AN EVALUATION OF THE IMPACT OF AN AGRICULTURAL SCIENCE OUTREACH PROGRAM ON THE ATTITUDES OF RURAL STUDENTS

Jessica Lewis, Richard Oliver and Mary Oliver

A ‘citizen science’ outreach program was aimed at high school students in Western Australia with a focus on agricultural sciences. The program had two main objectives: the collection of samples and the mapping of the distribution of the leaf disease powdery mildew of barley across the state; and support for the teaching and learning of agricultural science. Nearly one thousand students participated in the Mildew Mania intervention that involved class experimental work for a Curtin University GRDC-funded project and interactions with scientists visiting schools. Alongside this, data was collected about attitudes towards agricultural science. Following the intervention, a moderate effect size (0.45) is reported for students wanting to learn more about investigative work on agricultural issues. Attitudinal data showed a negative correlation of interest in agriculture with the Index of Community Socio-Economical Advantage (ICSEA), and an increase in interest in careers in agriculture with older students. Limitations are the constraints in gaining appropriate permissions and consent for all parties to use survey data.

LITERATURE REVIEW

Declining interest in school and university science is a well-documented issue in many developed countries (Hackling, Goodrum & Rennie, 2011; Haynes, 2008; Osborne, Simon, & Collins, 2003). Suggestions to address this decline include changes in the curriculum, pedagogy and teacher education. This problem is even more pronounced in the agricultural sciences, with declining enrolments and availability of tertiary courses and an ageing workforce (Menzies & Basford, 2012).

Agriculture is one of Australia’s most important export sectors, so it is critical to have local experts to work in the laboratory and field, and also a population that understands the issues faced by farmers. The current situation facing agriculture can be best summarised as an ‘image crisis’ with negative publicity about economic and health issues (particularly suicides) (see Scarr & Hogan, 2011) in farming communities, and concerns around the use of genetically modified (GM) crops, salinity and fertiliser/pesticide overuse among the most prominent (Menzies & Basford, 2012). Despite its economic importance, agriculture is rarely taught by subject specialists in school and surprisingly there is no explicit reference to agriculture in the Australian Curriculum (ACARA, 2013). However, in the Year 8 statement
(ACSSU149) students are meant to be able to “distinguish plant cells from animal or fungal cells” (ACARA, 2013).

While some schools have a vegetable patch and encourage children to grow plants, there are few examples of students testing the more practical side of disease control (see Oliver et al., 2011). Concerns around GM crops in the food supply are a classic example of the importance in understanding the science behind modern agriculture. Controversial issues such as this have been shown to readily engage students (for example, Byrne, Ideland, Malmberg, & Grace, 2014; Sadler, 2009).

One of the common reasons to explain the lack of engagement of high school students in science is that it is not seen as relevant to the individual student and thus there is little motivation to learn (Jalongo 2007; Jenkins, 2006; McCrae, 2006). For example, learning and writing about scientific discoveries more than 100 years old is of little interest and the decline coincides with early high school when decisions about future careers are critical (Bennett & Hogarth, 2009). Students need to be presented with learning opportunities that give meaning and motivation to the content being taught (Thomson, 2009). Activities that include dialogue, discussion or action allow students the chance to interact with science and construct their own understanding (Bray, France & Gilbert, 2012). Connecting interesting tasks with worthwhile academic goals and thus increasing motivation deserves the further attention of the modern science teacher (Jalongo, 2007) with a greater emphasis placed on the learning of strategies and methodologies rather than numbers and names. Scientific literacy and positive attitudes to science are important outcomes that both need be valued and these often appear to be in conflict with each other (Bybee & McCrae, 2011; McConney, Oliver, Woods-McConney, Schibeci, & Maor, 2014).

The growth of ‘citizen science’ projects is increasingly recognised as a powerful alternative method for gathering information about locally relevant issues. An important feature of any public outreach program is the emphasis on mutual benefit between all parties involved and this is supported by evidence where genuine student partnerships increase motivation and attainment (Jenkins, 2006). Ecological surveys that collect data using volunteers have been found to be accurate and useful (Brewer, 2002), “creating motivation, providing options and maintaining connectedness” (McCaffery, 2005, p 74). The participants in this citizen science project were kept interested by an interactive website where they could add and see other results and they had some choice in where they could be involved in the experiment. While McCaffery acknowledged there could be some criticisms of using non-practising scientists, these could be minimised with repeated data measures and good experimental design.

