

SCIENCE BY DOING STAGE 4 (2016 TO 2018)

FINAL REPORT
MARCH 2018

UTS:

ARTS AND
SOCIAL SCIENCES



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EXECUTIVE SUMMARY

Background

Science by Doing is an evidence-based online science program for Years 7 to 10, developed by the Australian Academy of Science (AAS). The program resources are free to all Australian students and teachers and are supported by award-winning professional learning modules and a research based professional learning approach. *Science by Doing* is aimed at improving science learning by:

- Better engaging high school students through a guided inquiry approach.
- Supporting teachers with relevant resources using innovative technology.

The program is aligned to and supports the implementation of the *Australian Curriculum: Science*. All *Science by Doing* curriculum units and professional learning modules are available free on the *Science by Doing* website.

There are four stages in the development of *Science by Doing*:

- Stage One 2009 – 2011
Develop professional learning approach, professional learning modules and initial curriculum resources
- Stage Two 2012 – 2013
Transpose existing curriculum resources to online delivery and develop an additional seven curriculum units for online delivery
- Stage Three 2013 – 2016
Complete final eight curriculum units plus new professional learning modules for online delivery
Use the Professional Learning Approach to implement *Science by Doing* within Australia
- Stage Four 2016 – 2018
Revise curriculum units embedding each with a student e-Notebook component
Implement Teacher Education with universities
Evaluate *Science by Doing*

This research was undertaken to identify perceptions of Stage 4 of the program, in particular Elements 4 and 5: Revise curriculum units embedding each with a student e-Notebook component; and Implement Teacher Education with universities.

Context of the *Science by Doing* Stage 4 Evaluation

The evaluation of Stage 4 of the *Science by Doing* (SbD) program focused on the revised curriculum units and the students' e-Notebooks. The timing of the release of the revised curriculum units within the Stage 4 evaluation phase involved only Years 7 and 8 updated units and e-Notebooks. Hence this report accounts largely on the use of these resources in schools and teacher education programs at the universities.

Science by Doing Stage 4 evaluation involved qualitative and quantitative research to be conducted in approximately six case study schools and with teacher education providers. The research questions relate to the four research areas for this evaluation: Effectiveness, Appropriateness, Efficiency and Governance. In summary, effectiveness of implementation of *Science by Doing* units within schools was determined through surveys of school science teachers and students together with case studies with teachers and students in six schools. Effectiveness of science teacher educator workshops and resources was determined using focus groups and a survey of science teacher educators and science teacher education students. Existing data on *Science by Doing* held by the AAS was also reviewed to investigate effectiveness. Appropriateness was evaluated using document mapping and interviews, and efficiency evaluated via a document audit and discussions with stakeholders. The surveys noted above also obtained information on participant perceptions of appropriateness. Finally, governance was evaluated using an audit of existing governance plans procedures and practices.

Findings

Effectiveness

School teachers and students

Impact of the *Science by Doing* modules and e-Notebook on teachers and students was gathered from two online surveys of teachers and case studies from six schools across the nation that included focus group interviews with teachers and students, class observations and observation of e-Notebook samples. The initial survey was conducted after the release of the updated Year 7 curriculum units with their e-Notebooks. The follow-up survey was conducted about six months later after the release of the updated curriculum units and their e-Notebooks for both Year 7 and Year 8. According to the evidence gathered from the high school teachers and students during this evaluation process, the revised curriculum units containing the student e-Notebook has had a very positive impact on their teaching and learning experience. The students taking part in focus groups conducted in the six case study schools were very positive about using *Science by Doing* and said they found it interesting and fun to use. They stated that they enjoyed learning science using these resources.

There was a great deal of variability in the technology provision evident in the case study schools and in the responses of teachers nationally to the teacher surveys. This dictated the ways that teachers used *Science by Doing* but it is a tribute to the program's flexibility and its adaptability, that teachers find ways to use it in a way that's more useful for their students and which works for them in their schools. Teachers value the ability to adapt the *Science by Doing* resources and modify them to their needs. For example, more than half of the participating teachers in the evaluation cherry-picked *Science by Doing* resources while more than a quarter engage with the resources from beginning to end. Overall, teachers indicated *Science by Doing* as an excellent resource that assists them to implement the *Australian Curriculum: Science* and to use a guided inquiry approach in their science classes. This is evident from the good level of uptake (55%-67%) of all the revised Year 7 and 8 modules by the teachers in their classes.

Technically, the vast majority (70%-92%) of the teachers surveyed completely/mostly agreed with the effectiveness of the online features (navigation, appearance, functionality, flexibility, balance of hands-on activities and the unit at-a-glance feature) of the resources. The teachers were also interested in receiving feedback on students' performance when using *Science by Doing* resources and suggested that analytics that they could view be embedded into the online resources.

The uptake of the e-Notebook appears somewhat slower than the curriculum units but a significant increase from 35% to 57% of the teachers reported using the e-Notebook from the initial to the follow-up survey. The e-Notebooks were used in different ways by the teachers but most notably was for students to download the e-Notebook and complete selected parts of the e-Notebook digitally or complete hard copies of the selected activities. Teachers are still attuned to handwritten work as they believed that students learned more handwriting than typing. The vast majority of the teachers believed that the e-Notebook improved their students' learning outcomes although some suggested more differentiation in the questions and activities to cater for the diversity of students in the classroom.

In case study schools where the teachers cherry-picked *Science by Doing* resources and embedded them into the school's learning management system, it was sometimes difficult for the students to distinguish between *Science by Doing* resources and other science resources that were already on the learning management system. However, the experience of the students involved in the case studies where they were able to login to *Science by Doing* websites expressed very positive responses. The outcome is the same with students who filled in the online survey even though they came from one school only. These students indicated agreement (completely/mostly/somewhat agree) of 68%-97% for the items asked: ease of use, improving understanding of how scientists work, *Science by Doing* being suitably challenging, *Science by Doing* improving their engagement and achievement in science and *Science by Doing* promoting peer collaboration and discussion.

Science teacher educators and teacher education students

The focus group data from university teacher educators and the online responses of university science teacher education students to the *Science by Doing* resources indicated that both groups had positive attitudes toward the resources. Teacher educators found the *Science by Doing* workshops to be particularly useful and effective. The focus on and use of the resources however were slightly different for the two groups. Teacher educators emphasised on and used the Professional Learning (PL) modules, which they found to be very helpful resources and excellent discussion starters about pedagogy. About half of the science teacher education students surveyed had accessed the PL modules and a smaller number had accessed the curriculum units, particularly the Year 8 units as part of their university class and for planning their lessons. Both the teacher educators and the teacher education students expressed the view that they would appreciate more online video examples of *Science by Doing* in the classroom.

Appropriateness

Evidence from the analysis of policy documents indicates that *Science by Doing* Stage 4 aligns with the current Australian Government education policy priorities in relation to science education in schools. Evidence from the interviews illustrates that *Science by Doing* designers and developers have designed resources to contribute to the achievement of Australian Government education policy priorities in school science education.

There is some ambiguity regarding the ways in which *Science by Doing* contributes to project based learning. It may be advantageous to clarify this in future developments of the program. An opportunity exists to expand the contribution of *Science by Doing* to the evidence base for improving STEM education outcomes in Australia. This would entail a more extensive application of data analytics. Possible developments in the use of data analytics in *Science by Doing* is discussed elsewhere in the report (see Recommendations section)

Science by Doing makes a contribution to the National STEM School Education Strategy (NSSSES) 2016-2026. It contributes the key areas for action including: Area 1: Increasing student STEM

ability, engagement, participation and aspiration; Area 2: Increasing teacher capacity and STEM teaching quality; and Area 3: Supporting STEM education opportunities within school systems.

Efficiency

At the time of reporting, *Science by Doing* had achieved all of its targets and all indications were that this would be done within the budget allocated for Elements 4 and 5, which are the subject of this evaluation. Therefore the program implementation of Stage 4 is achieving its targets and goals within the identified budget and time frame.

Governance

The evaluation of governance indicates that the Australian Academy of Science, the Department of Education and Training and the Steering Committee have been able to support and oversee the implementation and delivery of Stage 4.

There have there been no major contract management issues relevant to Stage 4.

The Reference Group theoretically provides an opportunity for additional input by key education stakeholders to ensure that *Science by Doing* is relevant and meeting the needs of secondary education systems across Australia. However, although face-to-face engagement of this group is cost prohibitive there appears to be merit in AAS continuing to engage members of the Reference Group on key issues related to program delivery and content. This is especially important given that the Steering Committee does not appear to govern the latter.

Some suggestions were made by committee members on how to improve oversight of AAS projects but consideration of these was beyond the scope of this study, which focussed on *Science by Doing* Stage 4 only. The suggestion for an overarching STEM program advisory group relates to the quality of all AAS programs and not just *Science by Doing*.

Recommendations

Recommendation 1

The space of online learning and technology changes quickly and if *Science by Doing* is to have the maximum impact, there is a need to continually keep up with that technology and adjust accordingly. The evaluation findings indicated that *Science by Doing* caters for a very wide range of school circumstances and that schools vary widely in their ability to utilise the digital resources. It is recommended that future *Science by Doing* development utilises technologies that are universally compatible with the wide range of devices found in schools to allow participation by the maximum number of students.

Recommendation 2

Many teachers are now seeing the benefits of being able to access learning analytics. It would be advantageous if *Science by Doing* were able to incorporate student feedback and learning analytics into the program that teachers could access to monitor their students' performance. This means that teachers need to be able to access feedback data from the students' digital activities online and e-Notebook.

Recommendation 3

Teachers, both in-service and pre-service teachers, have expressed their need to be able to differentiate the curriculum to cater for the different abilities of students in their classes. It is

recommended that *Science by Doing* explore ways that this can be done through digital means, such as using adaptive technologies.

Recommendation 4

In many schools, the time that teachers have available for teaching science is limited. Many teachers have said that they find it difficult to condense the *Science by Doing* units for the time available. This is despite the provision of optional units. It is recommended that *Science by Doing* provide more guidance for teachers who have limited teaching time with their classes so that the integrity of the curriculum unit is preserved.

Recommendation 5

Teacher educators who attended the *Science by Doing* workshops expressed the view that they gained a lot in terms of how to use the PL units and the other *Science by Doing* resources, including the student e-Notebook. It is recommended that AAS continue to offer *Science by Doing* teacher educator workshops.

Recommendation 6

Given that many schools are using learning management systems and including both *Science by Doing* resources and other science resources in their science programs, it would be advantageous to 'brand' the *Science by Doing* resources to make it clear where the resources originated.

EVALUATION OF SCIENCE BY DOING STAGE 4

Background to *Science by Doing* Stage 4

Science by Doing (SbD) is an evidence-based online science program for Years 7 to 10, developed by the Australian Academy of Science (AAS). The program resources are free to all Australian students and teachers and are supported by award-winning professional learning modules and a research based professional learning approach. SbD is aimed at improving science learning by:

- Better engaging high school students through a guided inquiry approach.
- Supporting teachers with relevant resources using innovative technology.

The program is aligned to and supports the implementation of the *Australian Curriculum: Science*. All SbD curriculum units and professional learning modules are available free on the SbD website. There are four stages in the development of SbD:

- Stage One 2009 – 2011
Develop professional learning approach, professional learning modules and initial curriculum resources
- Stage Two 2012 – 2013
Transpose existing curriculum resources to online delivery and develop an additional seven curriculum units for online delivery
- Stage Three 2013 – 2016
Complete final eight curriculum units plus new professional learning modules for online delivery
Use the Professional Learning Approach to implement SbD within Australia
- Stage Four 2016 – 2018
Revise curriculum units embedding each with a student e-Notebook component
Implement Teacher Education with universities
Evaluate SbD

This research was undertaken to evaluate Stage 4 of the program, in particular Elements 4 and 5: Revision of curriculum units embedding each with a student e-Notebook component; and Implement Teacher Education with universities.

Design of the Evaluation

This section lists each research question relating to the four research areas for this evaluation: Effectiveness, Appropriateness, Efficiency and Governance. The information following each research area provides additional details of the methodologies employed to address the research questions posed.

There has already been research and evaluative work conducted that investigates SbD and its impact. The first stage of this evaluation was to review data already gathered by SbD, to inform the design of surveys and focus groups/interview schedules and to identify case study schools and teacher education providers.

This evaluation sought to investigate the views of key stakeholders in Stage 4. Focus groups were employed to gather views that allowed researchers to understand how participants perceive and think about using SbD. Individual interviews were conducted to provide an in-depth analysis of issues. The combination of focus group, interview and survey data afforded multiple opportunities for participants and agents in SbD to express views on the phenomena under investigation. The comparison of similarities in responses contrasted with areas of difference provided triangulation, increasing confidence in the findings.

Effectiveness

Research question 4.11: What has been the impact of the revised curriculum units containing the student e-Notebook to the teaching and learning experience of high school teachers and students?

Survey of school science teachers

This component of the evaluation involved the collection of survey data from teachers regarding their experience with the revised SbD resources. The evaluation plan called for two teacher surveys, the first, or pre-survey, to be completed before the release of the revised curriculum units with the student e-Notebook. Data from this pre-survey was intended to be compared with a second survey following the release of the revised curriculum units and the student e-Notebook at the end of 2016. The timeline for the revised curriculum units release was: December 2016, all year 7 units¹ and July 2017, all Year 8 units² released. However, the evaluation project did not begin until after the release of the revised curriculum units for Year 7. Hence data was not gathered for the pre-survey. Instead, an initial teacher survey to capture the views of Year 7 teachers using the revised curriculum units was administered in June and July of 2017. A follow-up teacher survey to capture the views of teachers after the release of both the Year 7 and Year 8 revised units and the respective student e-Notebooks was administered in November and December 2017. This is detailed in Table 1. Informed by the experience of the case studies already undertaken by the evaluation team, the follow-up survey included additional items to elicit more information on the use of SbD resources, particularly the provision of technology in schools, the e-Notebook and the manner students access

¹ Year 7 units are: Circle of Life, Enough Water Fit for Drinking, Science of Toys and Earth & Space

² Year 8 units are: From Little Things Big Things Grow, Rock Paper Scissors, Energy and Rock Your World

the SbD website and resources. The initial and follow-up surveys sought teachers' views on the SbD updated units and the student e-Notebook, how the resources were utilised within their schools, and suggestions for improvement. The surveys, as shown in Appendix 1 and 2 respectively were hosted online on UTS' Qualtrics platform. A list of schools registered to use SbD was obtained from AAS and the survey links were emailed to the coordinator of the program in each school with an invitation to participate in the evaluation and disseminate the surveys to relevant staff in their schools.

TABLE 1. TEACHER SURVEY DETAILS

Teacher survey	Time administered	Captured teacher experience
Initial survey	June and July, 2017	Effectiveness of Year 7 revised units and e-Notebook
Follow-up survey	November and December, 2017	Effectiveness of Year 7 and Year 8 revised units and e-Notebook

Case studies with teachers in six schools

Case studies were conducted with 6 schools distributed across states and territories and these included varied school types and locations (including rural/remote) to ensure diversity in school types and SES conditions in the sample. Case study schools were finalised following discussion with AAS to determine priorities, to ensure that those involved in the purposive sample included schools that reflect AAS and national priorities.

Case studies analysis investigated the effectiveness of SbD in assisting teachers to meet the outcomes outlined in the *Australian Curriculum* for the learning area of science. In each case, one to two observations of teaching using SbD resources were conducted. Teachers were interviewed about their approach to science teaching, their use of the inquiry approach they are using and the extent to which they use it. Feedback was obtained in relation to the updated SbD resources, the benefits and limitations of the new e-Notebook as well as website design and navigation platform.

Focus groups and survey with students in case study schools

Focus groups and a survey (see Appendix 3) were conducted with student groups in the case study schools. These had a primary focus on determining student perceptions of the SbD learning materials and the e-Notebook. Where possible, student e-Notebook work samples were examined in each case study school.

Online resources usage

A review was conducted on the data that the AAS currently has with respect to SbD registration and usage data as well as the number of hits on the SbD online resources. These data informed the research questions about the effectiveness and efficiency of the SbD program

Research question 4.12: What has been the response of University teacher educators and their university students to the Science by Doing workshop and the Science by Doing resources?

Focus group and survey of science teacher educators

Focus groups were conducted with volunteer science teacher educators immediately after their SbD workshop preceding the 2017 ASERA conference to determine their views of SbD as a resource for initial teacher education. An evaluation survey of the teacher educators to the SbD workshop was administered by AAS at the end of the workshop and the findings are presented in this report in the 'Results' section below. The focus groups collected data on perceptions of the usefulness of the SbD professional learning resources and the updated curriculum units with their e-Notebooks as well as how the resources are being used in their universities. The focus group data were used to inform survey design to allow for a survey of more science teacher educators across Australian universities to be conducted.

The survey was emailed to 133 science teacher educators across the nation. Science teacher educators were identified from the Australian universities that offered secondary science teaching courses and from ASERA registration data. They were invited by email to respond.

Survey of science teacher education students

Science teacher education students were surveyed to determine their perceptions of SbD, their intentions with respect to future use, and their actual use of SbD during professional experience placements. The students were invited to participate in the survey by their teacher educators, who were emailed a link to the survey and asked to pass it on. All surveys were conducted online on UTS' Qualtrics platform.

A summary of the Effectiveness evaluation procedures and timeline of data gathering is shown in Table 2 below.

TABLE 2. SUMMARY OF THE EFFECTIVENESS EVALUATION PROCEDURES AND TIMELINE OF DATA GATHERING

Research question	Sources	Data gathering	Timeline (2017)	Data analysis	Deliverable
RQ 4.11: <i>What has been the impact of the revised curriculum units containing the student e-Notebook to the teaching and learning experience of high school teachers and students?</i>	School science teachers initial and follow-up surveys	Surveys	Initial survey: June – July Follow-up survey: November – December	SPSS	Report
	Case studies with teachers	Teachers: Focus groups On site	August- November	Thematic analysis	Reported as vignettes/cases emphasis

	and students in 6 schools	observations e-Notebooks content-analysed to assess impact on science learning		Content analysis Content analysis	g teacher and student voice to examine patterns and rationale for use and non-use
	Focus groups with students (in case study schools)	Students: focus groups	August-November	Thematic analysis	Report
	Survey of students in case study schools	Students: online survey	November	SPSS	Report
	SbD registration and usage data Online resources and learning analytics including review of information within e-Notebooks	Analytics	September	Google analytics	Report
RQ 4.12: <i>What has been the response of University teacher educators and their university students to the Science by Doing workshop and the Science by Doing resources?</i>	Science teacher educators	Focus groups and survey	June (focus group) October–November (online survey)	Thematic analysis SPSS	Report of gap analysis and potential developments
	Science teacher education students	Survey	October-November	SPSS	Report

Appropriateness

Research question 4.2: How consistent is the Science by Doing program, particularly elements 4 and 5, with Australian Government priorities in respect of science education in schools?

Document mapping and focus groups

The SbD resources and results from other components of this evaluation were reviewed by the research team and compared to the government priorities for science education as defined in the *Australian Curriculum*. Content analysis was used to analyse SbD resources to compare them to government priorities. Content analysis is “a research technique for making replicable and valid inferences from data to their context” (Krippendorff, 1989, p. 403)³. The developers and designers were also interviewed to determine their intention with respect to creating alignment of SbD student outcomes with education policy. A summary of the evaluation procedures and data gathering is shown in Table 3 below.

TABLE 3. SUMMARY OF THE APPROPRIATENESS EVALUATION PROCEDURES AND DATA GATHERING

Research question	Sources	Data gathering	Data analysis	Deliverable
RQ 4.2: <i>How consistent is the Science by Doing program, particularly elements 4 and 5, with Australian Government priorities in respect of science education in schools?</i>	Documents (resources and reports from other aspects of this evaluation)	Document mapping of Gov priorities and SbD program	Content analysis	Report comparing Australian Government education policy priorities to Stage 4 outcomes and materials
	Developers/designers and AAS SbD leadership team	Interviews	Open coding thematic analysis with NIVO	Report comparing Australian Government education policy priorities to Stage 4 outcomes and materials

³ Krippendorff, K. (1989). Content analysis. In E. Barnouw, G. Gerbner, W. Schramm, T. L. Worth, & L. Gross (Eds.), *International encyclopedia of communication* (Vol. 1, pp. 403–407). New York: Oxford University Press. Retrieved from http://repository.upenn.edu/asc_papers/226

Efficiency

Research question 4.3: Is the program implementation of Stage 4 achieving its targets and goals within the identified budget and time frame?

Audit and discussions

Efficiency was analysed through an audit of the degree to which targets have been met within budget and timeframe constraints. This included analysis of documents and discussions with SbD representatives. The survey and focus groups of teachers, reported on in the Effectiveness section of this report, also provided information on patterns of use, fidelity of use, adaptations and penetration. This information was mapped against the program's targets and goals. A summary of the evaluation procedures and data gathering is shown in Table 4 below.

TABLE 4. SUMMARY OF THE EFFICIENCY EVALUATION PROCEDURES AND DATA GATHERING

Research question	Sources	Data gathering	Data analysis	Deliverable
RQ 4.3: <i>Is the program implementation of Stage 4 achieving its targets and goals within the identified budget and time frame?</i>	Financial and planning documents SbD representatives	Document analysis Discussions	Descriptive analysis comparing proposed and actual	Report comparing program deliverables to targets

Governance

Research question 4.4: How effective are the governance arrangements for Stage 4 of Science by Doing?

Audit of plans procedures and practices

This component audited current governance plans, procedures and actual practices. The objective was to review the implementation of current practices and governance procedures and to provide advice on potential improvements.

The governance arrangements were reviewed to ensure appropriateness and effectiveness. The arrangements were reviewed to ensure that committee members have clarity regarding their roles and appropriate decisions are being undertaken around the implementation of stage 4. Effectiveness includes how decisions are modified following adjustments to the program following supplier and program feedback. A summary of the evaluation procedures and data gathering is shown in Table 5 below.

TABLE 5. SUMMARY OF THE GOVERNANCE EVALUATION PROCEDURES AND DATA GATHERING

Research question	Sources	Data	Data analysis	Deliverable
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		gathering		
RQ 4.4: <i>How effective are the governance arrangements for Stage 4 of Science by Doing?</i>	Documents	Review of governance documents: terms of reference and meeting minutes	Document analysis	Review of background material and method
	Committee members	Interviews with members of governing body committee	Descriptive analysis comparing proposed and actual	Review of decisions performance over stage 4

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EVALUATION FINDINGS

The findings of SbD Stage 4 evaluation are reported according to the four research areas for this evaluation: Effectiveness, Appropriateness, Efficiency and Governance.

Effectiveness

This section of the report addresses the following research questions:

RQ 4.11: *What has been the impact of the revised curriculum units containing the student e-Notebook to the teaching and learning experience of high school teachers and students?*

RQ 4.12: *What has been the response of University teacher educators and their university students to the Science by Doing workshop and the Science by Doing resources?*

Impact on school science teachers

To capture high school science teachers' perceptions and experiences of the revised SbD curriculum units and the student e-Notebook, an initial survey link was sent in June 2017 to an email list of 190 teachers, provided by the AAS. At that time the revised Year 7 units were available online. There were 70 valid responses from teachers to the survey in June and July 2017 and analysis of results showed that 40 of those 70 teachers had used the revised Year 7 units in their teaching. A link to a follow-up survey was emailed to teachers in the same list in November 2017 and there were 80 valid responses to that survey during November and December 2017. Of those 80 teachers, 51 had used the revised units, which were now available for both Years 7 and 8.

