students with his work in Blue Carbon research in the local North West region of WA. Students learned about the importance of coastal micro-algae in the carbon cycle and investigated the chlorophyll content of sediment to show the amount of benthic micro-algae growing on it.

## 8. Program Outcomes

The Sustainable Futures – CarbonKids integrated curriculum units and DIY kits are proving to be teacher friendly and easy for students to use. With ongoing support for the program, teachers and students gain an awareness and improved understanding of carbon and their environment as well as learning about local science research projects.

Teacher feedback includes:

*“I just wanted to say a huge THANK YOU again for the amazing resources you delivered and left with us. I had another look through everything today and was blown away by how well everything was organised and put together, and the comprehensiveness of the information and accompanying equipment and resources.”*

*“I value and appreciate the partnership we have established and look forward to it continuing and growing.”*

*“Using, the kits provided, the students will be able to pass on their knowledge to the students in lower year groups. I will continue to present this unit of work to the yr 5's and 6's in years to come.”*

Cluster school workshops provide an opportunity for students to share their understandings and increase their knowledge about carbon and their environment.

Teacher feedback includes:

*“The kids were very engaged and the ‘Students become teachers’ idea, and buddying up with kids from another school brought out some great team work and responsibility in them.”*

*“The main strengths of this event were that it was well run and provided students with some great experiences that allowed all children to participate regardless of their abilities. It also encouraged students to scaffold and challenge each other’s knowledge of science.”*

*“The speakers were quality and involved in the cutting edge science around carbon capture and monitoring. The experiments were valid and age appropriate. The day was more a culmination of a unit of work on Carbon, and linked with primary connections chemical sciences investigations.”*



Figure 6 Students carry out activities which explore carbon dioxide and CCS technology.

## **9. Raising community awareness**

During the course of the program over several years, there have been a number of occasions when schools could participate in raising community awareness of sustainability issues. As a result of cluster school workshops, several radio interviews and newspaper articles have highlighted local science projects including the SW Hub and encouraged the wider community to consider sustainable activities they might adopt.



Figure 7 Left – Raising community awareness about sustainability. Right – Students ask questions of science experts.

Two Bunbury Primary school students became celebrities for a day when interviewed by the local ABC South West Radio during a clean energy workshop. Local press representatives were also in attendance, subsequently running the headlines 'Sustainable options for Bunbury students' in the Bunbury Mail and 'Students get hands-on with science ideas' in the South Western Times (Figure 7).

Annual agricultural shows, including the Harvey Agriculture Show and the Brunswick Agriculture Show, also provide opportunities to collaborate with the SW Hub project and engage with the community about local science. The agricultural shows have proven to be an ideal opportunity to engage with the community about science research. The audience at a typical agricultural show is a broad cross section of the community including plenty of Sustainable Futures - Carbonkids students and their families as well as teachers from schools involved with the program. It is not unusual to hear adults at the local Harvey Agricultural Society Show say they had heard about CCS and the SW Hub CCS project from their children. These events are also an ideal opportunity to introduce the program to teachers who are unaware or have not yet embedded it in their program.

## 10. Case study: "A Day in the Life of a Carbon Atom: Starring Adom" - from local to international

"A Day in the Life of a Carbon Atom: Starring Adom" is a children's book about carbon and CCS written by children for children. This colourful publication is the creation of some Year 6 and Year 7 students attending St Michael's Catholic Primary School in Brunswick Junction in 2012. Having attended CarbonKids workshops, students from South West schools were issued with a challenge by the GCCSI to create something for other students that conveyed what they had learned about carbon capture and storage.



Figure 8 The Hon Bill Marmion, Minister for Mines and Petroleum launches the Adom book at St Michael's Catholic Primary School in 2014. The book has been translated into Japanese and Chinese editions.

The results of the challenge were presented at a subsequent workshop where the St Michael's students presented their story in a PowerPoint format along with presentations from other schools ranging from video to live performances. The illustrated story follows the adventures of Adom, a carbon atom, taking the reader on a journey from his initial un-earthing for use as a fuel, through to his capture and geosequestration.

The story became part of the National CCS Week which was held in Perth in 2012 through the use of video materials put together by GCCSI<sup>[10]</sup>. In recognition of the student's talent and the story's wide appeal, it was published as a book which was launched by Dominique Van Gent from the SW Hub during the 2014 National CCS Conference. A book launch was also held at St Michael's where a State Government Minister presented copies of the book to the authors who were, by then, high school students (Figure 8).

The "Adom Book", as it is known, has proven a favourite with youngsters and has been widely distributed to school and public libraries throughout the South West (Figure 9). The book has also created new international links for Australia, through its distribution to schools in Scotland and Canada, as well as being published in Japanese and Chinese for language classes in local schools.

A video of the young local authors reading the book was played in a booth at the Harvey Show and proved more of an attraction than videos of drilling or seismic activities carried out for the SW Hub, illustrating the power of local recognition as part of community engagement<sup>[10]</sup>.

The writing and illustration of the Adom Book by students from St Michael's and the facilitation by their teacher, is the culmination of the program outcomes. The book is an example of a work piece created by teachers and students using the program resources which has been shared and subsequently become a part of the program's teaching resources.



Figure 9 The Adom Book immersing some young readers in a world of carbon and CCS.

Feedback from the students teaching other students on the use of the Adom book included comments such as:

*"It was really good; it was interesting to see how they used the story to show what happens in Carbon Capture."*

*"That looked like a really fun project. It must have taken a lot of time to make the story and draw all the pictures."*

*"I liked it. It was funny, creative, and the illustrations were really good."*

*"It was a good way to teach younger kids about CO<sub>2</sub>. It made it easier to understand."*

## 11. Conclusion

The CSIRO Sustainable Futures - CarbonKids program has grown since its inception in 2009 and there is now a vibrant community engaging in the program in the South West of WA and beyond. The range of materials provided to schools has been recognized as a valuable method for engaging teaching staff and students in a range of energy, climate and carbon research that is pertinent to the local environment where the children attend school.

Since October 2013, the program's collaboration with the SW Hub, with the support of WA DMP, has provided schools in the South West with an example of a real, local CCS scientific research project which can be embedded within learning resources and linked to curriculums.

This collaboration has provided an opportunity to increase awareness and expand knowledge about carbon and the environment, as well as introducing CCS as a low carbon emission technology and the subject of a local research project. Visits by researchers and WA DMP staff to schools during the workshops have given students and staff the opportunity to investigate real-world examples of science activities that relate to their use of energy and climate.

The collaboration has seen the creation of some valuable science-based learning activities and some enduring CCS communications tools with broad appeal that have both local and global applications.

## Acknowledgements

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Kirsty Anderson (GCCSI) is acknowledged for her previous collaboration with CarbonKids, her ongoing input and advice as well as the opportunity to share CCS learning internationally on the CO<sub>2</sub> degrees website.

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