Teachers are keen to be involved in genuine science outreach projects (Chankook & Fortner, 2007) and bringing a scientist into the classroom can have a positive impact on interest and eagerness to learn for both students and teachers (Laursen, Liston, Thiry & Graf, 2007).

This paper seeks to provide an example of an authentic research project where the efforts of students, with the support of their science teachers, can have a real impact on their local community.

**BACKGROUND TO THE STUDY**

The Mildew Mania project was conceived in response to the problem of fungal sample collection. It was born out of a concern that a powdery mildew disease (caused by the fungus *Blumeria graminis hordei* or *Bgh*) that grows on barley (the second most important economic grain crop for Western Australia) had overcome the genetic resistance present in commonly grown cultivars and was developing resistance to the demethylation inhibitor (DMI) class of fungicides that have been solely used to treat it. The barley growing areas of Western Australia are the Wheat Belt and Great Southern regions, a roughly triangular area of 200,000 km². The collection of samples by the single Perth-based researcher investigating this problem was limited by the vast distances involved and the sporadic nature of the disease and the need to culture samples promptly after their removal from the plant. *Bgh* can only grow on living plant tissue and does not survive refrigeration. Powdery mildew diseases require modest temperatures (15 °C to 20 °C) and high humidity but low rainfall and are therefore very ephemeral. Collection trips could be no longer than two days and so could only cover a fraction of the barley areas during the relevant periods.

The control of barley powdery mildew follows two main strands. The first involves the use of genetically-determined resistance in barley cultivars. *Bgh* exists in many pathotypes that each have the ability to
overcome one or more resistance genes in the barley cultivar. This strategy requires knowledge of which resistance genes have been defeated by the pathogen populations in the different parts of the barley growing area. In this way, barley growers and breeders can select cultivars that are resistant to the prevailing pathogen population. The second method is to use fungicides. The researchers suspected that resistance to the main DMI class of fungicide then in use was widespread, and so it was important to map the occurrence. Both control methods require the acquisition of a large number of isolates from different barley cultivars, treated with and without fungicides and from different parts of the region. Mildew Mania was designed as a cost-effective and efficient means to collect these isolates.

Curtin University has a long history of engaging with the public with outreach projects, and so in 2011 the project began with the primary aim of Bgh collection. The key to the technical success of the extended Mildew Mania project was the design of the kit, which comprised barley seeds and growing instructions. By growing the seeds at the appropriate time and in the appropriate conditions, the plants would act as 'baits' for the pathogen. The disease is easy to observe and samples were then sent by express mail to researchers in Perth for analysis and mapping the distribution of the fungus. The uptake of this project by schools was impressive with 94 schools and 975 students participating in 2012.

In order for any benefits of the project to be mutually experienced, each school was visited twice by a scientist who had also completed high school science teacher training. The initial visit was to provide background to the project, including the relevance to each school's community, and to resolve any issues that may cause the project or results to be compromised. Each school was visited again near the end of the project to discuss results, implications of the experiment and to make explicit the link with science curriculum. Pre-and post-project questionnaires were completed by students, and it is this tool that will be used to evaluate the project’s effect on students’ attitudes towards and opinions of agriculture. Demographic questions asked about students’ gender and grade were compared with SES data obtained from the Australian Governments My School website, available at www.myschool.edu.au.

Survey questions were adapted from existing surveys such as the attitudes of students to science questionnaire (Bennett & Hogarth, 2009) to include locally relevant topics. Students were asked about performing experiments, pesticide use, current issues such as GM crops, and career options in agriculture (for the full questionnaire, please see Appendix A). All questions had a three-part, Likert scale structure with three extended-response questions.

The questionnaire was administered at the beginning of each visit to minimise any bias that may be caused by the presentation or lesson that was delivered. Correlations and one-way ANOVAs were performed using SPSS Statistics Version 22. For this purpose, it was necessary for the data to be converted to numeric form, with female = 1, male = 2 and disagree = 1, not sure = 2 and agree = 3. These were deemed significant if below the 0.05 level for a 2-tailed test.

RESULTS

DEMOGRAPHIC DATA

Twenty schools (including two agricultural colleges) in barley growing regions participated, 17 government and three faith-based. Two schools had their experiments vandalised and were unable to complete the project.