This evaluation is concerned with teachers' views of the revised resources, so for this report only the responses from teachers with experience of the revised units were examined, i.e. N=40 for the initial survey and N=51 for the follow-up survey. As such, the reported responses represent teachers' views of the effectiveness of the revised Year 7 and Year 8 resources and student e-Notebook. The results from both surveys are presented and discussed concurrently.

Findings

Demographics of participating teachers

Approximately half the teachers in both surveys taught in metropolitan schools (Figure 1), with about 40% in regional schools and a small percentage in remote areas.

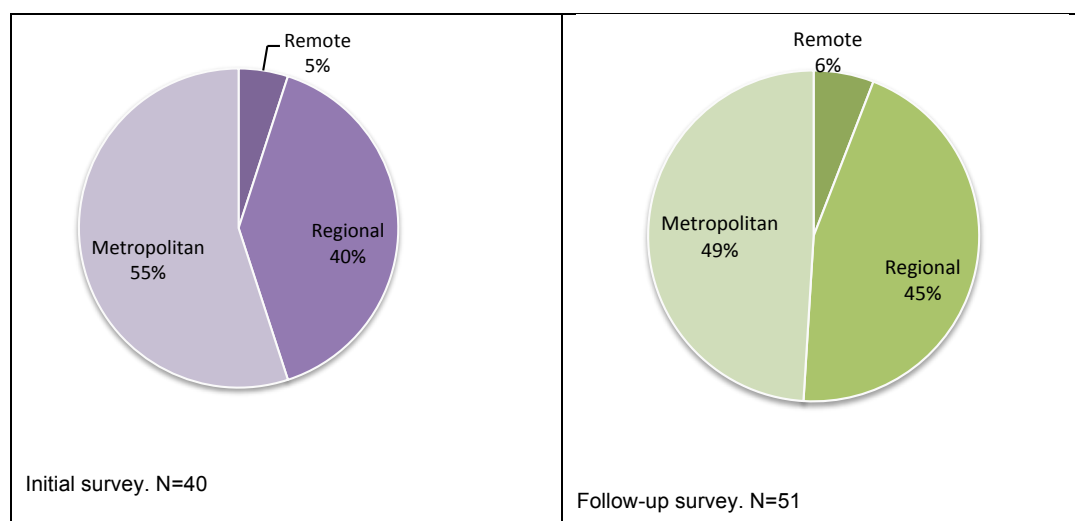


FIGURE 1. LOCATION OF SCHOOLS REPRESENTED IN TEACHER SURVEY

Between 60-70% of the teachers in both surveys had been teaching for more than ten years (Figure 2).

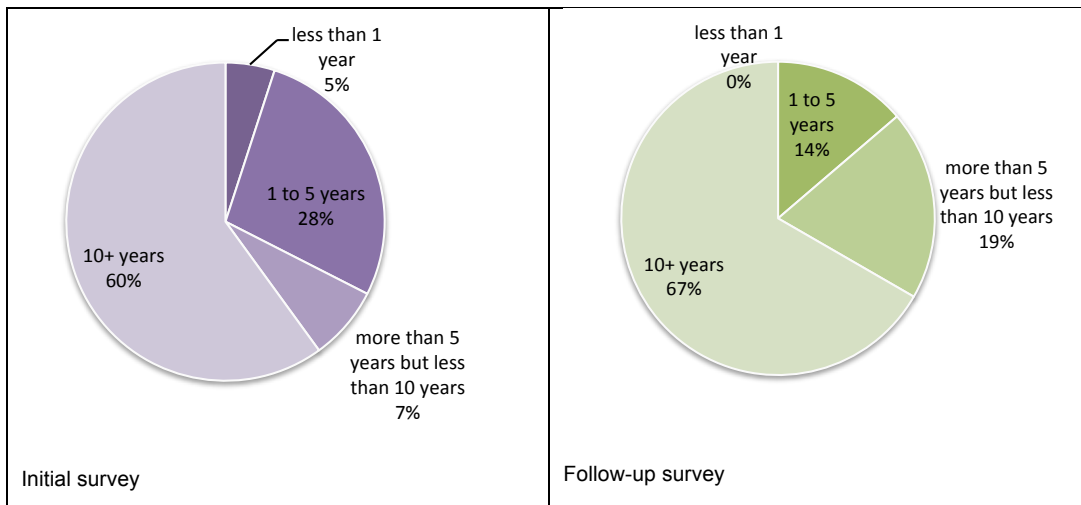


FIGURE 2. TEACHING EXPERIENCE

Teacher confidence in using guided inquiry approaches

In both surveys teachers generally expressed confidence in using a guided inquiry approach in their science teaching, with more than half (60% in the initial survey and 73% in follow-up survey) rating their confidence as high or very high (Figure 3).

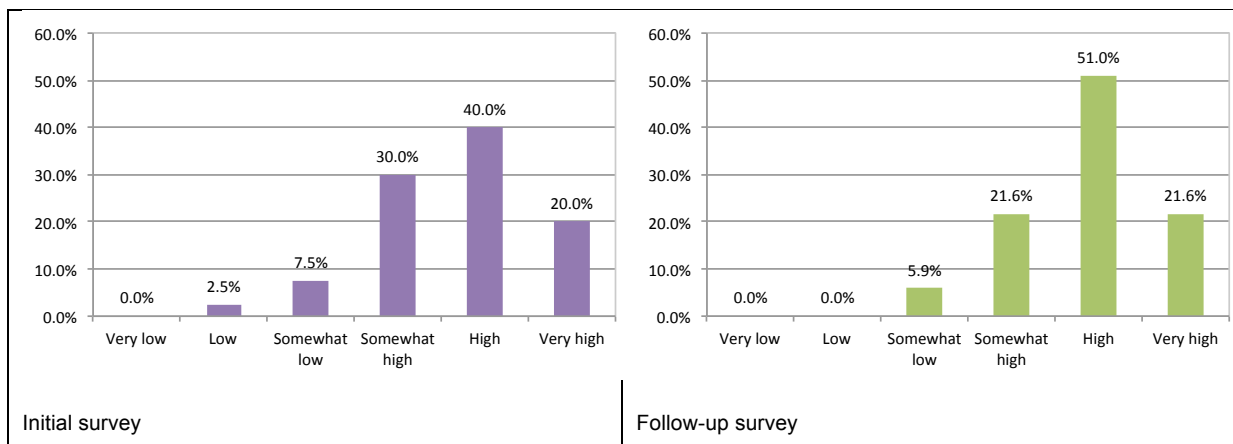


FIGURE 3. TEACHER CONFIDENCE IN USING GUIDED INQUIRY

Technology provision in schools

The patterns of technology provision at the schools between the initial and follow-up surveys were similar, with laptops being the most prevalent devices used, followed by tablets (Figure 4).

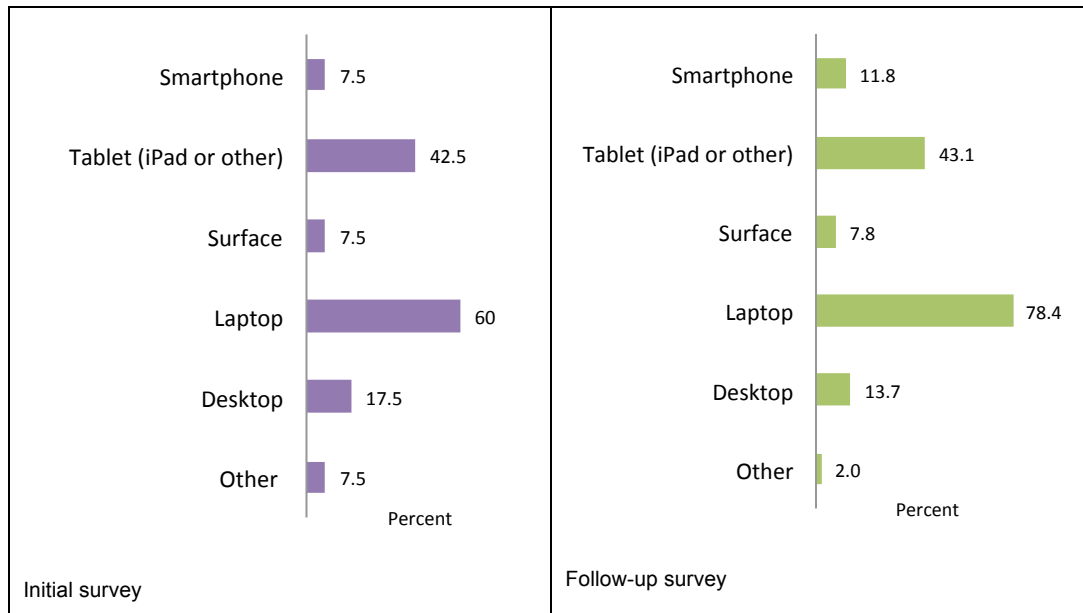


FIGURE 4. DEVICES USED BY STUDENTS

More than half of the digital devices used by students were student-owned, about a third belonged to the school and were shared by other students and about a fifth were school owned but for the exclusive use of one student (Figure 5).

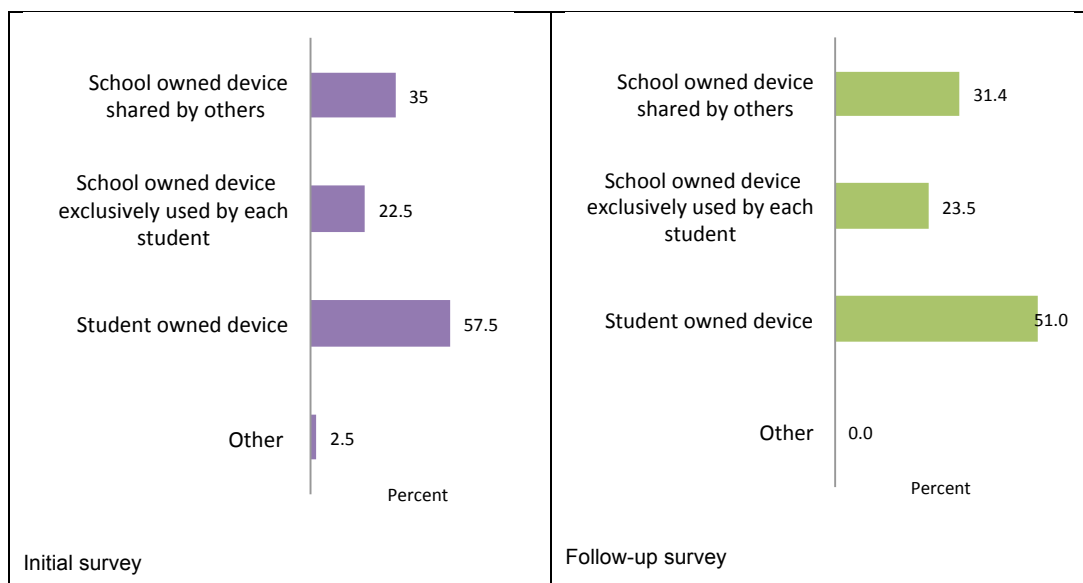


FIGURE 5. DEVICE OWNERSHIP

An additional item was added to the follow-up survey when the provision of technology in the case study schools proved to be very variable. As shown in Figure 6, 43% of teachers reported that students always had access to a digital device in class.

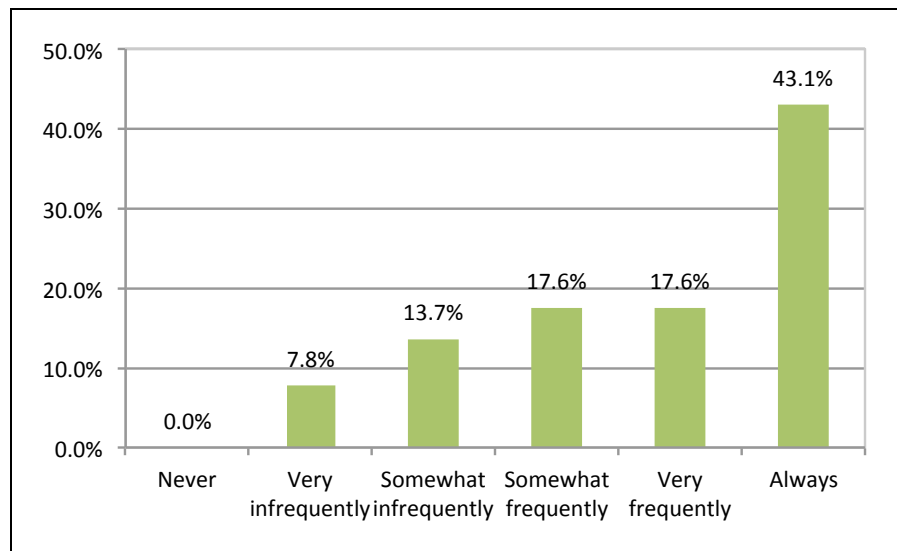


FIGURE 6. FOLLOW-UP SURVEY: FREQUENCY OF ACCESS TO DEVICES IN SCIENCE LESSONS

Accessing *Science by Doing* website

It also became apparent at the case study schools that students accessed SbD in various ways and this was explored in the follow-up survey. As shown in Figure 7, over 60% of teachers indicated that their students use individual logins to access SbD and a similar percentage of teachers project the SbD activities for the students to view.

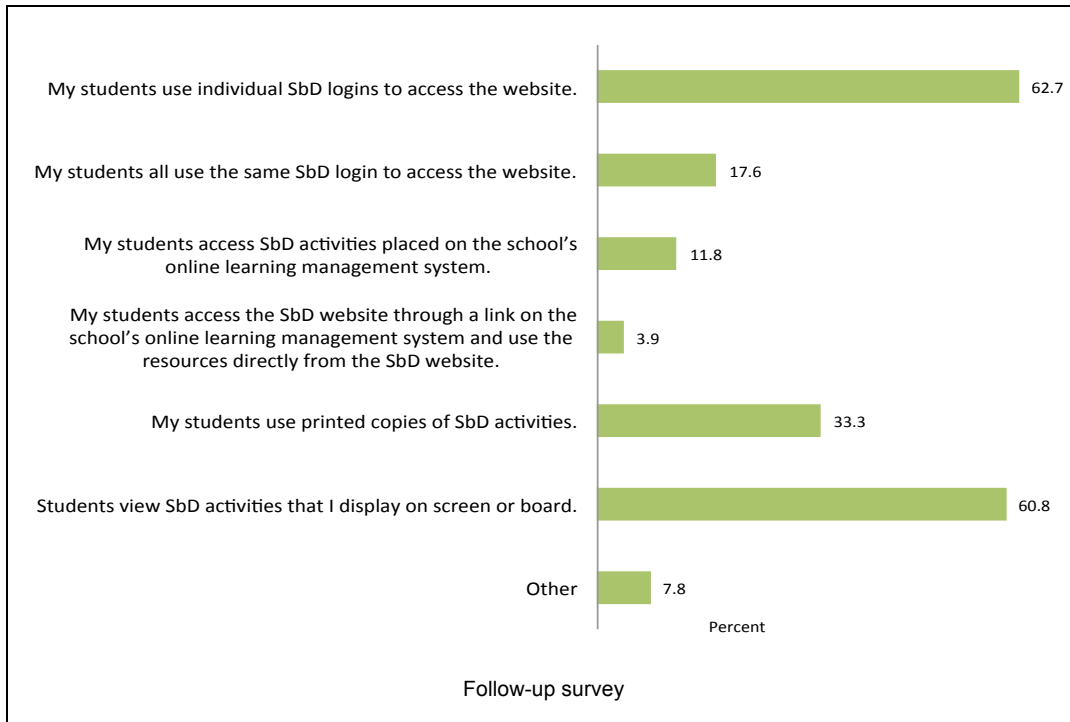


FIGURE 7. FOLLOW-UP SURVEY: HOW STUDENTS ACCESS SCIENCE BY DOING IN CLASS

How teachers made use of Science by Doing resources

Because of the flexibility of the Sbd resources, teachers were asked about the way the program is used at their school. Figure 8 shows that the most common way that teachers utilise Sbd is to cherry-pick selected parts and supplement with other resources (63% and 57% respectively for initial and follow-up survey). A substantial number of teachers engaged with the units from beginning to end (28% and 43% respectively).

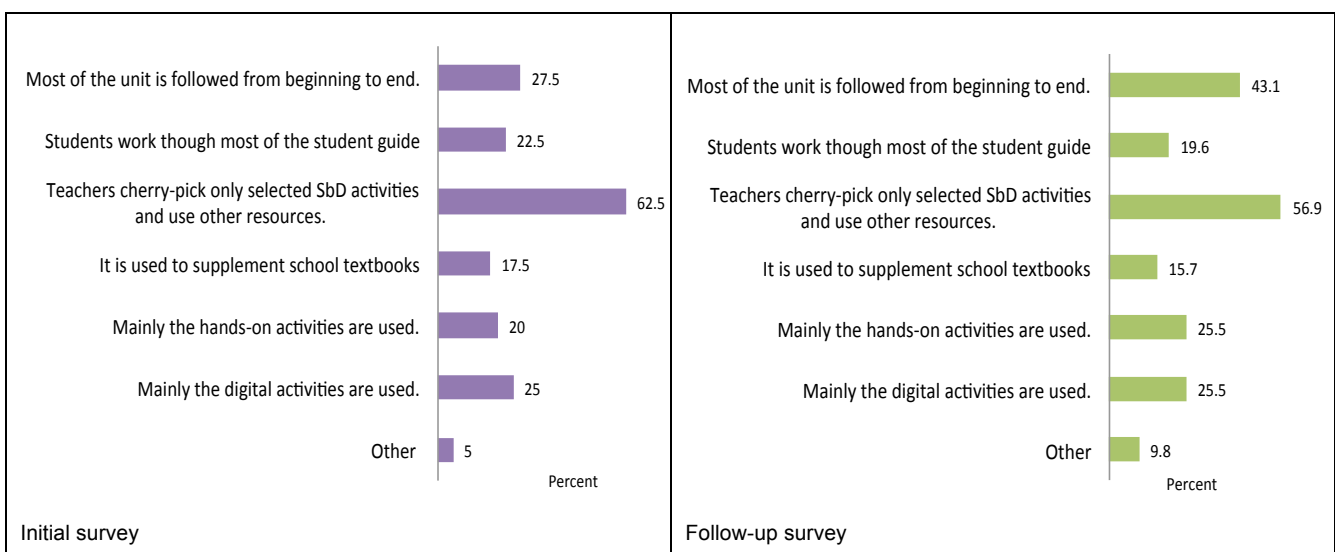


FIGURE 8. HOW TEACHERS USE SCIENCE BY DOING

Teachers’ perceptions of the impact of *Science by Doing*

Teachers’ views of SbD were generally very positive in both the initial (see Figure 9) and the follow-up survey (see Figure 10). As shown in these figures, there was more than 90% agreement (*Somewhat agree, Mostly agree, Completely agree*) with all of the statements. The majority of the teachers completely or mostly agreed that SbD is easy to use (68% initial survey) (80% follow-up survey)*, it is useful (88%) (86%), it improves students’ understanding on how scientists work (63%) (61%), the SbD units were suitably challenging for students (60%) (53%), SbD improves students’ engagement with science (65%) (55%), it improves students’ achievement in science (53%) (46%), it promotes student collaboration and peer discussion (55%) (69%), and SbD provides a way of implementing the Australian Curriculum: Science (85%) (86%). Seventy-five percent (84%) of teachers completely or mostly agreed that the navigation through the updated units is easy.

* Follow-up results in italics

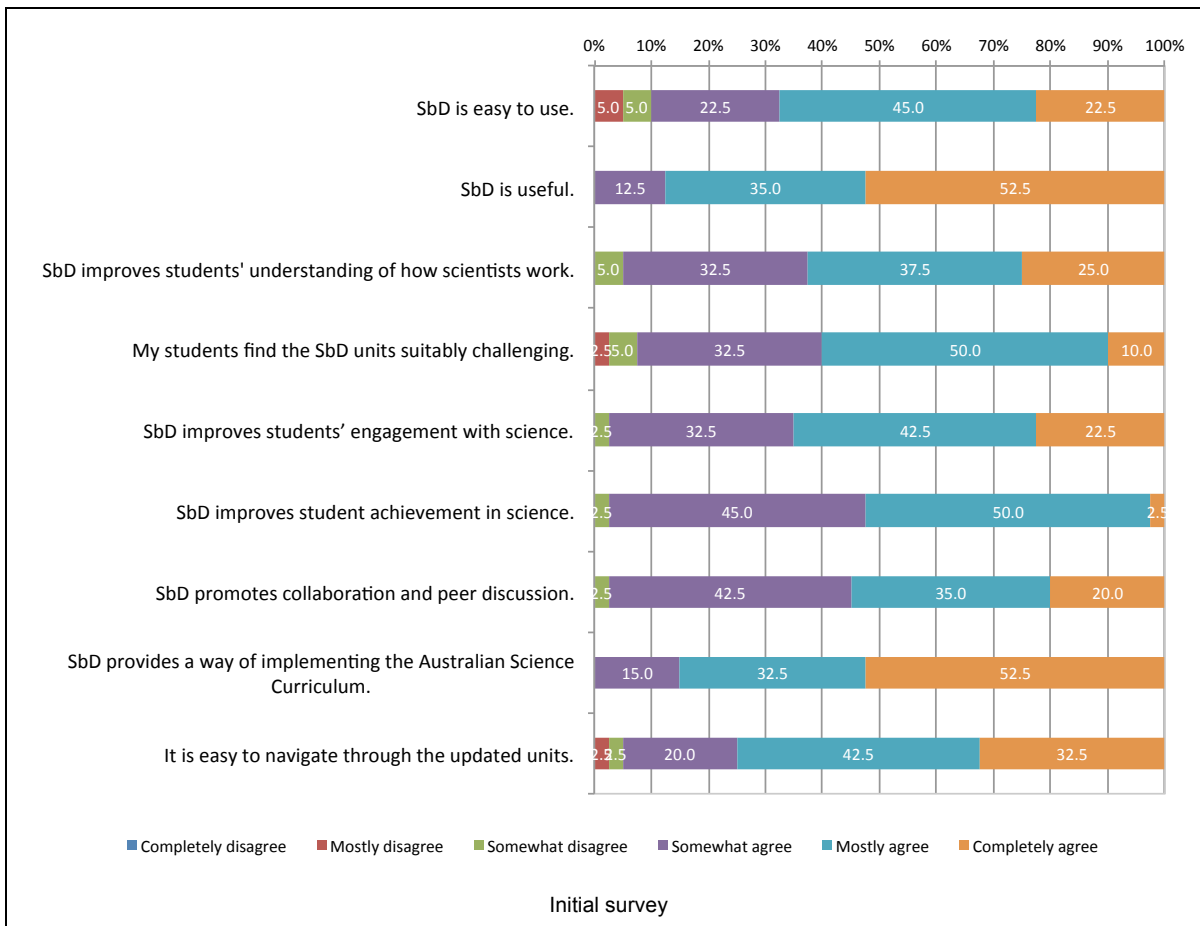


FIGURE 9. TEACHER PERCEPTIONS OF SCIENCE BY DOING IN THE INITIAL SURVEY

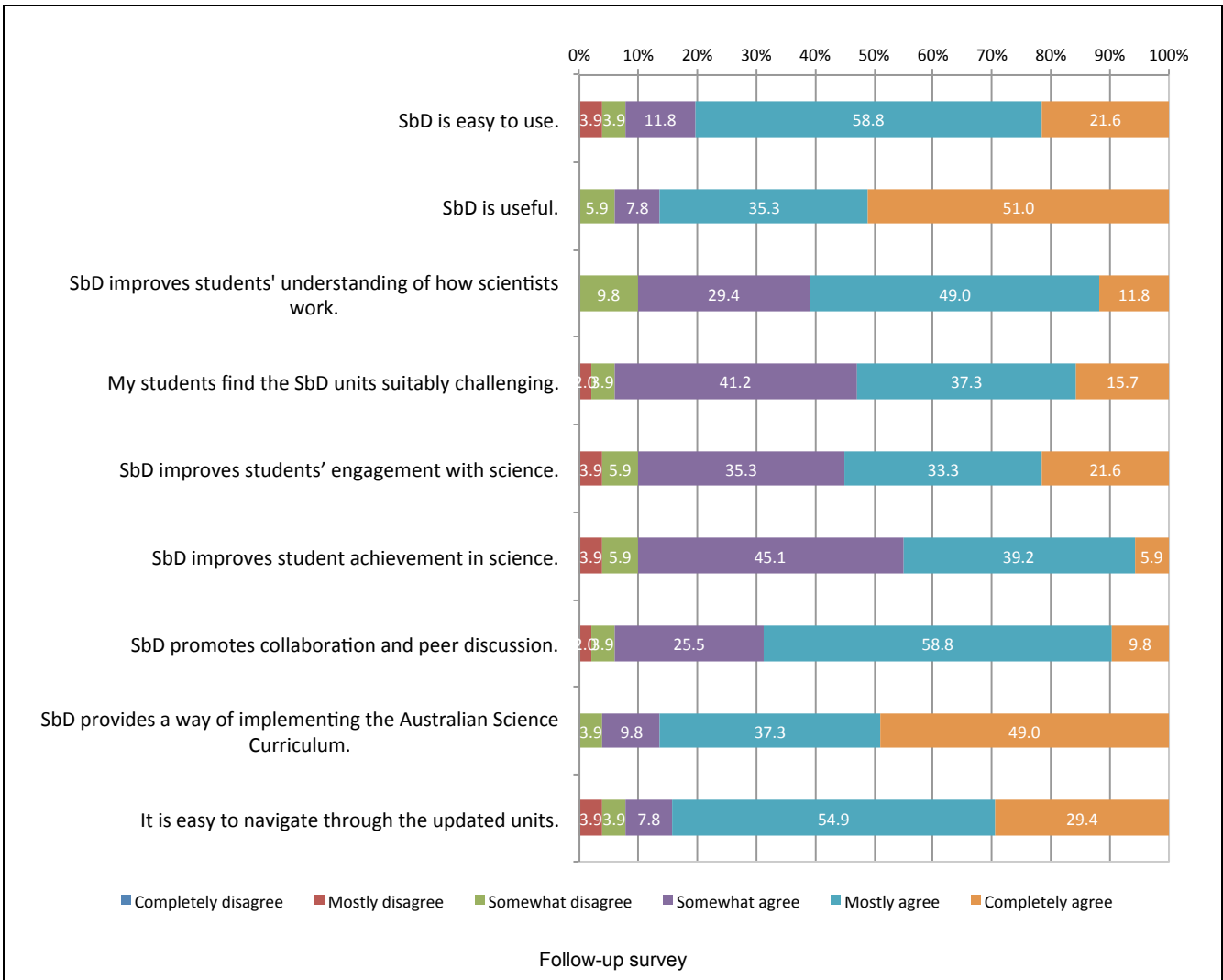


FIGURE 10. TEACHER PERCEPTIONS OF SCIENCE BY DOING IN THE FOLLOW-UP SURVEY

Teachers' perceptions of the online features of Science by Doing

When asked about the online features of SbD, teachers in both survey groups were very complimentary, as shown in Figure 11. The Appearance and Unit at A Glance features were rated as Good or Very Good by more than 80% of teachers in both surveys. Navigation was positively viewed by 83% (initial survey) and 90% (follow-up survey) of the teachers. Features of functionality, flexibility and balance of hands-on activities were rated as Good or Very Good by 75% (75%), 73% (65%) and 78% (67%) respectively.

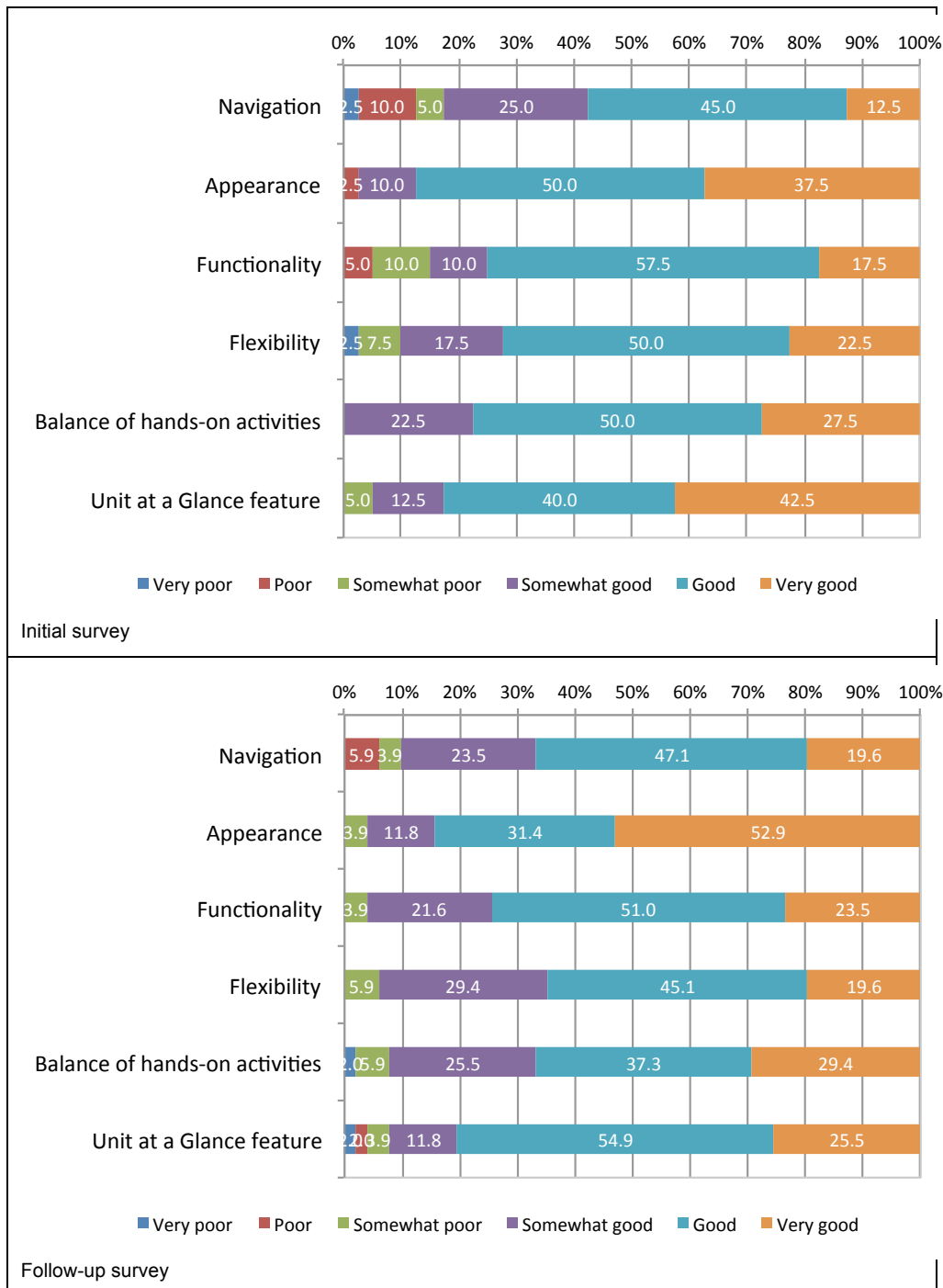


FIGURE 11. TEACHER PERCEPTIONS OF THE ONLINE FEATURES OF SCIENCE BY DOING

Revised units used by teachers in initial and follow-up surveys

Figure 12 shows the percentage of teachers who had used the revised Year 7 units at the time of the initial survey. As shown in the figure, the most popular unit, used by 60% of Year 7 teachers, was Enough Water Fit for Drinking. Thirty percent or more of the participating teachers had used Circle of Life, Science of Toys and Earth and Space.

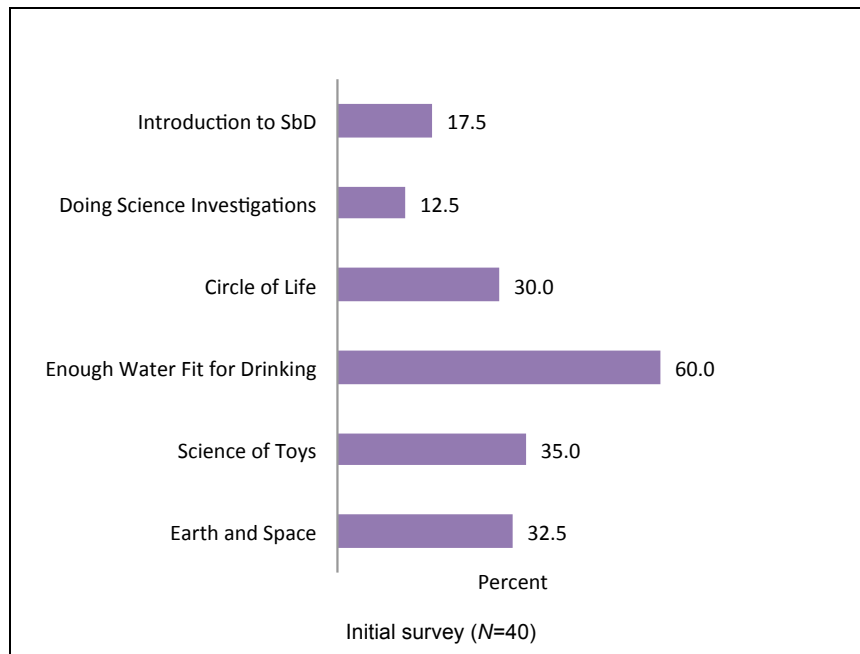


FIGURE 12. REVISED CURRICULUM UNITS USED BY TEACHERS IN THE INITIAL SURVEY

Figure 13 shows the percentage of teachers who had used the Year 7 and Year 8 revised units that were available at the time of the follow-up survey. Two-thirds of the participating teachers had used the Year 7 unit Earth and Space and the Year 8 unit From Little Things Big Things Grow. The remaining units had been used by 55% of teachers or more.

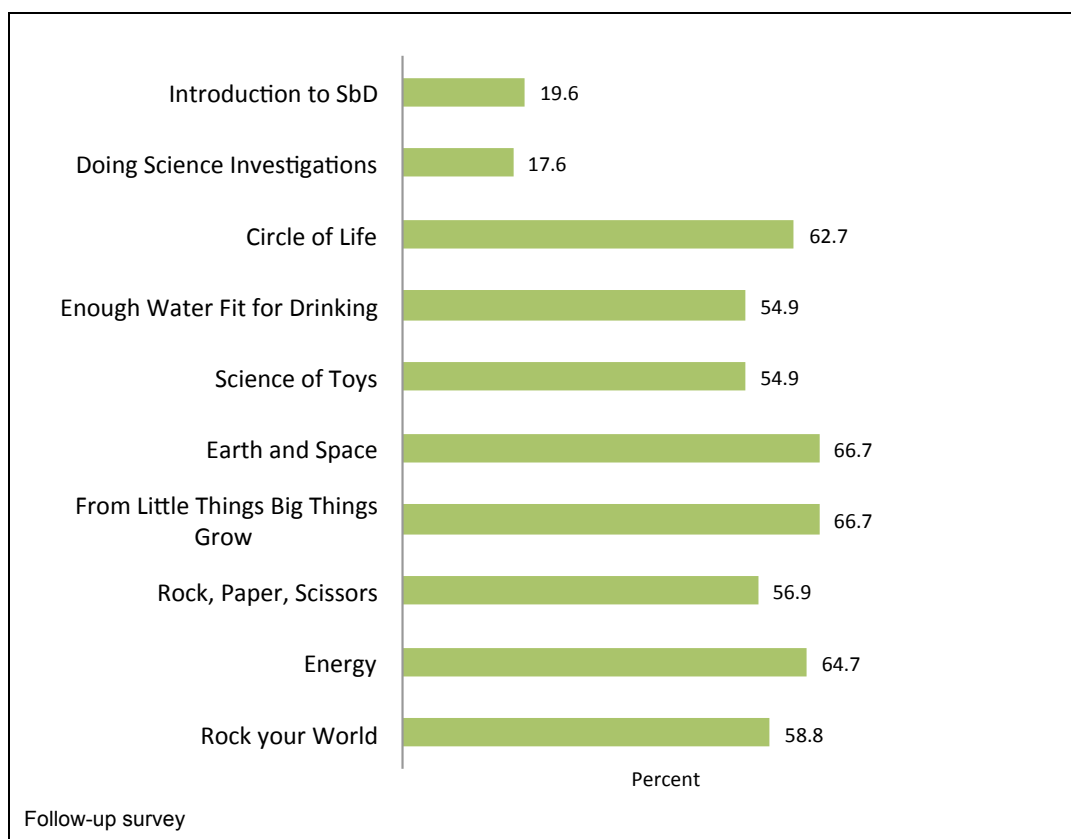


FIGURE 13. REVISED CURRICULUM UNITS USED BY TEACHERS IN THE FOLLOW-UP SURVEY

How students record their work in science

Figure 14 shows that the most common method of recording science work is for students to take their own notes in a book (50%) (36%). At the time of the initial survey, 52% of teachers said their students had never used the student e-Notebook but by the time of the follow-up survey this percentage had decreased to 29%. This indicates that by the time of the follow-up survey, more than 70% of teachers had used the e-Notebook with their students. The teachers' views of the student e-Notebook are captured in the open survey responses and case studies, described later in this report.

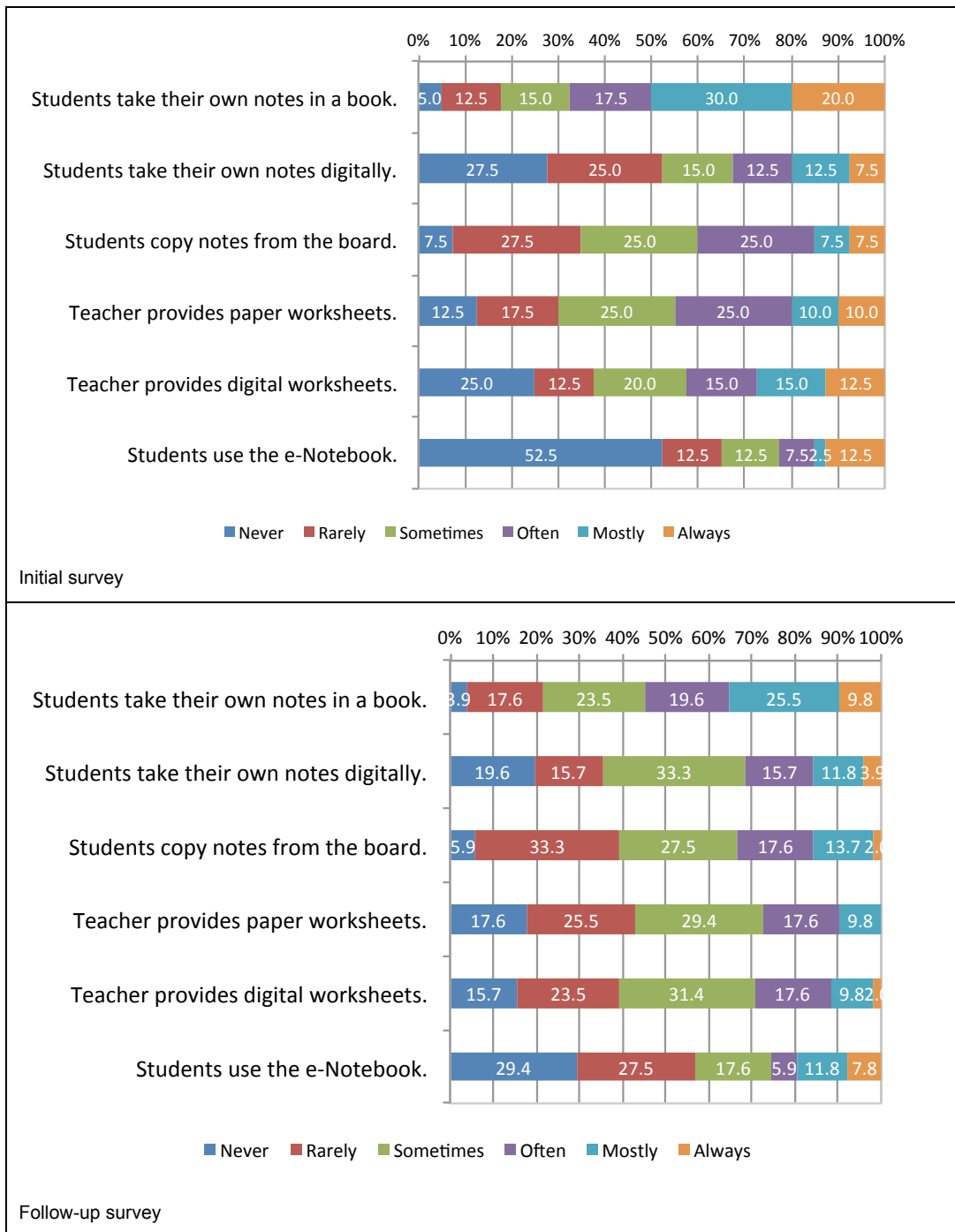


FIGURE 14. METHODS USED BY STUDENTS TO RECORD THEIR WORK IN SCIENCE

Use of student e-Notebook

Figure 15 shows the ways in which teachers make use of the student e-Notebook. The follow-up survey included additional items, as it had become apparent during the case study visits that teachers were using the e-Notebook in many different ways. The most common practice according to both surveys was for teachers to have their students download and complete parts of the e-

Notebook (50% (41%) mostly/completely agree). However, as the follow-up survey indicates, teachers may also download the e-Notebook and either have students complete parts of it digitally (35% completely agree or mostly agree) or print parts for students to complete on paper (21% completely agree or mostly agree).

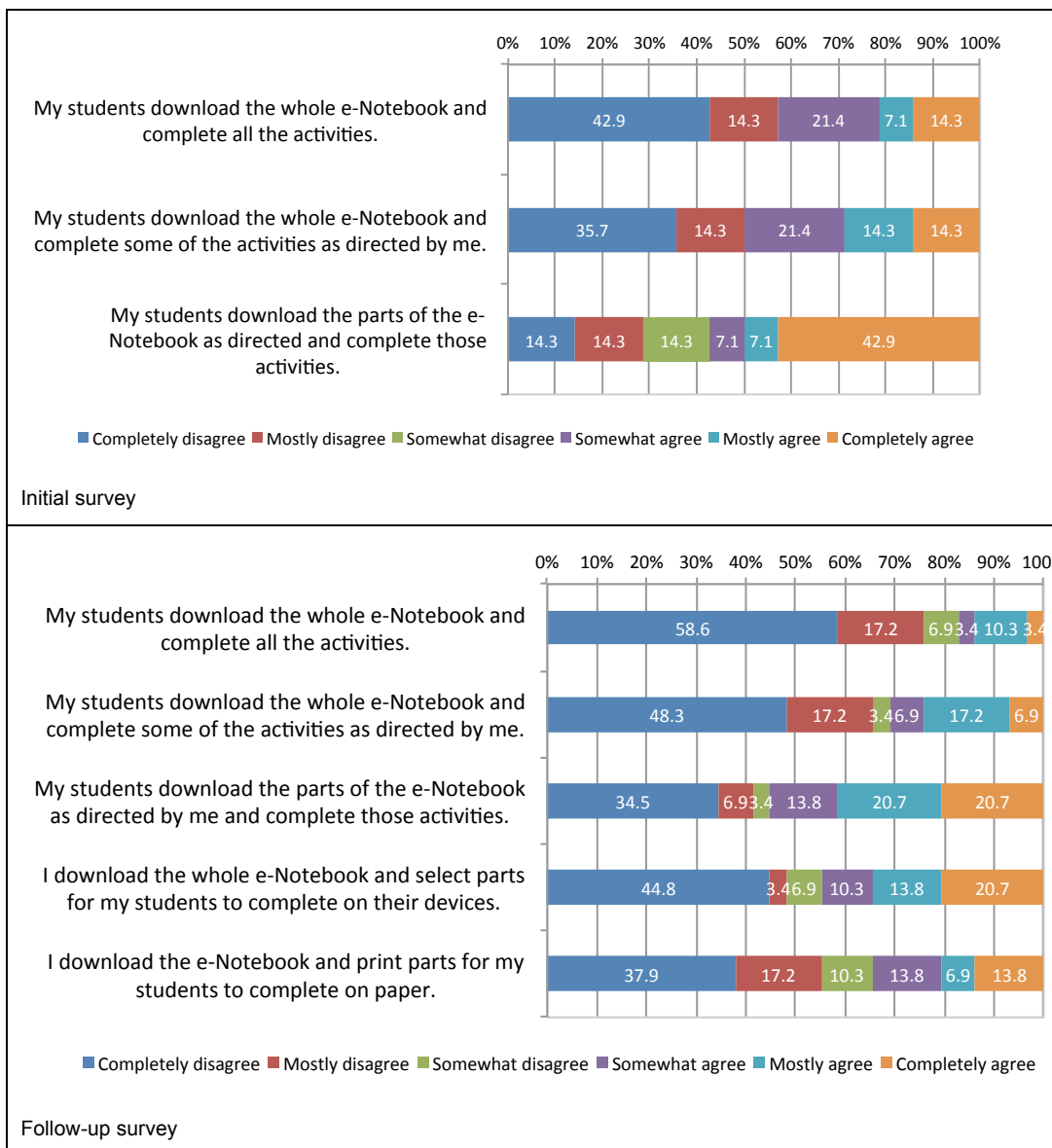


FIGURE 15. WAYS IN WHICH TEACHERS MAKE USE OF THE STUDENT E-NOTEBOOK

In the initial survey only 14 teachers responded to the statement, ‘The e-Notebook has improved the learning outcomes for my students’. In the follow-up survey, 29 responded. As shown in Figure 16, 100% (76%) of teachers agreed with the statement (Somewhat agree, Mostly agree, Completely agree responses).