1. I like performing new experiments where no one knows what the result will be
   Agree  |  Not sure  |  Disagree

2. I think Agricultural science is interesting
   Agree  |  Not sure  |  Disagree

3. Crop diseases are a food security issue for Australia
   Agree  |  Not sure  |  Disagree

4. Agriculture provides a large range of career choices
   Agree  |  Not sure  |  Disagree

5. I find it difficult to understand how agricultural science research can improve my life
   Agree  |  Not sure  |  Disagree

Figure 1: Example survey questions.
There was a period of 12–18 weeks between visits to allow the experiment to run, with the average interlude being 15 weeks. Approximately 330 students from Years 6 to 12 participated in the project. Signed ethical consent for data collection was limited to 87 students, with successful return of forms requiring the student, their parents and the classroom teacher to all sign documentation for their data to be used here.

Data were collected from a diverse range of country locations from small towns to remote district schools. Some of these differences can be measured via the Australian Government’s Index of Community Socio Economic Advantage (ICSEA) where the average value for a school is 1,000. Schools in this study ranged from 926–1,051, with the majority falling below average. There were more girls than boys (n = 33) in the study cohort.

**PRE- AND POST-RESPONSE ANALYSIS**

Given the small numbers of participant responses that are able to be included in this study, there are nevertheless some interesting findings that emerge. There were few gender differences in responses to the statements in the questionnaire. One statement in the post-test was found to have a significant correlation with gender (p=0.038), where males were more likely to agree (54.1%) with the statement, “Fungicides are an effective tool for agriculture in Australia”, compared to females (29.8%). Likewise, the statement on the pre-test, “Agriculture provides a

<table>
<thead>
<tr>
<th>Statement on questionnaire</th>
<th>Pre-test Mean (SD)</th>
<th>Post-test Mean (SD)</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performing experiments helps me to better understand the scientific theory that we learn in class</td>
<td>2.89 (0.36)</td>
<td>2.89 (0.43)</td>
<td>0.00</td>
</tr>
<tr>
<td>I like performing new experiments where no-one knows what the result will be</td>
<td>2.80 (0.51)</td>
<td>2.77 (0.51)</td>
<td>0.06</td>
</tr>
<tr>
<td>I think agricultural science is interesting</td>
<td>2.42 (0.65)</td>
<td>2.17 (0.69)</td>
<td>0.37</td>
</tr>
<tr>
<td>Crop diseases are a food security issue for Australia</td>
<td>2.59 (0.52)</td>
<td>2.70 (0.49)</td>
<td>-0.22</td>
</tr>
<tr>
<td>I would like to perform more experiments which investigate agricultural issues</td>
<td>2.44 (0.67)</td>
<td>2.14 (0.65)</td>
<td>0.45</td>
</tr>
<tr>
<td>Agriculture would be more successful if we could make chemicals to fight more diseases</td>
<td>2.49 (0.59)</td>
<td>2.38 (0.73)</td>
<td>0.18</td>
</tr>
<tr>
<td>Fungicides are an effective tool for agriculture in Australia</td>
<td>2.32 (0.54)</td>
<td>2.31 (0.63)</td>
<td>0.02</td>
</tr>
<tr>
<td>Fungicides can force plant diseases to evolve into something that can be more damaging to crops</td>
<td>2.37 (0.62)</td>
<td>2.39 (0.52)</td>
<td>-0.03</td>
</tr>
<tr>
<td>Plant diseases are something which I would like to study further</td>
<td>1.89 (0.83)</td>
<td>1.72 (0.74)</td>
<td>0.22</td>
</tr>
<tr>
<td>Genetic resistance is the best way to control plant disease</td>
<td>2.24 (0.51)</td>
<td>2.16 (0.52)</td>
<td>0.16</td>
</tr>
<tr>
<td>Agricultural crops will evolve more resistant to disease if they are mostly healthy</td>
<td>2.53 (0.62)</td>
<td>2.46 (0.67)</td>
<td>0.11</td>
</tr>
<tr>
<td>Agriculture provides a large range of career choices</td>
<td>2.82 (0.45)</td>
<td>2.71 (0.48)</td>
<td>0.24</td>
</tr>
<tr>
<td>I think genetically modified organisms (GMOs) should be used more in agriculture</td>
<td>2.12 (0.62)</td>
<td>1.96 (0.62)</td>
<td>0.26</td>
</tr>
<tr>
<td>I find it difficult to understand how agricultural science research can improve my life</td>
<td>1.62 (0.69)</td>
<td>1.70 (0.78)</td>
<td>-0.11</td>
</tr>
<tr>
<td>I think that agriculture requires farmers to make some difficult decisions</td>
<td>2.68 (0.59)</td>
<td>2.70 (0.52)</td>
<td>-0.04</td>
</tr>
</tbody>
</table>

Table 1: Students’ responses to statements on the pre- and post-questionnaire.