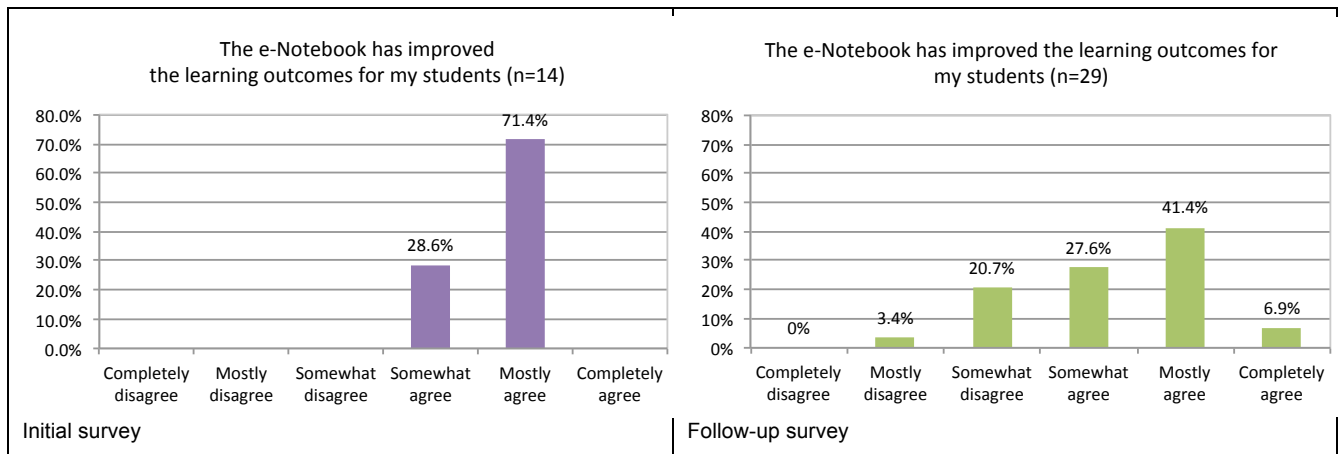


FIGURE 16. TEACHERS' PERCEPTIONS OF THE STUDENT E-NOTEBOOK

Teachers' views of the benefits and limitations of the student e-Notebook

Teachers were asked to comment on both the benefits and limitations of the student e-Notebook. Many of the comments in both the initial and follow-up teacher surveys reflected the level of technology provision at the school as this influenced the teachers' utilisation of the student e-Notebook. Depending on the technology available, teachers' views could be diametrically opposed.

Teachers' comments on benefits of the student e-Notebook included:

Pre updated units I would cut and paste from digital activity to make worksheets. e-Notebook makes it a lot easier for me.

We have made a few modifications to the e-notebook to suit our network and student devices and it works fantastic. This has been a HUGE step forward in the SbD program and has allowed us to focus on delivery and differentiation for students then completely focusing on lesson development

Quick to get students to start answering questions. No need to rewrite question. Many students more engaged to type answers on the digital ebook rather than write in notebook. Digital notebook work can be uploaded to our emarkbook for checking and marking online

I can convert them to a Google Doc and attach them to a Google Classroom assignment as is - no need to prepare anything else.

Comments on limitations of the e-Notebook included:

Difficult to pick and choose - because we don't have access to computers students have printed copies and can't answer the deeper research questions without additional resources

My school has bandwidth problems that prevent my students from using it like it was intended.

A lot of my students struggle using the sheet electronically. My school has really slow and unreliable IT. I cannot rely on it so must have printouts.

Other comments regarding the e-Notebook were:

The questions are clear and ready to go for the teachers

It is well organised and prompts students to reflect on their learning.

Guides students as to how their notes/observations/etc could or should be recorded

useful to print off some sections for use in class

allows practise and formative assessment

I intend to use this resource extensively in the remainder of the year. It saves a tremendous amount of time and teaches the students good digital book keeping practices

Teachers' suggestions for improving the SbD curriculum units or the student e-Notebook

The majority of the comments to the open question on how to improve the SbD resources were positive, with most of the teachers expressing satisfaction with the display, navigation and content of the resources.

My only worry is that we have implemented the SbD resource and so will always be concerned if it gets cancelled or stopped. It is a tremendous resource and the e-notebook has now become a significant part of our program.

Navigation on the updated units are great - thank you.

Im really pleased that the resource is being constantly updated and made relevant.

They are wonderful but more videos would be amazing.

Areas where the teachers offered suggestions for improvement of the SbD resources were wide ranging and include the topics of compatibility, differentiation, time available for science teaching, learning analytics and website organisational issues.

Compatibility:

Activities should be updated so that they are HTML5 versions so that they will work on any device.

You need to regularly check links to online activities to make sure they either 1) are current live links and still suitable and 2) will work on all machines, some of the links in the physics units won't work on our Surface Pros or require extra downloading.

some of the animations requires flash which are not compatible with some devices.

It would be more useful if it [the student e-Notebook] was in a form with fields for the students to complete.

Ability to differentiate for a variety of students:

I would recommend the e-notebook to include questions aimed at students working at different levels of difficulty.

Often it is too simple. Would also be great to have differentiated notebook activities including audio text for those who find reading a lot of textual info challenging.

Most of the notebooking is aimed at the more academic and higher literacy students. Differentiated questions would be more inclusive. Ideas in teachers guide as to notebooking answers would be of assistance as at times it is difficult to understand exactly what the writer is expecting.

More differentiation at both ends of the ability scale. Longer assessments, out of more marks for a clearer picture and to prepare them for exams later on.

Addressing the limited time available for science in the curriculum:

there is little to no way we could get through it in the indicated time (4 weeks) at the start of high school. Consequently, this unit blew out in terms of time and has put us well behind for the rest of the year.

Curriculum needs an abridged version - we only get 3 lessons a week and cannot possible cover it in this time. The e-books look great but our problem is the inconsistency of the devices students bring or rather dont bring!

There is a lot of content - perhaps the year 7 and 8 units could be smaller?

Access to learning analytics

Give the teacher access to their logon like Education Perfect. This way you manage your class and can remove or add in students where appropriate and make sure they are logging in with a correct email address and can reset passwords.

differentiation would be great and the idea of analytics showing student understanding coming to the teacher via email or text message would be wonderful.

Website organisational issues

It would be easier for the user if all the resources were in one place rather than Student, Teacher, Digital all separate.

Make the student digital clearer for teachers without student access to use. I think the videos and questions/activites are great, but the way to get to them when they're tied up in the stuent digital makes them inaccessible. I would also love to do a paper version (indepent or group) of some of the quiz-like questions that are in the student digital - like matching up.

One of the biggest hurdles that I have faced is having too many parts. It is really difficult to bounce between the student guide, the online portal, the notebooks etc. It would be much better if everything were in one website. So have the student guide be part of the student digital that can be worked through that way. This would make me much more likely to use the SbD units.

Case studies

This section summarises the findings from the case studies conducted in six schools from a cross section of school sectors and socio-economic backgrounds in the three states of NSW, Tasmania and Queensland. Table 6 shows the six schools that participated in the evaluation study. The individual case studies are included in this report as Appendix 7.

TABLE 6: PARTICIPANT SCHOOLS

School	Location	Sector	Type	Year range	Size	ICSEA*	Top quartile students
1	QLD, major city	Non-Government	Co-ed.	Prep-12	1900-2000	1100-1200	>80%
2	QLD, major city	Government	Co-ed.	7-12	2000-2100	900-1000	<5%
3	NSW, regional area	Non-Government	Co-ed.	7-12	600-700	900-1000	10%
4	Tasmania, semi-rural area	Government	Co-ed.	7-11	200-300	800-900	<5%
5	Tasmania, major city	Government	Single sex (boys)	7-10	700-800	900-1000	10%
6	NSW, major city	Non-Government	Single sex (girls)	7-12	1100-1200	1000-1100	>40%

Source: www.myschool.edu.au

* Index of Community Socio-Educational Advantage. Average ICSEA is 1000.

The case study schools provided a comprehensive view of the use of SbD in a range of different settings. The focus in these schools was on the updated Year 7 and Year 8 curriculum units and the use of the E-notebook. At each school data were collected from at least:

- One classroom observation of a Year 7 or 8 class using SbD including the e-notebook
- One focus group with teachers who were using SbD for Years 7 or 8 including the use of the e-notebook
- One focus group with students in Years 7 or 8 who had used the e-Notebook.
- View of three samples of student work in the e-Notebooks where possible

The detailed report of each case study school is shown in Appendix 7. The overall findings from the case studies are summarised below.

Technology provision

The provision of technology in the schools varied enormously. Some schools had a limited IT infrastructure and students had limited access to digital devices while in other schools all students had access to their own device and accessed their learning activities via an online learning management system.

Implementation of SbD

The proportion of SbD resources used in each school's program varied from using almost all the activities in the units to using some of the SbD resources to supplement the science program. The implementation of SbD in the schools was in most cases dependent on the technology provision in the school. The schools with better technology provision that were using an online learning management system had incorporated SbD resources into the learning management system (LMS), either as links to SbD activities/resources or SbD materials downloaded into the LMS so that students do not have to login but use the materials directly from the LMS. Most teachers, regardless of student technology provision, projected the SbD website onto a screen at the front of the room and may or may not have had students access it individually. Some teachers printed the resources for the students.

Impact of SbD in case study schools

Impact on teachers

The interviews with the year 7 and 8 teachers in the case study schools indicated that they were overwhelmingly positive about the updated units, which concords with the survey findings discussed in the previous section.

The teachers commented favourably on the improved navigation of the resources, liked the balance of activities and found that they were pitched appropriately. Examples of quotes from teachers are shown below:

There used to be like three things you had to look at to teach a lesson. Now you have the teachers guide all in that one spot and I think that is probably the best new feature. (NSW Govt school teacher)

SbD beautifully matches the curriculum and the Unit at a Glance and Teachers Guides are fantastic. (Tas. Govt boys' school teacher)

it's more learning through observation, learning through looking at a video, through discussion and through activities and a lot of these students engage that way. (Tas. Govt school teacher)

I think there's been a big improvement to that [The Science of Toys]. The way it starts off has changed ... The activity about making a paper helicopter reinforces the scientific method, the fair test. And it's a just a fun activity for Year 7 students to do. They enjoyed it and learnt a lot at the same time. (NSW non-Govt girls' school teacher)

Some of the teachers had been unaware of the student e-Notebook until it was brought to their attention because of the case study evaluation process and invitation to participate in it. Despite this, all of the schools had utilised the e-Notebook in some way by the time of the case study visits. Depending on the technology provision at the school this was used as an element imported into the LMS or as printed worksheets that the students completed by hand. The student work samples viewed by the researchers showed that those teachers who collected paper copies of the student-e-Notebook particularly valued the exercise.

I do use the e-Notebook but more use it on the board or printing out the e-Notebook sections. (QLD Govt school teacher)

I like the content of the e-Notebook but I don't like that the students don't have devices so they don't use it. (Tas. Govt boys' school teacher)

Many of the teachers indicated that they liked their students to handwrite their own notes and to keep a record of their learning in a book. They felt that the process of note taking helped to consolidate thinking and it was easier to manage.

Switching over to the e-Notebook, I think we would always want to keep the written one as well. I wouldn't let go of the hand written notebook, especially when there is a focus in the school on improving handwriting. (Tas. Govt boys' school teacher)

it enables kids to cut, copy and paste so that's part of the reason I like them to write their own answers down in their workbook. They can draw an answer or they can just write their own. (Tas. Govt school teacher)

The e-Notebook is guiding you into a structure that is somebody else's structure, therefore you're taking away the skill from the student to organise their own thoughts in some way. And then they don't learn that skill if they're using an e-Notebook. With writing it down, as you saw today, some students decided to draw a table, some used sentences – I think discovering your own way to organise your notes is important. (NSW non-Govt girls' school teacher)

I miss books. ... they don't think when they type. I like them to physically write it down... it slows that process down (Qld non-Govt school teacher)

Suggestions for improvement

Many of the suggestions for improvement came from teachers in schools where the use of online learning programs such as Mathletics and Education Perfect that allowed them to assign tasks and monitor the learning of their students. They suggested that similar features to monitor their students' progress in the SbD learning space would be very advantageous for assessment (both formative and summative) purposes.

that is one of the things about Education Perfect it tracks the students and it marks them (Qld Govt school teacher)

[With Education Perfect] you can see what each student has done and how they have done. It helps with auditing, giving evidence of [learning and] providing students with feedback. With SbD having all that feedback in it would be brilliant. If it had those capabilities you wouldn't do much else. (NSW non-Govt school teacher)

If it was possible to have some sort of indicator, not just whether they had done the activity, but have it as part of an assessment, that would be very useful. (Tas. Govt school teacher)

Some of the teachers who based their programs on SbD would like guidance on how to optimise the program to fit with the limited time that they often had with their science classes.

The length is the big issue, I know there are optional topics but that is not enough. (NSW non-Govt school teacher)

The teachers in the case study school also would like more help from SbD to differentiate learning for their students, e.g.

It would be helpful if there was a button for students to be able to access different levels of language for a task so that the language is differentiated. (Tas. Govt boys' school teacher)

Teachers in a school where iPads were used requested making interactive games and videos 'iPad friendly', as students were not able to access videos and games that use *Flash*, which results in whole class playing of games on the whiteboard, limiting active participation.

When the roller coaster one worked, the vibe in the room with the girls playing was different
 (NSW non-Govt girls' school teacher)

Another area for improvement suggested by some of the case study teachers was that the screen area could be bigger, as this would help with visibility when it is projected onto a screen for the class.

it would be useful if the unit window could be made to project full screen to make it visible to the whole class (Tas. Govt school teacher)

These suggested improvements, based on case study school interviews with teachers, in the areas of technology provision, differentiation and analytics concord with the written comments of teachers completing the online survey that are discussed in the previous section.

The student voice

In all the case study schools, the students who participated in focus groups interviews were very positive about SbD. In particular, they enjoyed the revised Year 7 and 8 units and found them interesting and fun. For example,

it's easy to use and all you have to do is click on a button and it downloads to our desktop
 (Qld non-Govt school student)

It answers a lot of questions – even if they're just like random questions, it helps you understand it. (Qld Govt school student)

the different media's good like watching the videos and then the worksheets as well so, say if you are more of a visual learner, it's easier to watch them and say if you work better on paper it's easier as well (Tas Govt school student)

These students' suggestions for improvement included screen size and tracking students but they were mostly happy with the program as it is. Their comments included:

It would be nice if the screen was bigger because there is a lot of blank space around the edges (Qld non-Govt school student)

Maybe a system where a teacher can assign a topic to a class and put in all the names from the class and then when they log in it will come up as the first thing on their topic bar, so they know what to click into (Tas Govt boys' school student)

Student survey results

Five out of the six case study schools incorporated the SbD resources into a learning management system or integrated other science resources while using SbD resources. In the case of one school, the SbD resources were placed into Powerpoint presentations for their classes. As a result of these practices, the teachers felt that it would be difficult for their students to distinguish SbD activities

from their other science lesson materials. As a result only one school felt that it was useful to invite their students to complete the online student survey. This school was a girls' school, where there were 166 responses. The results of the survey confirmed the positive attitude, obtained from the interview data, of the other case study school students to the SbD resources. As shown in Figure 17, the students' agreement (*Somewhat agree, Mostly agree, Completely agree*) with all statements about SbD was between 68 and 97 percent.

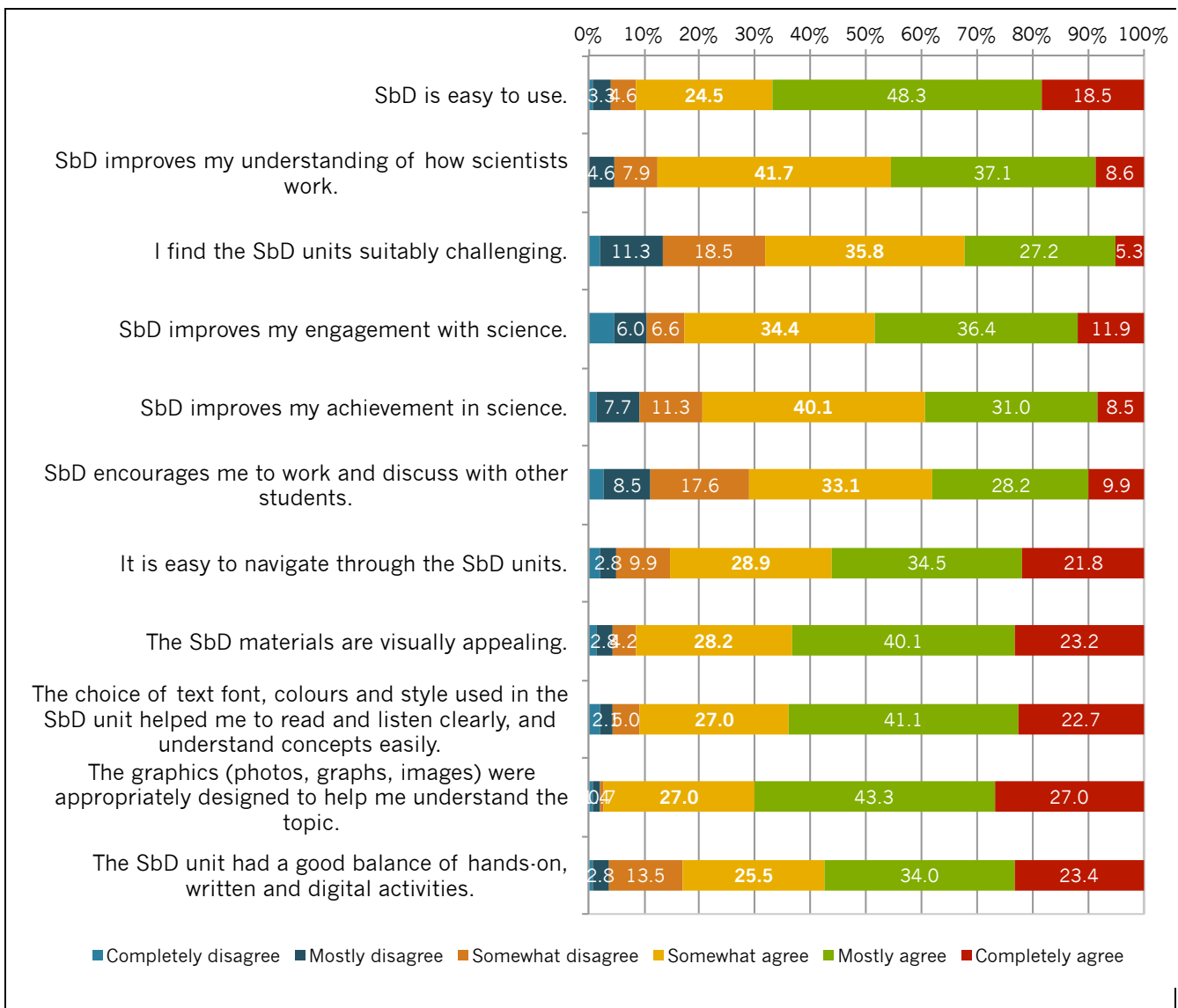


FIGURE 17. SCHOOL STUDENTS' PERCEPTIONS OF SCIENCE BY DOING

Many of the open-ended student survey responses to suggestions for improvement related to the use of SbD on iPads, e.g.

Some activities are using flash and and mobile devices can not access them so it would be great to access them

Make it able to use without flash player as it is hard to do on an iPad.

If I could give any suggestions for the SbD curriculum, I would say to make it easier to do activities for a tablet and iPad, as we use iPads at school.

The students also mentioned some login and navigation issues, e.g.

Every time I go on to iBooks and click the access student guide, I have to login in, go back to the book and then it lets me go in to see the work. it would be better if there was a way to login in faster.

Even when I save my password it still make me login which is cutting into the science lesson

Making it so that you do not have to log in every time and have to also download it every time.

When asked to suggest improvements, about half the students indicated that they were happy with the program as it is or made constructive comments, e.g.

I like the SbD Curriculum units and student e-Notebook as it is!

Make more of the activities hands on because I find that I answer questions best after a practical lesson or experiment. SbD is really good and I find that it makes things easier in most ways.

Include more images and little facts as well as definitions to explain thoroughly

More experiments/hand on work because that makes science fun and I remember things more that way.

Online resources usage

A review was conducted of the data that the AAS presently has regarding SbD registration and usage data and the number of hits on SbD online resources. The results of this review can be found in the Efficiency section of this report.

Impact of SbD on teacher educators and pre-service teachers

Research question 4.12: What has been the response of University teacher educators and their university students to the Science by Doing workshop and the Science by Doing resources?

Focus group and survey of science teacher educators

A one-day SbD professional learning (PL) workshop, conducted by the Australian Academy of Science (AAS), was held just before the start of the ASERA conference at UTS in 2017. The workshop was attended by 25 Australian university staff and 11 international academics. The AAS evaluation completed after the workshop by 24 of the attendees was very positive, as shown in Table 7, with all means over four on a five-point scale.

TABLE 7. TEACHER EDUCATOR EVALUATION OF *SCIENCE BY DOING* WORKSHOP

	Mean rating (n=24)
How enthused were you about the SbD project before your participation in the Professional Learning Workshop?	3.4
How enthused are you about the SbD project after your participation in the Professional Learning Workshop?	4.75
How easy do you think it will be to use the SbD professional learning resources?	4.4
How easy do you think it will be to use the SbD curriculum learning resources?	4.4
The workshop helped me understand the <i>Science by Doing</i> professional learning resources.	4.5
The workshop helped me understand how to use the curriculum units.	4.4
My confidence in using inquiry based teaching was reinforced.	4.1
<i>Science by Doing</i> provides a way of implementing the Australian Science Curriculum.	4.4
My own views and attitudes were valued.	4.4

Two focus groups of eight participants were conducted with the science teacher educators following the workshop to elicit their views of SbD as a resource for initial teacher education and how the resources are being used in universities. One focus group represented teacher educators who had experience of the SbD resources and the other represented those who were being introduced to SbD. The data from these focus groups were also used to inform the items included in an online survey to be conducted with a larger population of science teacher educators across the nation to obtain more representative data on science teacher educators' perceptions of SbD and how they used it in their science teacher education programs.

Both focus groups of teacher educators found the AAS-conducted workshop very useful. They found the professional learning (PL) modules to be particularly useful and those who had used the PL resources considered the modules to be very valuable to them. They made the point that their focus was on pedagogy rather than teaching resources. They considered the Questioning module to be particularly useful. Examples of quotes from the teacher educators are:

I used the Questioning module when I was a Head Teacher in a school and the teachers really learnt a lot from it. In fact, they learned so much that we took it to the whole school.

The Professional learning units are excellent as discussion starters.

One of the suggestions from the focus group of science teacher educators for the future of SbD included providing online video of teachers or pre-service teachers actually using the resources in classrooms. They thought that such videos would be of great benefit to pre-service teachers. Another suggestion that was seen as being very useful was the mapping of the PL modules to the

Australian Professional Standards for Teachers. The teacher educators, who had not used SbD in their teaching but based their responses on the learning at the workshop, also indicated positive attitudes about it. They offered suggestions for making the professional learning resources more interactive for pre-service teachers and the curriculum resources to better cater for differentiated learning.

A teacher educator survey, the design of which was based on the focus group data, was placed online in October 2017 (see Appendix 4 for the survey questions). One hundred and thirty-three science teacher educators were invited by email to respond. These included academics who attended the ASERA conference as well as identified science methods lecturers from the Australian universities that offered secondary science teaching courses. However, there were only ten valid responses to the survey and, of these, six had not used the resources with pre-service teachers. The remaining four responses were considered too small a sample to provide meaningful data.

The low rate of survey return by educators may be explained by (i) inaccuracy in identification of science method teachers and the fact that many are casuals in the list (ii) the timing of the survey at the end of university teaching year meant that the survey was easily overlooked and (iii) it is also possible that the teacher educators who took part in the focus groups after the pre-ASERA SbD workshop, who were also included in the email invitation to participate, did not participate.

Survey of science teacher education students

When the link to the online teacher educator survey was emailed, the teacher educators were also asked to pass on a link to a survey for science teacher education students. This was a modified version of the teacher educator survey and it elicited science teacher education students' views of the SbD resources, how they had experienced them to date, and how they perceived that they would use them in the future (see Appendix 5 for survey questions). There were 20 responses to the online survey. These students were in the first or second year of a Masters program at their university. More than half the students (11 out of 20) indicated that they had used the program's PL modules (see Figure 18). Of the PL modules used, about 50% of the students indicated having used the Inquiry-based Teaching and Student Learning modules. The use of 'Effective Questioning', 'Assessment' and 'Implementing *Science by Doing*' PL modules were undertaken by 18%, 27% and 36% respectively of the science education students. None of the students used the 'Leading for Change' and 'Inquiry DIY Guide' modules.

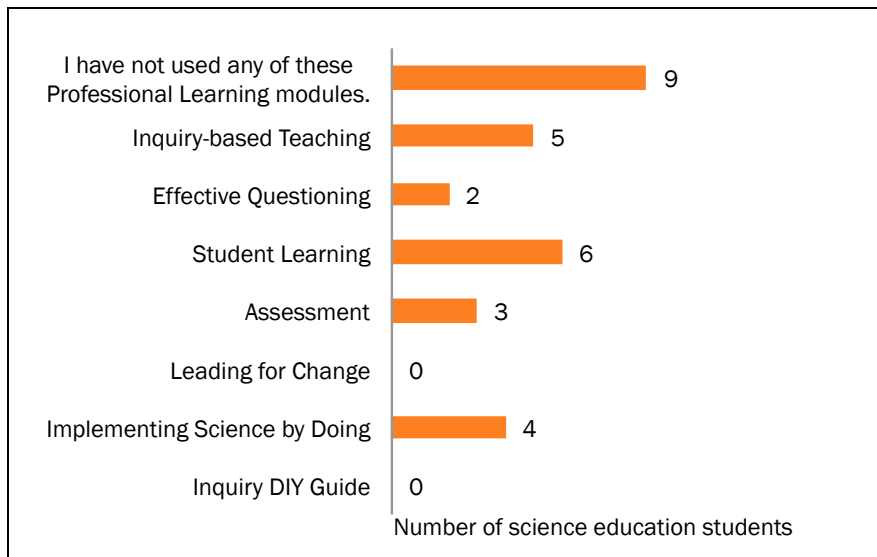


FIGURE 18. SCIENCE TEACHER EDUCATION STUDENTS' USE OF PROFESSIONAL LEARNING MODULES

The science teacher education students' perceptions of the PL modules were very positive, as shown in Figure 19. There was 100% agreement (completely, mostly or somewhat agree) for the three items surveyed: 'the SbD professional learning modules are useful resources for pre-service teachers', 'the SbD professional learning modules have improved my understanding of guided inquiry teaching' and 'SbD PL could be improved by mapping professional learning modules against APSTs (professional standards)'.

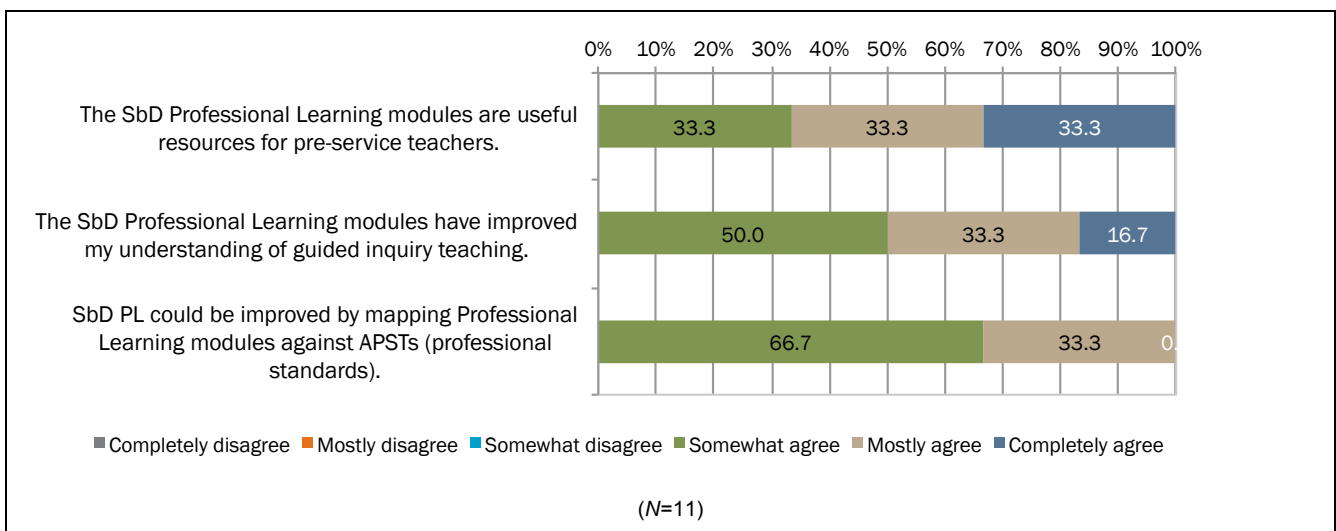


FIGURE 19. SCIENCE TEACHER EDUCATION STUDENTS' PERCEPTIONS OF PROFESSIONAL LEARNING MODULES

The science teacher education students had used most of the Year 7 and 8 curriculum units and, as shown in Figure 20, they had mostly used them in a university class or as resources for lesson planning.

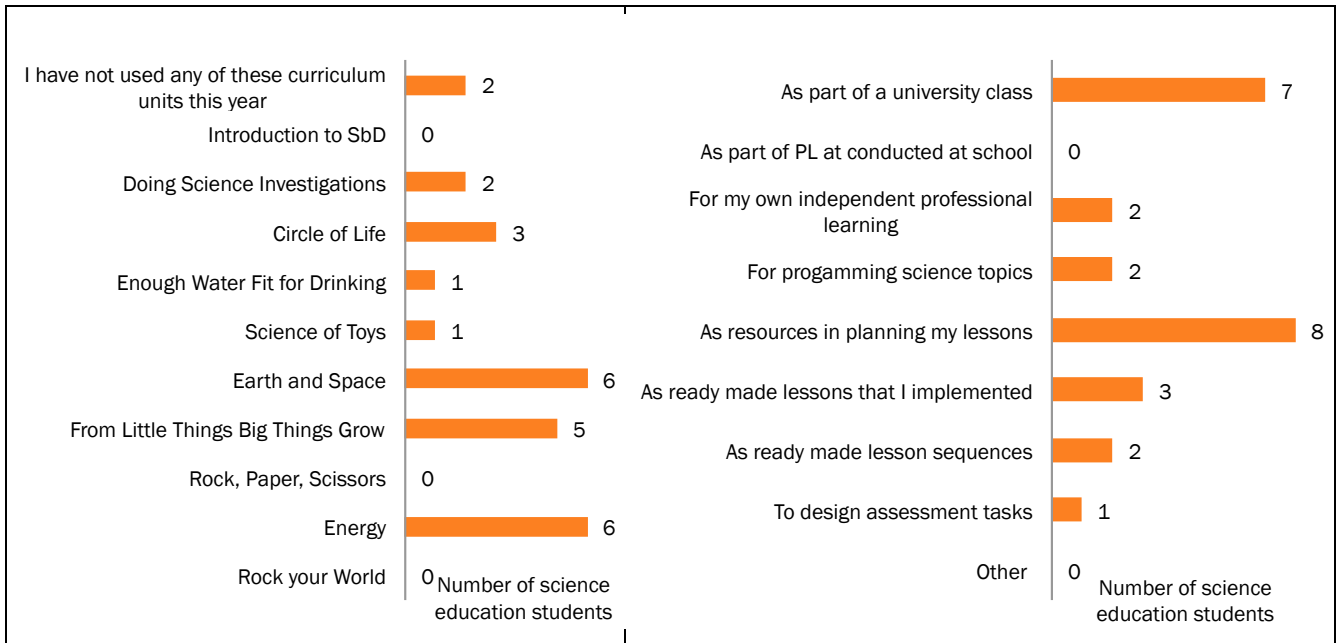


FIGURE 20. SCIENCE TEACHER EDUCATION STUDENTS' USE OF CURRICULUM UNITS

The science teacher education students were generally positive about the online features of SbD as shown in Figure 21. Every one of the features was rated Good or Very Good by at least 70% of the respondents.

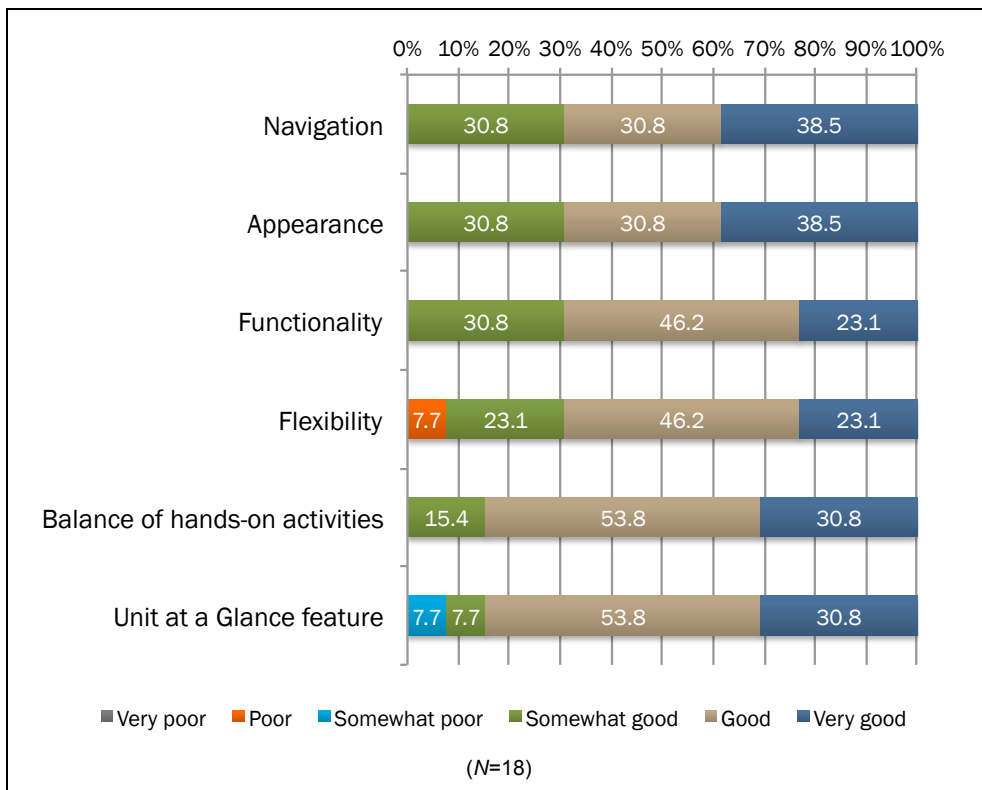


FIGURE 21. SCIENCE TEACHER EDUCATION STUDENTS' PERCEPTIONS OF THE ONLINE FEATURES

The science teacher education students found the SbD materials to be very useful teaching resources, as shown in Figure 22. More than 85% of respondents mostly agreed or completely agreed that the materials were useful resources and supported them to implement the Australian Science Curriculum. They broadly agreed with the suggestions for improvement that had been generated as a result of the teacher educator focus groups, particularly that the materials could be improved by including differentiation to cater for different student learning abilities. These results concord with data from teacher surveys and focus groups.

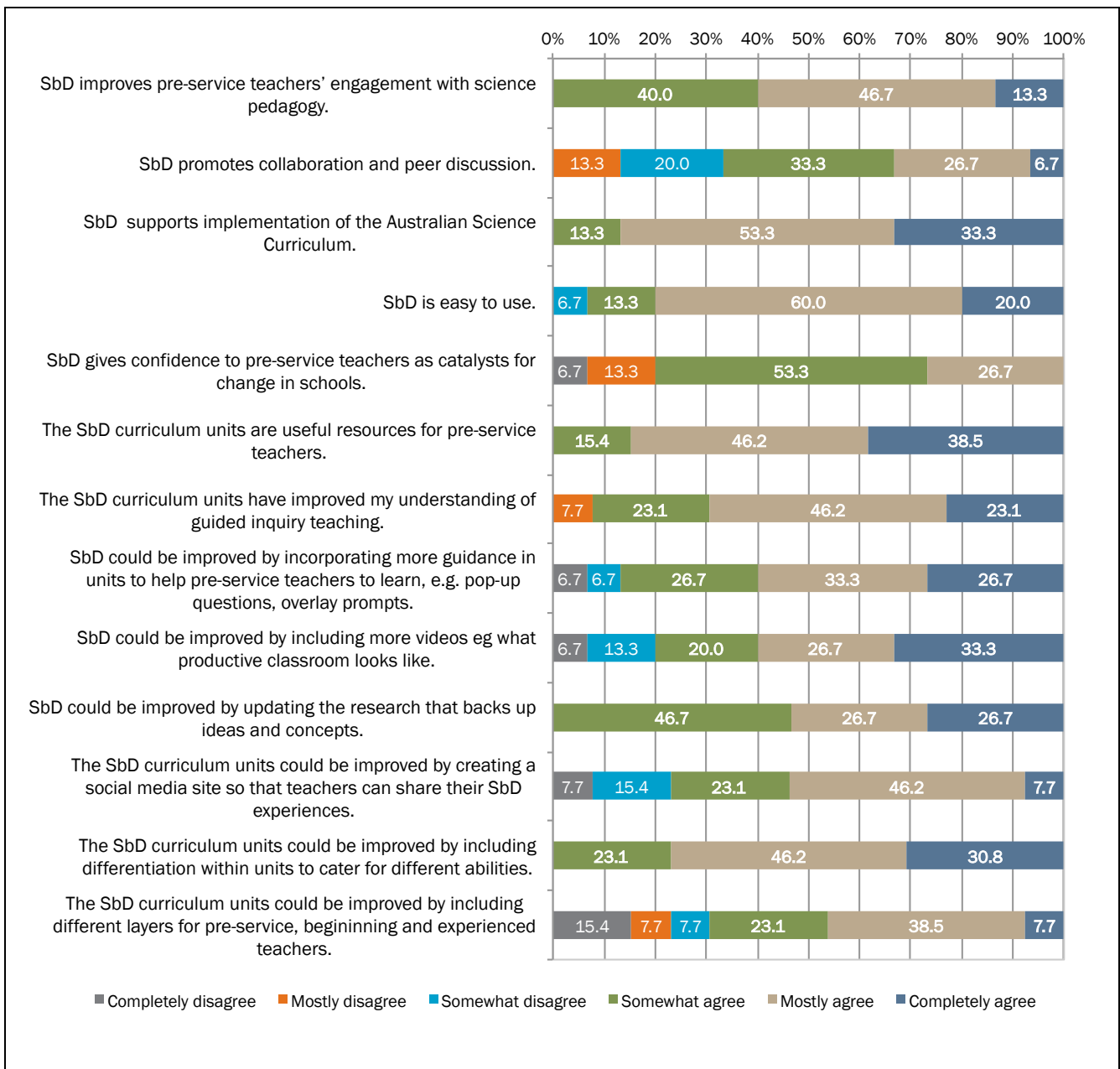


FIGURE 22. SCIENCE TEACHER EDUCATION STUDENTS' VIEWS AND SUGGESTIONS FOR IMPROVEMENT

These pre-service teachers were very likely to use the SbD resources, especially the curriculum units, in their future teaching practice (see Figure 23).

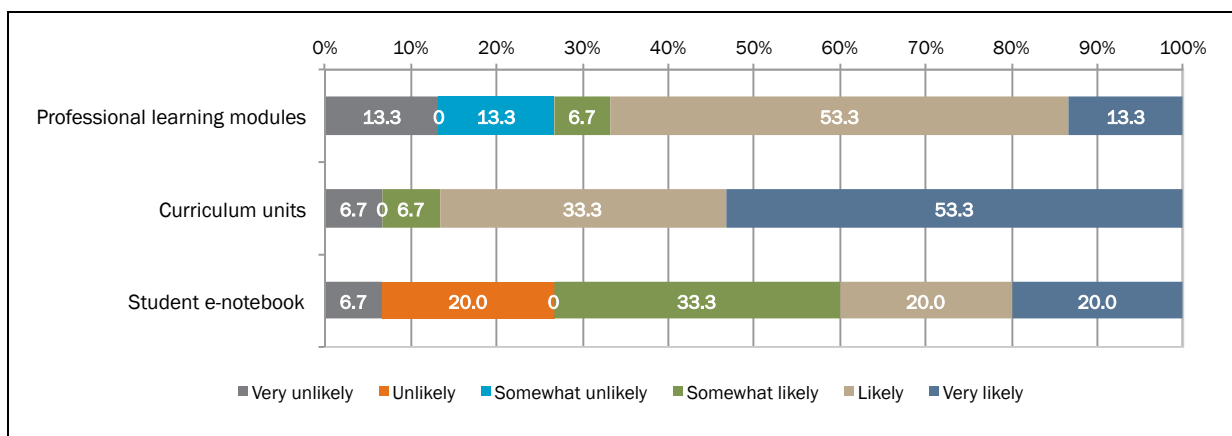


FIGURE 23. LIKELIHOOD OF PRE-SERVICE TEACHERS TO USE SCIENCE BY DOING RESOURCES IN THE FUTURE

Conclusion

According to the evidence gathered from high school teachers and students during this evaluation process, the revised curriculum units containing the student e-Notebook has had a very positive impact on their teaching and learning experience. The students taking part in focus groups conducted in the six case study schools were positive about using SbD and said they found it interesting and fun to use. They said that they enjoyed learning science using these resources.

There was a great deal of variability in the technology provision, as evident in the case study schools and in the responses of teachers nationally to the teacher surveys. This dictated the ways that teachers used SbD but it is a tribute to the quality and flexibility of the program that the teachers found ways of making it work for them in their schools. Teachers are making use of the updated SbD resources in many different ways and this is evident in their comments and suggestions for improvement of the program. In some schools, students have their own devices and can log in to the SbD resources in all their science lessons, some students rarely access the website themselves but view it on a screen at the front of the room. Some teachers prefer their students to have individual logins, while others prefer the class to use a common login. Some teachers import SbD materials into an LMS and some teachers print resources for students.

In general, schools value the revised SbD units as an excellent resource that assists them to implement the Australian Curriculum: Science and to use a guided inquiry approach in their science classes. The teachers who had used the units before their revision commented on the improved structure. At the time this evaluation was conducted, many teachers were either not aware of the student e-Notebook or had not made much use of it. Teachers' views of the value of the e-Notebook varied. Not many teachers had their students download and complete the e-Notebook as a whole. Many teachers printed parts of the e-Notebook for students to complete and others did not like the idea of a digital notebook but preferred their students to use an exercise book to record their science work.

Similar to the secondary school teachers' response, the response of University teacher educators (based on focus group data) and their students (based on online survey) to the Science by Doing workshop and the Science by Doing resources has been very positive and constructive. The teacher educators who took part in the focus groups stated that they found the Professional Learning modules to be particularly helpful resources and excellent discussion starters about pedagogy. Both

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the teacher educators and the teacher education students expressed the view that they would appreciate more exemplar online video examples of Science by Doing in the classroom. The teacher education students found the ready-made science lessons from SbD particularly useful.

Appropriateness

This section of the report addresses the following research question:

RQ 4.2: *How consistent is the Science by Doing program, particularly elements 4 and 5, with Australian Government priorities in respect of science education in schools?*

Although this research question refers particularly to elements 4 (Student e-Notebooks) and 5 (Pre-service teacher education) of the SbD program, it was considered appropriate to consider broader aspects of SbD in determining consistency with government priorities.

In answering the research question, the research team has examined three relevant and current 'policy' documents, and interviewed SbD developers and designers to determine their intention with respect to creating alignment of SbD student outcomes with education policy.

Policy documents relevant to this evaluation were identified in consultation with AAS and the Department of Education. Policy documents considered in this evaluation were:

Quality Schools Quality Outcomes (Australian Government, 2016. Available at: https://docs.education.gov.au/system/files/doc/other/quality_schools_acc.pdf)

Quality Schools Quality Outcomes. Areas of Future focus. *Boosting Literacy, Numeracy and STEM*. This document expanded on Quality Schools Quality Outcomes to focus on Literacy, Numeracy and STEM. (Australian Government, 2016. Available at: <https://www.education.gov.au/quality-schools-quality-outcomes-areas-future-focus>)

National STEM School Education Strategy 2016-2026. A Comprehensive Plan For Science, Technology, Engineering And Mathematics Education In Australia. (Education Council, 2015. Available at: <http://www.educationcouncil.edu.au/site/DefaultSite/filesystem/documents/National%20STEM%20School%20Education%20Strategy.pdf>)

With regard to STEM education strategy both *Quality Schools Quality Outcomes* and *Quality Schools Quality Outcomes: Areas of Future focus* refer to the implementation of *National STEM School Education Strategy 2016-2026*. The *National STEM School Education Strategy 2016-2026* was endorsed by all Australian education ministers on 11 December 2015. The purpose of the strategy is to build on the range of reforms and activities already underway in STEM education. It aims to coordinate better and to target this effort and to sharpen the focus on the key areas where collaborative action will deliver improvements to STEM education. Thus these are not distinct but related 'policies' and strategies.

The research team analysed these policy documents to determine the extent to which SbD supports the broad goals and strategic actions proposed. This analysis is limited to elements of policy documents addressed by SbD with an emphasis on Stage 4 in particular. There has been no attempt made to report on all goals and actions proposed in the policy documents because it is unrealistic to expect one program, in this case SbD Stage 4, to address every aspect of the national strategy. The analysis in relation to each document is reported below.

Quality Schools Quality Outcomes May 2016

Quality Schools Quality Outcomes May 2016 states:

A greater emphasis is also needed on science, technology, engineering and mathematics (STEM) skills to ensure that Australian students are equipped with the knowledge they need to thrive in a globalised, interconnected world.

Jobs of the future will require a high level of technological literacy from all workers. Increasing the uptake of STEM subjects by students at school and improving achievement in this important area will ensure that all young people are prepared for jobs of the future.

(Australian Government, 2016.

https://docs.education.gov.au/system/files/doc/other/quality_schools_acc.pdf)

SbD is consistent with this emphasis. As a program focused on secondary science education, SbD aims to improve student achievement in science and to contribute to increasing the uptake of STEM subjects.

Quality Schools Quality Outcomes: Areas of Future focus

Quality Schools Quality Outcomes: Areas of Future focus states:

In the context of rapidly changing technology, and with three quarters of the fastest growing occupations in Australia requiring STEM skills, the Strategy supports a long-term change agenda aimed at ensuring that students have a stronger foundation in STEM.

(Australian Government, 2016. <https://www.education.gov.au/quality-schools-quality-outcomes-areas-future-focus>)

SbD Stage 4 addresses the need to improve STEM, particularly science, teaching and learning, with the provision of online resources for secondary science students and teachers.

In the context of improving the quality of teaching, Quality Schools Quality Outcomes: Areas of Future focus further states:

Research tells us that quality teaching and school leadership are the most influential in-school factors on student outcomes.