The overall means analysis for question responses: 1 = disagree, 2 = not sure and 3 = agree.
large range of career choices”, showed a significant gender interaction (p=0.049) favouring males.

The statements, “Crop diseases are a food security issue for Australia”, “Genetic resistance is the best way to control plant disease” and “I think that agriculture requires farmers to make some difficult decisions”, positively correlated with grade (p=0.019), with more students agreeing as their age increased.

As well as showing a gender effect, the statement, “I think agricultural science is interesting”, also showed a grade level interaction for the post-test (p= 0.04), with more students agreeing as the grade increases, perhaps reflecting a growing awareness of careers and possibilities of the world of work.

Students in higher socio-economic schools were more likely to agree with the pre-test statements, “I think agricultural science is interesting”, “Crop diseases are a food security issue for Australia”, “Fungicides can force plant diseases to evolve into something that can be more damaging to crops”, (p=0.003, p=0.018 and p=0.025) and ANOVAs (p=0.008, p=0.039 and p=0.002 respectively) with the ICSEA of the students’ schools.

Interestingly, there was little change in response to the statement about investigations being important in helping to learn about the scientific theory, how crop diseases are important to Australia’s food security or the importance and use of fungicides.

In the pre-test, there was a significant correlation (p=0.032) between students who found agriculture interesting and those who want to study plants further. While there was a reduction in agreement to both of these statements in the post-test, the correlation between the questions strengthened, (p<0.001), indicating that the students who thought agriculture was interesting were more interested in further study. It is interesting to note that students who were interested in both of the above did not significantly agree in either test that agriculture offered a large range of career choices.

DISCUSSION

These data reflect the complex nature of some of the issues explored in the experiment. The relationship between fungicide use and disease, issues facing food security and the decisions made by farmers seem to be better understood by the older students in the study. This is to be expected, as the older students have selected to study subjects in which the issues of this project are relevant, and therefore are probably in a better position to make the links between these.

The impact of the project can be seen by the change in responses to the ‘pesticide’ questions with more students disagreeing with the statement, “Agriculture would be more successful if we could make chemicals to fight more diseases,” and the statement “Fungicides are an effective tool for agriculture in Australia” after the experiment. More students seem to agree that the use of pesticides to treat mildew on barley is not the best way to control disease. The lack of significant correlation between the pre- and post-test for statements, “Agriculture provides a large range of career choices”, is a curious finding and warrants further investigation.

Many students considered the statement, “I find it difficult to understand how agricultural science research can improve my life”, to refer specifically to future career options. Higher ICSEA schools tend not to be located in the more rural parts of the state, so finding that students from lower ICSEA schools express greater awareness of the importance of scientific research may well reflect very obvious close ties to ‘working the land’.

CONCLUSION

There may be a perception in rural communities that farming, and thus agriculture in general, are not good career choices in terms of opportunity or remuneration. A range of factors have been identified to detract from the viability of farming in Australia such as climate events, compressing terms of trade along with long leads for developing skills or enhancing natural resources (Scarr & Hogan, 2011). While this image crisis is due for a revision with advances in soil management, biofuels, organic foods and farmers markets (Menzies & Basford, 2012; Mittal, 2004), students living in rural areas in this study appear to view agriculture through a different lens.

ACKNOWLEDGEMENTS

This project would not have been possible without the generous cooperation of all principals, teachers, students and parents involved. Many thanks to them for their
support and assistance in getting students participating in the growing and monitoring of barley crops.

**LIMITATIONS**

Ethical approval for data collection from students in the outreach project required permission and consent from a number of individuals. Whilst data was gathered from all students via pre- and post-questionnaires, only a very small number of these were able to be used in the analysis and this may have had an impact on the final outcome.

This project had approval from Curtin University's Human Research Ethics Committee and the Western Australian Department of Education. Funding was provided by the Grains Research and Development Corporation (GRDC).