(Australian Government, 2016. <https://www.education.gov.au/quality-schools-quality-outcomes-areas-future-focus>)

SbD Stage 4 focuses on secondary science teaching, through the provision of workshops and extensive online professional learning material. Element 4 of SbD particularly targets pre-service science teachers by providing workshops for science teacher educators to assist them to “develop a thorough knowledge of the content they will go on to teach, and a solid understanding of teaching practices that are proven to make a difference to student learning” (Teacher Education Ministerial Advisory Group, 2014, p.x).

National STEM School Education Strategy (NSSSES) 2016-2026

The National STEM School Education Strategy recognises that

... a renewed national focus on STEM in school education is critical to ensuring that all young Australians are equipped with the necessary stem skills and knowledge that they will need to succeed. (p. 3)

The stated purpose of SbD is to improve science learning by better engaging high school students through a guided inquiry approach, and by supporting teachers with relevant resources using innovative technology.

National STEM School Education Strategy states:

Australian data shows that inequities currently exist in STEM. Girls, students from low socio-economic status backgrounds, Aboriginal and Torres Strait Islander students, and students from non-metropolitan areas can be less likely to engage with STEM education and therefore have a higher risk of not developing high capabilities in STEM-related skills. These groups are more likely to miss out on the opportunities STEM-related occupations can offer. (NSSES, p. 4)

SbD Stage 4 caters for students from non-metropolitan areas by providing rich online resources for students and teachers. SbD Stage 4 also provides professional learning workshops for teachers in rural and remote areas.

Key Areas for National Action

The National Strategy identified five key areas for national action through which school education has the greatest leverage. Elements from these actions of particular relevance to SbD Stage 4 are considered below.

Area 1: Increasing student STEM ability, engagement, participation and aspiration

Recognising the primary and middle years as critical periods when students begin to cement their aspirations for, and confidence in, STEM. (NSSES, p. 8)

SbD Stage 4, as noted above, targets secondary science teaching and learning. It therefore addresses the middle years, a 'critical' period of learning experiences.

Encouraging the uptake of online learning materials, linked to classroom practice ... (NSSES, p. 8)

SbD Stage 4 provides a new online curriculum unit format, which includes interactive activities and video and audio clips as well as a student e-Notebook (SbD element 4). The student e-Notebook provides a platform within each unit by which students can electronically provide answers to the questions posed within the unit, or prepare reports on the investigation that they undertake. The answers, notes and reports can be stored and accessed electronically.

Revised Teacher Guides allow teachers to capture an overview of the unit, then easily drill down when the need arises into the complexities of each lesson. Using this drill down approach based on need, teachers are able to find relevant information more efficiently. This allows for more efficient navigation of a significant amount of information that can be somewhat overwhelming for time-poor teachers.

Area 2: Increasing teacher capacity and STEM teaching quality

Collect and develop online exemplar teaching modules, in partnership with university and industry, to assist in the delivery of best practice STEM teaching ... (NSSES, p.8)

SbD Stage 4 has created online exemplar teaching modules with each of the online curriculum units including detailed lesson plans in the Teacher Guides. The SbD team is conducting workshops with university educators in order to increase their awareness of the online curriculum units and to

explain and demonstrate how the SbD professional learning modules can be used in pre-service teacher education courses.

Lift the quality of initial teacher education to support teacher confidence and STEM content expertise ... (p.9)

The purpose of element 5 of SbD Stage 4 is to inform and support university science teacher educators through workshops on the SbD curriculum and professional learning resources. The SbD professional learning modules, in particular, are available to support pre-service teachers in developing their science pedagogical skills and repertoire.

Area 3: Supporting STEM education opportunities within school systems

... effort under the national strategy will build on, and link to, the Australian curriculum and national assessments to support the attainment of core STEM subject knowledge and the underlying skills of problem solving and analytical thinking. (NSSES, p. 9)

SbD documentation provides clear links to knowledge and skills outlined in the Australian Curriculum: Science. As such, it is reasonable to interpret SbD as an effort to support the attainment of core STEM subject knowledge.

Develop online formative assessment tools that help teachers collect and use data about individual student learning needs ... (NSSES, p.9)

As noted above, element 4 of SbD refers to the provision of a student e-Notebook, as a formative assessment tool for teachers to collect and use to support individual student learning needs.

SbD developers' and designers' views

The developers and designers of SbD were asked to respond to questions relevant to the research question with reference to the Policy documents identified above. They affirmed that SbD Stage 4 is aligned to Australian Government education policy priorities for STEM/science education. The aim the analysis reported below is to elaborate the views of SbD developers and designers regarding how the *Science by Doing* program, particularly elements 4 and 5, is or is not consistent with Australian Government priorities in respect of science education in schools. Relevant comments from their responses to interview questions are summarised under excerpts from the relevant policy documents.

National STEM School Education Strategy, 2016 – 2026

Areas for national action

1. Increasing student STEM ability, engagement, participation and aspiration (NSSES, p.8)

Interviewees stressed that the design SbD is based on effective science education.

SbD resources are built on what the research says about effective science learning and the stated priority is to introduce a guided inquiry approach because that is what we believe the research says about the best way for students to learn, with opportunities for open inquiry but also with opportunities, where necessary, for a much more directed model of teaching. The important thing, though, is that all the resources are guided. They have the opportunity for being open but essentially they are guided and a tremendous amount of assistance is given to teachers to help them in terms of how they choose to implement the resources in their classroom.

Recognising the primary and middle years as critical periods when students begin to cement their aspirations for, and confidence in, STEM. (NSSES, p.8)

Interviewees explained that SbD targeted the middle years but noted that the ways in which the middle years of science education are organised varies across education systems in Australia. The middle years may be taken as years 7 to 10, or junior secondary, which are covered by SbD resources. Year 7 is treated differently by different states but SbD resources are geared to assist specialist science teachers to teach science.

Encouraging the uptake of online learning materials, linked to classroom practice ...
 (NSSES, p.8).

Interviewees emphasised that SbD is an online resource that has been developed to enhance classroom teaching practices. They noted the need to keep pace with technological developments and the opportunities this provides to improve SbD resources in future.

We worked with good classroom activities to support the classroom teacher to encourage the uptake of online materials, taking the best of classroom practice and augmenting this with online resources. We sought new and stimulating ways of learning and made them accessible to teachers, essentially curating a lot of resources so that teachers become aware of them. But the main aim was to augment classroom activities to consolidate the learning.

The space of online learning and technology is changing and changing reasonably quickly. SbD developers and designers have tried to keep ahead of where most people are at and they've been able to do that because of the experience and the background research that they've done but it is easy to get out of date and you have to keep on modifying the technology and making the best of it. Although they finished a complete set of units in 2016, they are now in the process of updating them and they will have that completed by the end of next year. By then the technology will have moved on and if this program is going to have the maximum impact, there is a need to continually keep up with that technology and adjust accordingly.

2. Increasing teacher capacity and STEM teaching quality (NSSES, p.8)

Interviewees explained that SbD has been designed as a professional learning resource to make it easier for teachers to teach science effectively.

While the SbD program is very much perceived as curriculum, the reality is it was always, and started as, a professional learning resource and so within the program there are a number of modules that try to help teachers to improve their pedagogy and their teaching capacity. The point is that the program is very much geared to providing resources using digital technology to better help teachers understand and action some of the pedagogy associated with STEM teaching. Currently a professional learning resource is being written on Science as a Human Endeavour, an area of the Australian curriculum, which is understood with varying degrees of insight.

From their research, interacting with teachers, the SbD team has found that, while the professional learning resources were very useful for many schools, many teachers also said, "Look, besides doing that in the abstract, what we really want is a curriculum resource that embeds those pedagogies". And so the resources themselves have a natural embedded pedagogy so you see it in action. That's the real ability of the program, to enhance STEM teacher capacity through those embedded pedagogies and many teachers have said how useful that is.

Teachers also value the ability to adapt the SbD resources and modify them to their needs. The program's been established for this flexibility and its adaptability, for teachers to use it in a way

that's more useful for their students, for example, for their lesser able students. It's the power of the digital technology that you can do things like that.

There's a perception in some quarters of science education that SbD is just a very teacher-proof type thing that to give to teachers and tell them they have to do it, like a technician. And the philosophy behind the program is so different from that. The philosophy behind the program is: here's a resource to make your job easier but you're the person who has to use it to the best of its ability, bringing your understanding as a teacher of what's required for your students. That's the real strength of the program and because of the technology it's been possible to enhance that in a way that one could never do with a textbook type of approach.

Collect and develop online exemplar teaching modules, in partnership with university and industry, to assist in the delivery of best practice STEM teaching, including a focus on, for example:

- Delivering project-based learning for STEM (NSSES, p.8)

Interviewees noted that SbD includes resources supporting individual open-ended investigations and that units are based in appropriate contexts but there was some ambiguity in the response to project based learning.

If project work means open investigation, there is a unit that's been developed on open investigation that has a scaffold for open investigations. However, each unit has the opportunity to provide the basis for an open investigation if the teacher wishes to go down that pathway. If it means contextual learning, then the program is built around context. There is a strong contextual basis to each of the units that have been developed and that's reflected in the Science as a Human Endeavour sub-strand that is so heavily interwoven through all the lessons that are available.

Lift the quality of initial teacher education to support teacher confidence and STEM content expertise (NSSES, p.9)

Interviewees noted that SbD Teacher Guide provided a support for 'out of field' teachers of science. Currently many science teachers teaching out of their field of expertise and many young teachers are not given adequate support. The SbD Teachers Guide provides support for teachers on how to do activities and there are full lessons for them to follow. Many highly experienced teachers never look at this but the SbD team receives feedback from new teachers who are very much appreciative of the work put into the Teachers Guide.

3. Supporting STEM education opportunities within school systems

While there are a wide range of curriculum resources available, effort under the national strategy will build on, and link to, the Australian curriculum and national assessments to support the attainment of core STEM subject knowledge and the underlying skills of problem solving and analytical thinking (p.9).

Interviewees emphasised that the Australian Curriculum: Science was the framework for resources developed for SbD

In relation to alignment with the Australian Curriculum: Science, the national curriculum was used to frame the whole SbD program. Writers were presented with descriptors they had had to cover and the links to the national curriculum. They were always conscious that there were three strands in the curriculum.

Develop online formative assessment tools that help teachers collect and use data about individual student learning needs, which builds on the continuum and utilises the nationally agreed and supported online assessment platform (NSSES, p.9).

Interviewees noted that diagnostic, formative and summative assessment tools are integrated throughout the SbD program.

There are diagnostic, formative and summative assessment elements built in to the SbD program. This provides evidence to individual teachers that their students are learning. The student e-Notebook can be used by students as a continual record of their work and it can be continually annotated by the teacher. Currently each SbD unit has quizzes that offer students feedback on each answer but there is great scope to develop this. Through adaptive learning, it would be possible to give a tremendous amount of feedback to students and to teachers on every student in the class and the SbD developers would like to take the next step by partnering with people skilled in adaptive learning packages.

5. Building a strong evidence base

Establishing a culture of evaluating programs and initiatives to help build an evidence base for what works to improve STEM outcomes in Australian contexts and for particular sub-groups (in particular girls, low SES and Aboriginal students) (p.10).

Interviewees noted that analysis of data available in SbD could contribute to the evidence base for improving STEM education outcomes in Australia.

The SbD developers and designers have held reference group meetings and convened meetings with people active in using SbD and they've sought feedback on new initiatives. The current developments are very much guided by feedback from meetings with teachers and school visits where SbD materials were being used in the classroom. This constitutes a culture of feedback but they haven't had the resources or time to do all they'd want to do.

At this point in time in the country there is no national measurement basis for science learning. The best we have is PISA for fifteen year olds and that doesn't actually measure the learning according to the national curriculum. What it does is give a snapshot of perceived scientific literacy in terms of a global broader perspective. But even through that it may be possible to better understand how successful the SbD program is by working with ACER in the future and trying to build in some components and aspects to differentiate between schools that are using SbD and those that are not.

Through the SbD online database there is available a huge amount of data that can be interrogated much more carefully. This hasn't been done because there are no financial resources to do it. But it provides a lens into the classroom in a way that has not been possible before. Our current opinion of what happens in the classroom is via isolated observations by individuals in each state and territory as they go into schools. But SbD now has a mechanism established that would provide some fascinating insights into what's actually happening in classrooms around the country that are using this particular program, SbD. The number of schools that are using SbD is growing exponentially so that insight is also growing exponentially. And in terms of evidence, it's beginning to provide some evidence of classroom actions and activities, much more powerful than ever before. This has never been never utilised or explored and many people are unaware of the potential of those types of insights.

Conclusion

Evidence from the analysis of policy documents indicates that SbD Stage 4 aligns with the current Australian Government education policy priorities in relation to science education in schools. Evidence from the interviews illustrates that SbD designers and developers have designed resources to contribute to the achievement of Australian Government education policy priorities in school science education.

There is some ambiguity regarding the ways in which SbD contributes to project based learning. It may be advantageous to clarify this in future developments of the program. An opportunity exists to expand the contribution of SbD to the evidence base for improving STEM education outcomes in Australia. This would entail a more extensive application of data analytics. Possible developments in the use of data analytics in SbD is discussed elsewhere in the report (see Recommendations section)

SbD makes a contribution to the National STEM School Education Strategy (NSSES) 2016-2026. It contributes the key areas for action including: Area 1: Increasing student STEM ability, engagement, participation and aspiration; Area 2: Increasing teacher capacity and STEM teaching quality; and Area 3: Supporting STEM education opportunities within school systems.

Efficiency

This section of the report addresses the following research question:

RQ 4.3: *Is the program implementation of Stage 4 achieving its targets and goals within the identified budget and time frame?*

The evaluation of Stage 4 of the SbD program focuses on Elements 4 and 5 as articulated in the SbD Stages Three and Four Revised Project Plan.

In summary, there are four stages in the development of *Science by Doing*:

- Stage One 2009 – 2011
Develop professional learning approach, professional learning modules and initial curriculum resources
- Stage Two 2012 – 2013
Transpose existing curriculum resources to online delivery and develop an additional seven curriculum units for online delivery
- Stage Three 2013 – 2016
Complete final eight curriculum units plus new professional learning modules for online delivery
Use the Professional Learning Approach to implement *Science by Doing* within Australia
- Stage Four 2016 – 2018
Revise curriculum units embedding each with a student e-Notebook component.
Implement Teacher Education with universities.
Evaluate *Science by Doing*

This research was undertaken to identify perceptions of Stage 4 of the program, in particular Elements 4 and 5: Revise curriculum units embedding each with a student e-Notebook component; and Implement Teacher Education with universities. The following tables set out in more detail the targets and achievements for Element 4 (Table 8) and Element 5 (Table 9).

TABLE 8. PLAN FOR ELEMENT 4: REVISED CURRICULUM UNITS WITH STUDENT E-NOTEBOOKS

Target	Achieved
<p>The curriculum units are to be revised based on user feedback and in order to embed a student e-Notebook dimension to each unit. The e-Notebook is to provide a platform within each unit by which students can electronically provide answers to the questions posed within the unit, or prepare reports on the investigation that they undertake. The answers, notes and reports can be stored and accessed electronically.</p> <p>The revision process will also develop a more effective navigation process to assist users to move between the components of each unit in the Student Guide, Student Digital and Teacher Guide. Using a</p>	<p>All Year 7, 8 and 9 updated units were published according to schedule.</p>

drill down approach for the Teachers Guide, based on need, teachers will be able to find relevant information more efficiently.

The timetable for releasing the revised curriculum units with the student e-Notebook:

December 2016:	All Year 7 units
July 2017:	All Year 8 units
December 2017:	All Year 9 units
May 2018:	All Year 10 units

TABLE 9. PLAN FOR ELEMENT 5: PRE-SERVICE TEACHER EDUCATION

Target	Achieved
<p>The purpose of this element is to inform and support university teacher educators with the <i>Science by Doing</i> curriculum and professional learning resources.</p> <p>Workshops are to be conducted by the <i>Science by Doing</i> team with university educators in order to:</p> <ul style="list-style-type: none"> • Increase their awareness of the <i>Science by Doing</i> program, especially the online curriculum units. • Explain and demonstrate how the professional learning modules can be used in pre-service teacher education courses. <p>The first workshop was conducted for university educators in July 2016. A possible second workshop may be conducted before August 2017.</p>	<p>The second teacher education workshop was conducted on 27 June 2017 at the University of Technology, Sydney. The workshop was held preceding the 2017 ASERA conference. The Academy supported the attendance of one teacher educator from each Australian university to the workshop. There were 25 Australian university staff and 11 international academics who participated in the workshop.</p> <p>For the two months preceding the teacher education workshop there were 456 science teacher education student registrations. For the two months after the workshop there were 557 science teacher education student registrations. The figures indicate an 18% increase in registration after the workshop. The total number of registrations of science teacher education students at 15 September 2017 was 3,427.</p>

Science by Doing website data analytics

Penetration of SbD has continued to increase. Two data measurements give a good snapshot of the impact of SbD. The first measure is the accumulated number of registrations. The graph below (Figure 24) shows how the registrations have grown since the website was first established in July 2013. The total number of people registered by 18 September 2017 was 148,779 with 64% of all Australian high school teachers registered. There are registrations from 80% of all high schools.

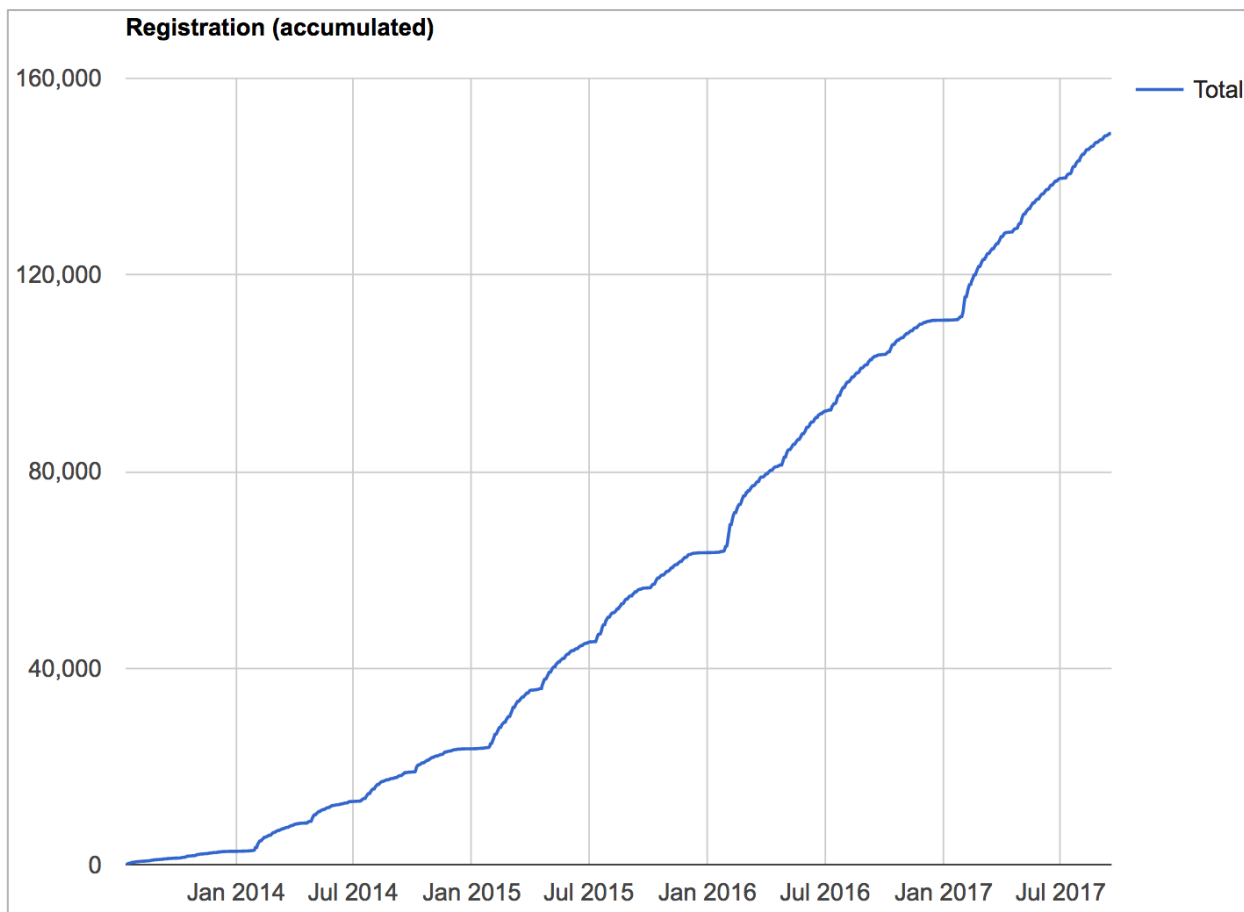


FIGURE 24. SCIENCE BY DOING REGISTRATIONS

The other data is a measure of usage. The measure that was initially selected was the number of hits in a mid-term month. A hit in this case indicates an interaction that occurs on the website. Up to this point in time it seemed a good measure. At the beginning of 2017, however, the Year 7 units were updated and revised. The units have a much more efficient navigation process built into them. The effect is that it is easier for students to use the curriculum units requiring less navigation action. The downloaded student guide also controls the student experience more than the older version. The result is that the number of hits has decreased as a consequence of the new updated units. This effect has been continued with the updated Year 8 units published on 7 July 2017.

This is reflected in Table 10 that shows three measures of website usage, number of visits, hits and bandwidth. The bandwidth means the amount of data and information transferred from the website to the user while the number of visits by users is self-explanatory.

During the history of the website there is generally overall growth in these three measures. It is interesting to observe a significant change in 2017 with the introduction of the new updated units. The amount of information download has tripled during 2017. This initial data suggests a much more sophisticated use of the website as a result of the new updated units, with many students now using the downloaded student guide connected to its related student digital component, rather than a more exclusive reliance on just the student digital material.

TABLE 10. NUMBER OF HITS ON THE SCIENCE BY DOING WEBSITE

Month	Number of Visits	Hits	Data transferred GB
August 2013	2,384	131,456	131
November 2013	4,802	274,765	163
March 2014	10,811	950,062	824
May 2014	14,017	1,102,453	729
August 2014	11,461	1,133,146	864
October 2014	12,631	1,471,135	1159
March 2015	18,698	2,154,536	1514
May 2015	19,754	2,520,811	2263
August 2015	22,195	2,676,200	2107
October 2015	19,290	2,418,523	1725
February 2016	31,260	3,763,949	2162
May 2016	30,665	3,810,511	2421
August 2016	31,562	3,810,110	3017
October 2016	26,243	3,222,439	2236
February 2017	30,908	3,172,538	9907
May 2017	32,502	3,220,133	8662
August 2017	30209	2,695,798	5707

Budget

For Stage 4 a total budget of \$1.5m was provided as a variation of contract and these funds were distributed among the existing line items, e.g. staffing, consultants, visual production etc. An overview of the breakdown of these funds as they apply to Elements 4 and 5 is shown in Table 11.

TABLE 11. OVERVIEW OF BUDGET FOR ELEMENTS 4 AND 5

Element 4:	Revision with Student e-Notebook Develop and trial prototype. Revise all curriculum based on the prototype	\$1,140,000
Element 5:	Teacher Education Undertake Professional Learning program for university educators.	\$300,000

Financial reporting for SbD has always been in terms of the line items and not the contract elements but with 4.5 months remaining of the contract, the prediction is that Elements 4 and 5 will be achieved within budget.

Conclusion

At the time of reporting, SbD had achieved all of its targets and all indications were that this would be done within the budget allocated for Elements 4 and 5, which are the subject of this evaluation. Therefore the program implementation of Stage 4 is achieving its targets and goals within the identified budget and time frame.

Governance

The University of Technology Sydney was commissioned to conduct an evaluation of *Science by Doing* – Stage 4. A component of the evaluation focused on the effectiveness of the governance arrangements for SbD. The University of Technology Sydney: Institute for Public Policy and Governance (UTS: IPPG) conducted this component of the evaluation.

The governance evaluation sought to answer the following question in relation to *Science by Doing* – Stage 4:

RQ 4.4: *How effective are the governance arrangements for Stage 4 of Science by Doing?*

Science by Doing Development and Funding Arrangements

The AAS first developed the pilot for SbD in 2007-2008. The pilot and subsequent stages have been funded by the Australian Government. Stage two was funded by the Australian Government through Education Services Australia (ESA). All other funding has been through the Australian Government Department of Education and Training (DET) or its predecessors. There was a period between Stage one and two when two staff were partly paid through the sales of SbD materials. The now Executive Director of SbD, Emeritus Professor Denis Goodrum, was not paid for work on SbD during this period. During Stage two, when the SbD website went live, all materials were made available free.

The Concept of Effective Governance

The concept of effective governance is variably defined across a range of contexts. There are many definitions related to corporate governance and to governance of projects and grants programs.⁴ Ultimately however, there is no universally agreed definition of governance.

When the concept of effective governance is considered, the focus of governance frameworks and guidelines are commonly directed at the structures and processes associated with decision making. Most frameworks and guidelines for effective governance identify a set of principles that commonly include the notions of:

- Transparency.
- Accountability.
- Effective stakeholder engagement.
- Risk identification and management.
- Delivery of agreed outputs and outcomes.

Governance frameworks and guidelines also tend to emphasise that governance systems, structures and processes need to:

⁴ See for example: Australian National Audit Office (2014) *Better Practice Guide: Public Sector Governance: Strengthening Performance Through Good Governance.*; Australian Institute of Company Directors (2013) *Good Governance Principles and Guidance for Not-for-Profit Organisations.*; Australian Public Service Commission (2007) *Building Better Governance.*; Australian National Audit Office (2013) *Better Practice Guide: Implementing Better Practice Grants Administration.*

- Have a clear structure, with defined roles and responsibilities.
- Be fit for purpose, as no single approach works for all situations.
- Be proportionate to the scale, nature, complexity, risks and duration of the program or project.
- Evolve over time, particularly as changes occur in the life of a program or project.

Methodology

The methodology for the governance evaluation of SbD – Stage 4 involved:

- Review of the steering committee terms of reference and meeting minutes.
- Interviews with steering committee members.

Interviews were held with five members of the Steering Committee. Further information is not provided in compliance with requirements for the ethical conduct of this research.

A discussion guide was prepared (Appendix 6) and used in the interviews. In summary, all of those interviewed were asked:

- About their role in the governance of SbD.
- To describe the governance arrangements for SbD.
- The activities of the governance groups.
- Decision making processes related to SbD – Stage 4.
- Access and use of data and information in decision making and monitoring processes.
- How advice and decisions of governance groups are used and the extent of any impacts.
- Their opinion on the effectiveness of the governance arrangements.

A draft Governance report was provided to the Executive Director of SbD for fact checking and to resolve some matters that remained unclear after interview and document analysis.

Current Governance Arrangements

Science by Doing Reference Group

The AAS established a Reference Group for SbD in 2013 to facilitate input from key stakeholders to inform and guide SbD. The Reference Group includes representation from the AAS, education sector peak bodies, the relevant Australian Government department and agencies and state and territory education departments.

The Reference Group met once during the early phase of Stage 3. There is no regular meeting of the Reference Group due to the prohibitive costs associated with bringing the group together. The Reference Group is now engaged informally by the Director, Science by Doing via email and telephone as required. Reference Group members were provided and updated on the program and information about the development of Stage 4 with feedback requested on some draft materials.

Reference Group members were not involved in the governance evaluation as consulting them is outside the scope of the contract.

Science by Doing Management Structure

The AAS has a Director, SbD who provides regular verbal and written updates to the Chief Executive Officer, AAS and the Academy Council. An annual report is provided to the Academy Council about financial and operational matters.

Day-to-day decisions about program delivery and content are primarily the responsibility of the Director, SbD in consultation with the Chief Executive Officer, AAS.

Science by Doing Steering Committee

The AAS has a *Science by Doing* Steering Committee that meets twice a year, generally after a report on progress is delivered.

The Steering Committee oversees the implementation of the contract for *Science by Doing – Stage 4*. The Steering Committee is the forum for any decisions required between DET, AAS and Education Services Australia. The current membership of the Steering Committee consists of the following:

Chair – Secretary of Education and Public Awareness, AAS

Director, *Science by Doing*, AAS

Assistant Director, Learning Areas Support Section, Curriculum and Students with Disability Branch, Schooling Group, Australian Government DET

Two representatives of the Australian Government DET

Director, Learning Partnerships, Education Services Australia

Establishing a *Science by Doing* Steering Committee was a condition of the Stage 3/4 contracts. Clause C.50 of the funding agreement contract states:

You must convene a Steering Committee consisting of representatives of the Department, the Australian Academy of Science and ESA, to oversee and monitor the Project. The Steering Committee is responsible for reviewing Project planning, Project reports, the curriculum units, professional learning modules and professional learning workshops developed under this agreement prior to each reporting milestone. The Steering Committee must meet twice yearly and at other times as agreed by members. You must hold the first meeting within two months of the agreement being signed.

Evaluation Findings

Governance Systems, Structures and Processes

AAS Internal Management of Science by Doing

AAS actions taken to ensure effective governance

The AAS has arrangements in place to ensure that SbD is appropriately monitored, managed and governed. This includes having the AAS Secretary of Education and Public Awareness on the Stage 4 Steering Committee and having an Executive Director responsible for the SbD program. The same Director has managed the program since 2009.

Transparency and accountability for deliverables and funding

The Director and AAS Secretary of Education and Public Awareness ensure internal accountability to the Chief Executive Officer and Academy Council. The Executive Director provides reports to the AAS Council annually and the Chief Executive Officer weekly.

The Academy provides detailed reports on progress to DET twice a year.

Risk identification and management

Project risks and risk mitigation strategies are outlined in the SbD Stage 4 Project Plan.

Challenges that have arisen in implementation are identified in reports on progress.

Effective stakeholder engagement

Engaging with the Reference Group was identified as an opportunity, particularly for the States and Territories to provide input to ensure the program meets their needs and expectations. Getting the group together was considered advantageous as the AAS received a significant level of direct input from members. It was reported that the AAS received limited feedback from some Reference Group members. More useful interactions with some members may have promoted more extensive uptake of SbD in a small minority educational sectors.

Delivery of outputs and outcomes

It was reported that the AAS Council provides vision and scientific expertise for the program which ensures content and delivery are of the quality and standard required.

The Director develops submissions for funding on future stages of the program.

The Academy Council receives an annual report on SbD activities.

Summary

The AAS has in place effective internal governance arrangements for SbD, which appears to have continued operating without concerns for a number of years.

Effectiveness of the Steering Committee

Role of the Steering Committee

All interviewees consistently identified the role of the Steering Committee as being focused on accountability for the *Stage 4 Project* contract. In particular, demonstrating accountability for deliverables in the contract and the expenditure of funding attached to the contract.

There were varying views among those interviewed on the extent to which the Steering Committee has or should have a role in advising on the quality of project outputs and implementation processes for the *Stage 4 Project*. There were also varying views on the extent to which the Steering Committee is and should be involved in decision making about program delivery and content of the *Stage 4 Project*.

Transparency and accountability for deliverables and funding

The Steering Committee receives the project plan, work plans and annual progress reports from the AAS on the deliverables and budget expenditure for the project.

The Steering Committee meetings have included presentation and discussion of progress reports and discussion of the *Stage 4* evaluation. In addition, the Steering Committee has discussed the future of SbD beyond the current funding contract.

All agreed action items are clearly recorded in the minutes of each meeting.

Risk identification and management

Project risks, particularly related to sustainability of SbD beyond the current funding contract, were discussed at a Steering Committee meeting. Other risks in the development of new resource materials have also been discussed at Committee meetings.

Effective stakeholder engagement

Education Services Australia (ESA) is represented on the Steering Committee. ESA is a national, not-for-profit company owned by all Australian education ministers. ESA has responsibility for quality assurance in the delivery of the Australian Curriculum and the public availability of meta-data and teaching services/resources through a range of online platforms at no cost. Descriptions of SbD resources are available on the platform *Scootle* with direct links to the SbD website so teachers can access the resources from the SbD website.

Interviewees generally agreed that having a representative from ESA on the Steering Committee as positive in ensuring there is alignment with the Australian Curriculum. It also appears beneficial in providing a forum for discussions related to the *Scootle* platform and the availability of information about the SbD resources on their website.

Delivery of outputs and outcomes

The Steering Committee has visibility of operations related to the *Stage 4* project as evidenced by the reports prepared for the Committee.

The Steering Committee is the forum for discussion of any issues or variations to the contract deliverables. There is no evidence in the minutes that any issues or variations have arisen in Stage 4 but the appropriate governance structure appears to be in place to address issues and variations related to the Stage 4 contractual obligations should they arise.

Summary

There was general agreement that the Steering Committee is an appropriate governance structure for the Stage 4 project at this time.

The Steering Committee is the only external formal governance structure currently meeting regularly and appears to be the only external formal governance structure currently providing significant input to the delivery of SbD.

The Reference Group members are accessed on an informal ad hoc basis. This provides a valuable source of advice for the development and implementation of SbD. There is not a systematic approach to engaging them. This potentially risks SbD not meeting the needs of the state and territory government and non-government education systems, which has the potential to limit uptake and relevance. It is noteworthy that a systemic involvement of the Reference Group would require funding to support this action.

A suggestion was raised by one stakeholder for the AAS to establish an overarching STEM program advisory group that covers SbD, *Primary Connections*, and other AAS programs. This would be made up of external representatives to ensure that the AAS STEM programs are evidence based and aligned to priorities for Australian Schools. It is difficult to see how this would contribute to enhancing governance per se. There may or may be efficiencies attained but further comment of this suggestion by one member of the committee is beyond the scope of this evaluation which is limited to SbD, Stage 4.

Records, Monitoring and Reporting

Formal reports on progress are prepared twice a year and provided to the Steering Committee. These Progress Reports detail activities and outputs against the elements of Stage 4 project.

Interviewees confirmed that progress reports are provided in advance of meetings of the Steering Committee.

Interviewees advised that they received information with enough time for review prior to meetings and that there was enough time for informed discussion.

Science by Doing has consistently used two measures to assess impact. The first measure is the number of people (including teachers and students) registered to use the SbD website. This measure provides information on the program's reach. The second measure is the number of 'hits' in a mid-term month. This measure gives insight into the use of the SbD resources. Data on both measures is provided at each Steering Committee meeting. Other data including feedback from workshops and sample unsolicited teacher emails has been provided at meetings.

Conclusion

The evaluation of governance indicates that the Australian Academy of Science, the Department of Education and Training and the Steering Committee have been able to support and oversee the implementation and delivery of Stage 4.

There have there been no major contract management issues relevant to Stage 4.

The Reference Group theoretically provides an opportunity for additional input by key education stakeholders to ensure that SbD is relevant and meeting the needs of secondary education systems across Australia. However, although face-to-face engagement of this group is cost prohibitive there appears to be merit in AAS continuing to engage members of the Reference Group on key issues related to program delivery and content. This is especially important given that the Steering Committee does not appear to govern the latter.

Some suggestions were made by committee members on how to improve oversight of AAS projects but consideration of these were beyond the scope of this study, which focussed on SbD Stage 4 only. The suggestion for an overarching STEM program advisory group relates to the quality of all AAS programs and not just SbD.

SUMMARY AND CONCLUSIONS

This section summarises the findings related to the four research areas for this evaluation: Effectiveness, Appropriateness, Efficiency and Governance and presents the conclusions of the evaluation process.

Effectiveness

School teachers and students

Impact of the *Science by Doing* modules and e-Notebook on teachers and students was gathered from two online surveys of teachers and case studies from six schools across the nation that included focus group interviews with teachers and students, class observations and observation of e-Notebook samples. The initial survey was conducted after the release of the updated Year 7 curriculum units with their e-Notebooks. The follow-up survey was conducted about six months later after the release of the updated curriculum units and their e-Notebooks for both Year 7 and Year 8. According to the evidence gathered from the high school teachers and students during this evaluation process, the revised curriculum units containing the student e-Notebook has had a very positive impact on their teaching and learning experience. The students taking part in focus groups conducted in the six case study schools were very positive about using *Science by Doing* and said they found it interesting and fun to use. They stated that they enjoyed learning science using these resources.

There was a great deal of variability in the technology provision evident in the case study schools and in the responses of teachers nationally to the teacher surveys. This dictated the ways that teachers used *Science by Doing* but it is a tribute to the program's flexibility and its adaptability, that teachers find ways to use it in a way that's more useful for their students and works for them in their schools. Teachers value the ability to adapt the *Science by Doing* resources and modify them to their needs. For example, more than half of the participating teachers in the evaluation cherry-picked *Science by Doing* resources while more than a quarter engage with the resources from beginning to end. Overall, teachers indicated *Science by Doing* as an excellent resource that assists them to implement the *Australian Curriculum: Science* and to use a guided inquiry approach in their science classes. This is evident from the good level of uptake (55%-67%) of all the revised Year 7 and 8 modules by the teachers in their classes.

Technically, the vast majority (70%-92%) of the teachers surveyed completely/mostly agreed with the effectiveness of the online features (navigation, appearance, functionality, flexibility, balance of hands-on activities and the unit at-a-glance feature) of the resources. The teachers were also interested in receiving feedback on students' performance when using *Science by Doing* resources and suggested that analytics that they could view be embedded into the online resources.

The uptake of the e-Notebook appears somewhat slower than the curriculum units but a significant increase from 35% to 57% of the teachers reported using the e-Notebook from the initial to follow-up survey. The e-Notebooks were used in different ways by the teachers but most notably was for students to download the e-Notebook and complete selected parts of the e-Notebook digitally or complete hard copies of the selected activities. Teachers are still attuned to handwritten work as they believed that students learned more hand writing than typing. The vast majority of the teachers believed that the e-Notebook improved their students' learning outcomes although some suggested more differentiation in the questions and activities to cater for the diversity of students in the classroom.

In case study schools where the teachers cherry-picked *Science by Doing* resources and embedded them into the school's learning management system, it was sometimes difficult for the students to distinguish between *Science by Doing* resources and other science resources that were already on the learning management system. However, the experience of the students involved in the case studies where they were able to login to *Science by Doing* websites expressed very positive responses. The outcome is the same with students who filled in the online survey even though they came from one school only. These students indicated agreement (completely/mostly/somewhat agree) of 68%-97% for the items asked: ease of use, improving understanding of how scientists work, *Science by Doing* being suitably challenging, *Science by Doing* improving their engagement and achievement in science and *Science by Doing* promoting peer collaboration and discussion.

Science teacher educators and teacher education students

The focus group data from university teacher educators and the online responses of university science teacher education students to the *Science by Doing* resources indicated that both groups had positive attitudes toward the resources. Teacher educators found the Science by Doing workshops to be particularly useful and effective. The focus on and use of the resources however were slightly different for the two groups. Teacher educators emphasised on and used the Professional Learning modules, which they found to be very helpful resources and excellent discussion starters about pedagogy. About half of the science teacher education students surveyed had accessed the PL modules and a smaller number had accessed the curriculum units, particularly the Year 8 units as part of their university class and for planning their lessons. Both the teacher educators and the teacher education students expressed the view that they would appreciate more online video examples of *Science by Doing* in the classroom.

Appropriateness

Evidence from the analysis of policy documents indicates that *Science by Doing* Stage 4 aligns with the current Australian Government education policy priorities in relation to science education in schools. Evidence from the interviews illustrates that *Science by Doing* designers and developers have designed resources to contribute to the achievement of Australian Government education policy priorities in school science education.

There is some ambiguity regarding the ways in which *Science by Doing* contributes to project based learning. It may be advantageous to clarify this in future developments of the program. An opportunity exists to expand the contribution of *Science by Doing* to the evidence base for improving STEM education outcomes in Australia. This would entail a more extensive application of data analytics. Possible developments in the use of data analytics in *Science by Doing* is discussed elsewhere in the report (see Recommendations section)

Science by Doing makes a contribution to the National STEM School Education Strategy (NSSSES) 2016-2026. It contributes the key areas for action including: Area 1: Increasing student STEM ability, engagement, participation and aspiration; Area 2: Increasing teacher capacity and STEM teaching quality; and Area 3: Supporting STEM education opportunities within school systems.

Efficiency

At the time of reporting, *Science by Doing* had achieved all of its targets and all indications were that this would be done within the budget allocated for Elements 4 and 5, which are the subject of this evaluation. Therefore the program implementation of Stage 4 is achieving its targets and goals within the identified budget and time frame.

Governance

The evaluation of governance indicates that the Australian Academy of Science, the Department of Education and Training and the Steering Committee have been able to support and oversee the implementation and delivery of Stage 4.

There have there been no major contract management issues relevant to Stage 4.

The Reference Group theoretically provides an opportunity for additional input by key education stakeholders to ensure that *Science by Doing* is relevant and meeting the needs of secondary education systems across Australia. However, although face-to-face engagement of this group is cost prohibitive there appears to be merit in AAS continuing to engage members of the Reference Group on key issues related to program delivery and content. This is especially important given that the Steering Committee does not appear to govern the latter.

Some suggestions were made by committee members on how to improve oversight of AAS projects but consideration of these was beyond the scope of this study, which focussed on *Science by Doing* Stage 4 only. The suggestion for an overarching STEM program advisory group relates to the quality of all AAS programs and not just *Science by Doing*.

RECOMMENDATIONS

The following recommendations are made on the basis of the evaluation of *Science by Doing* Stage 4 and should be interpreted in that context.

Recommendation 1

The space of online learning and technology changes quickly and if SbD to have the maximum impact, there is a need to continually keep up with that technology and adjust accordingly. The evaluation findings indicated that *Science by Doing* caters for a very wide range of school circumstances and that schools vary widely in their ability to utilise the digital resources. It is recommended that future *Science by Doing* development utilises technologies that are universally compatible with the wide range of devices found in schools to allow participation by the maximum number of students.

Recommendation 2

Many teachers are now seeing the benefits of being able to access learning analytics. It would be advantageous if *Science by Doing* were able to incorporate student feedback and learning analytics into the program that teachers could access to monitor their students' performance. This means that teachers need to be able to access feedback data from the students' digital activities online and e-Notebook.

Recommendation 3

Teachers, both in-service and pre-service teachers, have expressed their need to be able to differentiate the curriculum to cater for the different abilities of students in their classes. It is recommended that *Science by Doing* explore ways that this can be done through digital means, such as using adaptive technologies.

Recommendation 4

In many schools, the time that teachers have available for teaching science is limited. Many teachers have said that they find it difficult to condense the *Science by Doing* units for the time available. This is despite the provision of optional units. It is recommended that *Science by Doing* provide more guidance for teachers who have limited teaching time with their classes so that the integrity of the curriculum unit is preserved.

Recommendation 5

Teacher educators who attended the *Science by Doing* workshops expressed the view that they gained a lot in terms of how to use the PL units and the other *Science by Doing* resources, including the student e-Notebook. It is recommended that AAS continue to offer *Science by Doing* teacher educator workshops.

Recommendation 6

Given that many schools are using learning management systems and including both SbD resources and other science resources in their science programs, it would be advantageous to 'brand' the *Science by Doing* resources to make it clear where the resources originated.

UTS:

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Ethics Protocol

Approval for this research has been obtained in accordance with the UTS Ethical Conduct of Research Involving Human Participants Vice-Chancellor's Directive. The approval number is: UTS HREC ETH17-1465 and this number was quoted on all consents and information sheets provided to participants.

Research team

The UTS evaluation team comprises:

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Appendix 1. Initial Teacher Survey

My teaching experience is closest to:

- less than 1 year
- 1 to 5 years
- more than 5 years but less than 10 years
- 10+ years

My school could be described as:

- Remote
- Regional
- Metropolitan

Please rate your confidence in using guided inquiry teaching.

Very low Low Somewhat low Somewhat high High Very high

Please select the statement that best applies to you.

- I have not used *Science by Doing* (SbD).
- I have used SbD in the past.

Please select any SbD units you have used in the past.

- Introduction to SbD
- Doing Science Investigations
- Circle of Life
- Enough Water Fit for Drinking
- Science of Toys
- Earth and Space
- From Little Things Big Things Grow
- Rock, Paper, Scissors
- Energy
- Rock your World
- Ecosystems and Change
- Chemical Reactions
- Light, Sound, Action
- Big Systems
- Evolution and Heredity
- Chemical Patterns
- Motion and Energy Transfer
- Science Futures

How is SbD used in your school? Please select all that apply.

- Most of the unit is followed from beginning to end.
- Students work through most of the student guide
- Teachers cherry-pick only selected SbD activities and use other resources.
- It is used to supplement school textbooks
- Mainly the hands-on activities are used.
- Mainly the digital activities are used.
- Other (Please specify)

What type of devices do students use at your school?

- Smartphone,
- Tablet (iPad or other)
- Surface
- Laptop
- Desktop
- Other (Please specify)

How would you classify the device your students mainly use at school?

- School owned device shared by others
- School owned device exclusively used by each students
- Student owned device
- Other (Please specify)

SbD is easy to use.

Completely disagree	Mostly disagree	Somewhat disagree	Somewhat agree	Mostly agree	Completely agree
---------------------	-----------------	-------------------	----------------	--------------	------------------

SbD is useful.

Completely disagree	Mostly disagree	Somewhat disagree	Somewhat agree	Mostly agree	Completely agree
---------------------	-----------------	-------------------	----------------	--------------	------------------

SbD improves students' understanding of how scientists work.

Completely disagree	Mostly disagree	Somewhat disagree	Somewhat agree	Mostly agree	Completely agree
---------------------	-----------------	-------------------	----------------	--------------	------------------

My students find the SbD units suitably challenging.

Completely disagree	Mostly disagree	Somewhat disagree	Somewhat agree	Mostly agree	Completely agree
---------------------	-----------------	-------------------	----------------	--------------	------------------

SbD improves students' engagement with science.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD improves student achievement in science.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD promotes collaboration and peer discussion.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD provides a way of implementing the Australian Science Curriculum.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

It is easy to navigate through the updated units.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

How would you rate the following aspects of SbD?

Very poor Poor Somewhat poor Somewhat good Good Very good

Navigation

Appearance

Functionality

Flexibility

Balance of hands-on activities

Unit at a Glance feature

Are you planning to use any SbD units *this year*?

- Yes
- No

Please select all that apply to your reasons for not using SbD this year.

- I prefer to use other resources.
- It does not meet the requirements of the syllabus.
- The units do not suit the classes I am teaching this year.
- I spend too much time solving school-based technical problems such as student access to computers, login issues.
- My school's internet connectivity makes its use unreliable.
- Other reasons (Please specify)

Are you planning to use any of these updated units this year? Please select all that apply.