**REFERENCES**


**Jessica Lewis** is a secondary science teacher passionate about involving students in real-life science, and sharing the many opportunities available to students. Prior to becoming a teacher she worked in a variety of commercial and academic research laboratories.

**Richard Oliver** is the John Curtin Distinguished Professor and Professor of Agriculture at Curtin University and works across Australia with farmers, scientists and teachers to reduce the impact of fungal diseases on crops.

**Mary Oliver** is Associate Professor of Science Education, University of Nottingham. She is interested in supporting the teaching and learning of science inside and outside the classroom and has worked with Jessica on the Dip Ed course at UWA.
APPENDIX A

Student Questionnaire on Agricultural Science Research

Please circle the most appropriate answer:

1. I am: Male Female

2. In year: 8 9 10 11 12

3. Performing experiments helps me to better understand the scientific theory that we learn in class
   Agree Not sure Disagree

4. I like performing new experiments where no-one knows what the result will be
   Agree Not sure Disagree

5. I think Agricultural science is interesting
   Agree Not sure Disagree

6. Crop diseases are a food security issue for Australia
   Agree Not sure Disagree

7. I would like to perform more experiments which investigate agricultural issues
   Agree Not sure Disagree

8. Agriculture would be more successful if we could make chemicals to fight more diseases
   Agree Not sure Disagree

9. Fungicides are an effective tool for agriculture in Australia
   Agree Not sure Disagree

10. Fungicides can force plant diseases to evolve into something that can be more damaging to crops
    Agree Not sure Disagree

11. Plant diseases are something which I would like to study further
    Agree Not sure Disagree

12. Genetic resistance is the best way to control plant disease
    Agree Not sure Disagree

13. Agricultural crops will evolve more resistant to disease if they are mostly healthy
    Agree Not sure Disagree

14. Agriculture provides a large range of career choices
    Agree Not sure Disagree

15. I think genetically modified organisms (GMOs) should be used more in agriculture
    Agree Not sure Disagree

Please explain why:

16. I find it difficult to understand how agricultural science research can improve my life
    Agree Not sure Disagree

Please explain why:

17. I think that agriculture requires farmers to make some difficult decisions
    Agree Not sure Disagree
OUTCOMES OF A CHEMISTRY CONTENT PROFESSIONAL LEARNING SESSION:
TEACHERS’ PERSPECTIVES

Catherine Rowen, Amanda Woods-McConney, Leorie Hughes and Damian Laird

The national curriculum for chemistry includes topics that have not previously been taught at secondary level. In response to requests for teacher professional learning (PL) covering these topics, a course called ‘Divide and Analyse’ was developed. Investigations into the PL needs of chemistry teachers were carried out in conjunction with the pilot session. Pre- and post-PL survey responses and focus group discussions provided a wealth of information about the needs of chemistry teachers and how university chemists can support them. Three themes of support for chemistry teaching were identified: resources for chemistry teaching, content PL for chemistry teachers and enrichment excursions/incursions for school students. Teachers explained that this type of support may contribute to making the study of chemistry more interesting and relevant for their students. A partnership between chemistry teachers and university chemists can facilitate the provision of the identified support for chemistry teaching. It was concluded that a community of practice partnership had developed from the Divide and Analyse PL. A model that brings together the major findings of the study is proposed.

BACKGROUND
In 2015, the implementation of the national curriculum for senior secondary chemistry commenced in Western Australia. The Murdoch University Science Outreach office was approached by a number of chemistry teachers enquiring about PL in content areas of the new curriculum that had not previously been taught at secondary level. Community engagement is a key mission of the university and partnering with teachers to provide chemistry PL seemed an excellent way to contribute in this area. Having a group of chemistry teachers gathered for a PL course was also an opportunity to learn more about their specific needs. The aims of the study were to obtain information on the PL needs of chemistry teachers and teachers’ perspectives on how ongoing education and support might be provided by university chemists. Rather than just providing the PL, which may be of benefit to teachers in the short term, we asked teachers what they needed and how we might help them in the longer term.

DIVIDE AND ANALYSE PL
The PL course’s name, Divide and Analyse, reflected the new curriculum topics requested by teachers: mass spectrometry (MS), atomic absorption spectroscopy (AAS), and chromatography. While it included the five critical features of teacher PL identified by Desimone: content focus, active learning, coherence, duration, and