- I am not planning to use any of these updated units this year.
- Introduction to SbD
- Doing Science Investigations
- Circle of Life
- Enough Water Fit for Drinking
- Science of Toys
- Earth and Space
- From Little Things Big Things Grow
- Rock, Paper, Scissors
- Energy
- Rock your World

Please select any of these units that you have already used this year since they were updated.

- I have not used any of these units since they have been updated.
- Introduction to SbD
- Doing Science Investigations
- Circle of Life
- Enough Water Fit for Drinking
- Science of Toys
- Earth and Space

How do your students currently record their work?

Never Rarely Sometimes Often Mostly Always

Students take their own notes in a book.

Students take their own notes digitally.

Students copy notes from the board.

Teacher provides paper worksheets.

Teacher provides digital

Never Rarely Sometimes Often Mostly Always

worksheets.

Students use the e-
Notebook.

My students have already used the student e-Notebook.

- Yes
- No

How do you use the SbD student e-Notebook?

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

My students download the whole e-Notebook and complete all the activities.

My students download the whole e-Notebook and complete some of the activities as directed by me.

My students download the parts of the e-Notebook as directed and complete those activities.

The e-Notebook has improved the learning outcomes for my students.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

Please comment on any benefits of the student e-Notebook.

Please comment on any limitations of the student e-Notebook.

Do you have any suggestions for improving the SbD curriculum units or the student e-Notebook?

Appendix 2. Follow-up Teacher Survey

My teaching experience is closest to:

- less than 1 year
- 1 to 5 years
- more than 5 years but less than 10 years
- 10+ years

My school could be described as:

- Remote
- Regional
- Metropolitan

Please rate your confidence in using guided inquiry teaching.

Very low Low Somewhat low Somewhat high High Very high

Please select the statement that best applies to you.

- I have not used *Science by Doing* (SbD).
- I have used SbD.

How is SbD used in your school? Please select all that apply.

- Most of the unit is followed from beginning to end.
- Students work through most of the student guide
- Teachers cherry-pick only selected SbD activities and use other resources.
- It is used to supplement school textbooks
- Mainly the hands-on activities are used.
- Mainly the digital activities are used.
- Other (Please specify)

Please select the term that best applies to your students having access to digital devices in your science classes.

Never Very infrequently Somewhat infrequently Somewhat frequently Very frequently Always

What types of devices do students use at your school?

- Smartphone
- Tablet (iPad or other)
- Surface

- Laptop
- Desktop
- Other (Please specify)

How would you classify the device your students mainly use at school?

- School owned device shared by others
- School owned device exclusively used by each student
- Student owned device
- Other (Please specify)

Please select any of these units you have used this year since they were updated. Please select all that apply.

- I have not used any of these updated units this year.
- Introduction to SbD
- Doing Science Investigations
- Circle of Life
- Enough Water Fit for Drinking
- Science of Toys
- Earth and Space
- From Little Things Big Things Grow
- Rock, Paper, Scissors
- Energy
- Rock your World

SbD is easy to use.

Completely disagree	Mostly disagree	Somewhat disagree	Somewhat agree	Mostly agree	Completely agree
---------------------	-----------------	-------------------	----------------	--------------	------------------

SbD is useful.

Completely disagree	Mostly disagree	Somewhat disagree	Somewhat agree	Mostly agree	Completely agree
---------------------	-----------------	-------------------	----------------	--------------	------------------

SbD improves students' understanding of how scientists work.

Completely disagree	Mostly disagree	Somewhat disagree	Somewhat agree	Mostly agree	Completely agree
---------------------	-----------------	-------------------	----------------	--------------	------------------

My students find the SbD units suitably challenging.

Completely disagree	Mostly disagree	Somewhat disagree	Somewhat agree	Mostly agree	Completely agree
---------------------	-----------------	-------------------	----------------	--------------	------------------

SbD improves students' engagement with science.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD improves student achievement in science.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD promotes collaboration and peer discussion.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD provides a way of implementing the Australian Science Curriculum.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

It is easy to navigate through the updated units.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

How would you rate the following aspects of SbD?

Very poor Poor Somewhat poor Somewhat good Good Very good

Navigation

Appearance

Functionality

Flexibility

Balance of hands-on activities

Unit at a Glance feature

Please select any statement that describes how your students access SbD. Please select all that apply.

- My students use individual SbD logins to access the website.
- My students all use the same SbD login to access the website.
- My students access SbD activities placed on the school's online learning management system.
- My students access the SbD website through a link on the school's online learning management system and use the resources directly from the SbD website.
- My students use printed copies of SbD activities.
- Students view SbD activities that I display on screen or board.

- Other (Please specify)

How do your students currently record their work?

Never Rarely Sometimes Often Mostly Always

Students take their own notes in a book.

Students take their own notes digitally.

Students copy notes from the board.

Teacher provides paper worksheets.

Teacher provides digital worksheets.

Students use the e-Notebook.

My students have used the student e-Notebook.

- Yes
- No

How do you use the SbD student e-Notebook?

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

My students download the whole e-Notebook and complete all the activities.

My students download the whole e-Notebook and complete some of the activities as directed by me.

My students download the parts of the e-Notebook as directed by me and complete those activities.

I download the whole e-

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

Notebook and select parts for my students to complete on their devices.

I download the e-Notebook and print parts for my students to complete on paper.

The e-Notebook has improved the learning outcomes for my students.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

I would like to be able to access learning analytics to monitor my students' learning with SbD.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

It would be helpful if SbD activities were adaptive so that they were varied according to my students' learning.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

I would like my students to be able to get feedback on their learning as they use SbD.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

It would be helpful if SbD activities could be easily imported into my school's online learning management system.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

Please comment on any benefits of the student e-Notebook.

Please comment on any limitations of the student e-Notebook.

Do you have any suggestions for improving the SbD curriculum units or the student e-Notebook?

Appendix 3. School Student Survey

My gender is:

- male
- female

I am in:

- Year 7
- Year 8

My school could be described as:

- Remote
- Regional
- Metropolitan

What type of devices do you use at your school?

- Smartphone
- Tablet (iPad or other)
- Surface
- Laptop
- Desktop computer
- Other - please specify

How would you describe the device you mainly use at school?

- School owned device shared by others
- School owned device exclusively used by each students
- Student owned device
- Other - please specify

Please select all the *Science by Doing* (SbD) units you have used.

- Introduction to SbD
- Doing Science Investigations
- Circle of Life
- Enough Water Fit for Drinking
- Science of Toys
- Earth and Space
- From Little Things Big Things Grow
- Rock, Paper, Scissors

- Energy
- Rock your World

SbD is easy to use.

Completely disagree	Mostly disagree	Somewhat disagree	Somewhat agree	Mostly agree	Completely agree
---------------------	-----------------	-------------------	----------------	--------------	------------------

SbD improves my understanding of how scientists work.

Completely disagree	Mostly disagree	Somewhat disagree	Somewhat agree	Mostly agree	Completely agree
---------------------	-----------------	-------------------	----------------	--------------	------------------

I find the SbD units suitably challenging.

Completely disagree	Mostly disagree	Somewhat disagree	Somewhat agree	Mostly agree	Completely agree
---------------------	-----------------	-------------------	----------------	--------------	------------------

SbD improves my engagement with science.

Completely disagree	Mostly disagree	Somewhat disagree	Somewhat agree	Mostly agree	Completely agree
---------------------	-----------------	-------------------	----------------	--------------	------------------

SbD improves my achievement in science.

Completely disagree	Mostly disagree	Somewhat disagree	Somewhat agree	Mostly agree	Completely agree
---------------------	-----------------	-------------------	----------------	--------------	------------------

SbD encourages me to work and discuss with other students.

Completely disagree	Mostly disagree	Somewhat disagree	Somewhat agree	Mostly agree	Completely agree
---------------------	-----------------	-------------------	----------------	--------------	------------------

It is easy to navigate through the SbD units.

Completely disagree	Mostly disagree	Somewhat disagree	Somewhat agree	Mostly agree	Completely agree
---------------------	-----------------	-------------------	----------------	--------------	------------------

The SbD materials are visually appealing.

Completely disagree	Mostly disagree	Somewhat disagree	Somewhat agree	Mostly agree	Completely agree
---------------------	-----------------	-------------------	----------------	--------------	------------------

The choice of text font, colours and style used in the SbD unit helped me to read and listen clearly, and understand concepts easily.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

The graphics (photos, graphs, images) were appropriately designed to help me understand the topic.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

The SbD unit had a good balance of hands-on, written and digital activities.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

How do you currently record your science work?

Never Rarely Sometimes Often Mostly Always

I take my own notes in a book.

I take my own notes digitally.

I copy notes from the board.

The teacher provides paper worksheets.

The teacher provides digital worksheets.

I use the SbD student e-Notebook.

How do you use the SbD student e-Notebook?

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

I download the whole e-Notebook and complete all the activities.

I download the whole e-Notebook and complete some of the activities as directed by the teacher.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

I download the parts of the e-Notebook as directed by the teacher and complete those activities.

I like to use the SbD student e-Notebook.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

Do you have any suggestions for improving the SbD curriculum units or the student e-Notebook?

Appendix 4. Science Teacher Educator Survey

Please select the statement that best applies to you.

- I have not used *Science by Doing* (SbD).
- I have used SbD in the past.

Please select all the SbD **Professional Learning (PL) modules** you have used in the past with pre-service teachers.

- I have not used any of these Professional Learning modules.
- Inquiry-based Teaching
- Effective Questioning
- Student Learning
- Assessment
- Leading for Change
- Implementing *Science by Doing*
- Inquiry DIY Guide

How have you used the SbD **Professional Learning modules**? (Please select all that apply)

- As part of a university class
- As part of PL promoted or conducted at a school
- In PL workshop provided outside a school
- For my own independent professional learning
- Recommended for pre-service teachers' independent professional learning
- To help pre-service teachers with programming science topics
- As resources for pre-service teachers in planning their lessons
- To help pre-service teachers design assessment tasks
- Other (Please specify)

The SbD **Professional Learning modules** are useful resources for pre-service teacher education.

Completely disagree	Mostly disagree	Somewhat disagree	Somewhat agree	Mostly agree	Completely agree
---------------------	-----------------	-------------------	----------------	--------------	------------------

The SbD **Professional Learning modules** have improved my pre-service teachers' understanding of guided inquiry teaching.

Completely disagree	Mostly disagree	Somewhat disagree	Somewhat agree	Mostly agree	Completely agree
---------------------	-----------------	-------------------	----------------	--------------	------------------

SbD PL could be improved by mapping **Professional Learning** modules against APSTs (professional standards).

Completely disagree

Mostly disagree

Somewhat disagree

Somewhat agree Mostly agree

Completely agree

Please select all the SbD **curriculum units** that you have used **this year**.

- Introduction to SbD
- Doing Science Investigations
- Circle of Life
- Enough Water Fit for Drinking
- Science of Toys
- Earth and Space
- From Little Things Big Things Grow
- Rock, Paper, Scissors
- Energy
- Rock your World
- I have not used any of these curriculum units this year.

How have you used the SbD **curriculum units**? (Please select all that apply)

- As part of a university class
- As part of PL promoted or conducted at a school
- In PL workshop provided outside a school
- For my own independent professional learning
- Recommended for pre-service teachers' independent professional learning
- To help pre-service teachers with programming science topics
- As resources for pre-service teachers in planning their lessons
- As ready made lessons that pre-service teachers implemented
- As ready made lesson sequences for pre-service teachers
- To help pre-service teachers design assessment tasks
- Other (Please specify)

The SbD **curriculum units** are useful resources for pre-service teacher education.

Completely disagree

Mostly disagree

Somewhat disagree

Somewhat agree Mostly agree

Completely agree

The SbD **curriculum units** have improved my pre-service teachers' understanding of guided inquiry teaching.

Completely disagree

Mostly disagree

Somewhat disagree

Somewhat agree Mostly agree

Completely agree

How would you rate the following aspects of the SbD **curriculum units**?

Very poor Poor Somewhat poor Somewhat good Good Very good

Navigation

Appearance

Functionality

Flexibility

Balance of hands-on activities

Unit at a Glance feature

The SbD **curriculum units** could be improved by creating a social media site so that teachers can share their SbD experiences.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

The SbD **curriculum units** could be improved by including differentiation within units to cater for different abilities.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

The SbD **curriculum units** could be improved by including different layers for pre-service, beginning and experienced teachers

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

How have you used the SbD **student e-Notebook**? (Please select all that apply)

- As part of a university class
- As part of PL promoted or conducted at a school
- In PL workshop provided outside a school
- For my own independent professional learning
- Recommended for pre-service teachers' independent professional learning
- To help pre-service teachers with programming science topics
- As resources for pre-service teachers in planning their lessons
- As ready made lessons that pre-service teachers implemented
- To help pre-service teachers to design assessment tasks
- As ready made assessment tasks for pre-service teachers
- Other (Please specify)

SbD improves pre-service teachers' engagement with science pedagogy.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD promotes collaboration and peer discussion.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD supports implementation of the Australian Science Curriculum.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD is easy to use.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD gives confidence to pre-service teachers as catalysts for change in schools.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD could be improved by incorporating more guidance in units to help pre-service teachers to learn, e.g. pop-up questions, overlay prompts.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD could be improved by including more videos, e.g. what productive classroom looks like.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD could be improved by updating the research that backs up ideas and concepts.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

As a user of SbD resources, I would classify myself as a



- low user
- moderate user
- high user

How would you rate the likelihood of you using these aspects SbD **in the future?**

	Very unlikely	Unlikely	Somewhat unlikely	Somewhat likely	Likely	Very likely
Professional learning modules						
Curriculum units						
Student e-notebook						

Do you have any suggestions for improving the SbD **Professional Learning modules, curriculum units or student e-Notebook?**

Appendix 5. Science Teacher Education Student Survey

Please select the statement that best applies to you.

- I have not used *Science by Doing* (SbD).
- I have used SbD in the past.

Please select all the SbD **Professional Learning (PL) modules** you have used in the past.

- I have not used any of these Professional Learning modules.
- Inquiry-based Teaching
- Effective Questioning
- Student Learning
- Assessment
- Leading for Change
- Implementing *Science by Doing*
- Inquiry DIY Guide

How have you used the SbD **Professional Learning modules**? (Please select all that apply)

- As part of a university class
- As part of PL at school
- As own independent professional learning
- To help with programming science topics
- As resources for planning science lessons
- To help design assessment tasks
- Other (Please specify)

The SbD **Professional Learning modules** are useful resources for pre-service teachers.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

The SbD **Professional Learning modules** have improved my understanding of guided inquiry teaching.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD PL could be improved by mapping **Professional Learning modules** against APSTs (professional standards).

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree



Please select all the SbD **curriculum units** that you have used **this year** (e.g. during a professional experience placement).

- Introduction to SbD
- Doing Science Investigations
- Circle of Life
- Enough Water Fit for Drinking
- Science of Toys
- Earth and Space
- From Little Things Big Things Grow
- Rock, Paper, Scissors
- Energy
- Rock your World
- I have not used any of these curriculum units this year.

How have you used the SbD **curriculum units**? (Please select all that apply)

- As part of a university class
- As part of PL conducted at a school
- For my own independent professional learning
- For programming science topics
- As resources in planning my lessons
- As ready made lessons that I implemented
- As ready made lesson sequences
- To design assessment tasks
- Other (Please specify)

The SbD **curriculum units** are useful resources for pre-service teachers.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

The SbD **curriculum units** have improved my understanding of guided inquiry teaching.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

How would you rate the following aspects of the SbD **curriculum units**?

	Very poor	Poor	Somewhat poor	Somewhat good	Good	Very good
Navigation						
Appearance						
Functionality						

Very poor Poor Somewhat poor Somewhat good Good Very good

Flexibility

Balance of hands-on activities

Unit at a Glance feature

The SbD **curriculum units** could be improved by creating a social media site so that teachers can share their SbD experiences.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

The SbD **curriculum units** could be improved by including differentiation within units to cater for different abilities.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

The SbD **curriculum units** could be improved by including different layers for pre-service, beginning and experienced teachers.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

How have you used the SbD **student e-Notebook**? (Please select all that apply)

- As part of a university class
- As part of PL conducted at a school
- For my own professional learning
- To help with programming science topics
- As a resource for planning my lessons
- As a ready made lesson that I have implemented
- To help me to design assessment tasks
- As a ready made assessment task
- Other (Please specify)

SbD improves pre-service teachers' engagement with science pedagogy.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD promotes collaboration and peer discussion.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD supports implementation of the Australian Science Curriculum.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD is easy to use.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD gives confidence to pre-service teachers as catalysts for change in schools.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD could be improved by incorporating more guidance in units to help pre-service teachers to learn, e.g. pop-up questions, overlay prompts.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD could be improved by including more videos eg what productive classroom looks like.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

SbD could be improved by updating the research that backs up ideas and concepts.

Completely disagree Mostly disagree Somewhat disagree Somewhat agree Mostly agree Completely agree

As a user of SbD resources, I would classify myself as a

- low user
- moderate user
- high user

How would you rate the likelihood of you using these aspects SbD **in the future?**

	Very unlikely	Unlikely	Somewhat unlikely	Somewhat likely	Likely	Very likely
Professional learning modules						
Curriculum units						
Student e-notebook						

Do you have any suggestions for improving the SbD **Professional Learning modules, curriculum units or student e-Notebook?**

Appendix 6. Governance Interview Discussion Guide

QUESTION	RATIONALE
<p>1. What is your role in the governance of <i>Science by Doing</i>?</p> <p>> How long have you been involved in the programs</p>	Background – consistency of understanding of roles in governance
<p>2. Can you please describe the governance arrangements for <i>Science by Doing</i> and the roles of the different groups?</p> <p>> What is the role of each of the governance groups</p> <p>> What are the relationships between the various groups</p>	Background – overview of governance arrangements eg. <ul style="list-style-type: none"> > Scope of the role of each governance group and how they relate to each other > Is the role of each clear and distinct?
<p>3. How are these groups involved in assessing the quality of delivery of <i>Science by Doing</i> and whether the intended outcomes are being achieved?</p> <p>> What is the role of the various governance groups in these assessments?</p>	Clarifying the functions of each of the groups. Do participants in governance have a consistent understanding of their role? Involvement of governance groups in decision making
<p>4. How are decisions about changes to content and the delivery of <i>Science by Doing</i> made?</p> <p>> What is the role of the various governance groups in these decisions?</p>	Involvement of governance groups in decision making.
<p>5. What data, reports or other information are available to you to help make decisions about <i>Science by Doing</i>?</p> <p>> How far in advance of meetings do you receive this information?</p> <p>> Is data and information discussed at meetings and in general have you had sufficient time to review before meetings?</p>	Adequacy of information and support for governance group to make decisions.
<p>6. Is this data and information sufficient for you to be informed about the progress of <i>Science by Doing</i> and make decisions about program delivery?</p> <p>> If not what else would you like?</p>	Adequacy of support and evidence provided to governance groups to make decisions.
<p>7. How is the advice/recommendations of the various governance groups fed back into the delivery of <i>Science by Doing</i>?</p>	Effectiveness of governance framework for guiding program delivery
<p>8. What impacts has the advice from the various</p>	Impact of governance groups on program

governance groups had on the delivery of <i>Science by Doing</i> ?	delivery.
<p>9. Overall how would rate the effectiveness of the governance arrangements for <i>Science by Doing</i>?</p> <p>> Are there any changes or improvements that could be made?</p>	<p>Effectiveness of governance framework.</p> <p>Should anything be done differently?</p>

Appendix 7. Case studies

Case study 1: QLD Non-Government School

Context

The school

The school is an independent co-educational school in metropolitan Brisbane. It has about 1200 students in grades Prep-12 and an above average index for socio-economic advantage (1100-1200). The school has over 80% of its students performing in the top quartile. Source: www.myschool.edu.au

The teachers

Two teachers participated in the focus group. These were two of the seven Year 7 science teachers at the school and the two teachers who had used the e-Notebook in their classes. One had taught SbD at the school for three years and has been a teacher for 27 years. The other had taught SbD at the school for three years and had been a teacher for three and a half years.

The students

Observations were made of two Year 7 classes of 21 and 16 students. A focus group interview was conducted with five Year 7 students, three boys and two girls.

Technology provision at the school

The school has a BYOD policy and there is a range of devices in use by the students. Teachers displayed lessons on a screen at the front of the room. The students said they thought SbD worked well on the range of devices and noted that the screen looked exactly the same on different devices. The teachers said that the children were good with technology and using their devices. They could use the Google draw function to make diagrams and paste them in to the e-notebook and some could draw using the pad on their notebook or with a stylus if their device has one.

Implementation of SbD at Case study 1 school

The school began to use the SbD resources three years ago after the Head Teacher Science and another teacher attended a professional development session. The school initially used the resources in conjunction with a particular textbook and the teachers felt that that worked well. However, when the school moved to a different text at the beginning of the school year the integration with SbD became difficult. One teacher felt the new textbook lacked content and so has been using the SbD resources to supplement it. She noted that the better content in the revised SbD units has been very useful to address what is lacking in the new text. Next year they plan to rewrite their units to better embed the new textbook with SbD.

The school also has bought the online program 'Stile' that the teachers found very good, particularly for homework. They described how the students can do "click and drag" pages, view videos and submit work online. Teachers then go in and review this work through 'mark book' and use online commenting back to students. In addition, the teachers can click and download lessons that are linked to the homework tasks. They said that the e-Notebook does not have the level of functionality offered by Stile.

One teacher noted that the students enjoyed science because this was “one of the few subjects that they get to touch things” and every lesson she is asked “are we doing a prac today” at the laboratory door. She has embedded additional pracs in the SbD units. However, the teacher said that doing a lot of prac work can make it difficult with laptops and using the e-Notebook. She said that she had had a couple of incidents with laptops getting wet so they tend to keep them away from the work area. She said that could be a problem with recording results in the e-Notebook.

Impact of SbD

Teachers' perspective

Regarding the revised units, one teacher thought there was more content but thought there were now parts missing, for example ‘Matter’. She said the students liked the SbD interactive with water molecules and said the students could “get the correlation between how lowering the temperature slowed it down” and students could, “conceptualise that”. She also noted the Forces unit and that the students “loved the activities”, particularly on electrostatics. Some pages were considered to be too text heavy noting the “initial Matter page is all words and was too much for some of my lower readers”. She said her students grew up with iPads and are not willing to read the text. They “would rather Google than pull something [a definition] out of a sentence”. It was all about “how they can do it the fastest”. She commented, “I miss books. ... they don’t think when they type. I like them to physically write it down... it slows that process down” and “if they can cut and paste they will”. She believes that “when they have to write it down somehow they just take more in”.

The students used to use a logbook that they would fill in and could bring that into the exam. Both teachers believed students were encouraged to be organised and condense the information using this technique and it improved their note taking skills. They were considering going back to this practice next year. One teacher said that for Year 7 it is just “too much devices” and she wanted to “give them books again”.

Both teachers said they used the inquiry approach but could not use it every lesson because it is too time consuming. They did not think that SbD had influenced their use of guided inquiry.

The teachers commented on how much the students had enjoyed the Water unit. They had brought in bore water and water from a dam to study, some had water tanks and were knowledgeable and interested in water catchments and water treatment. The school was considering doing an entire term on water because the children liked it so much.

Students' perspective

In response to being asked what the best thing was about SbD, the students said, “I think it’s the pictures, we can click on them and it opens another web page” and “it’s interactive and that’s really good” whereas other resources were “all words”.

They found the water tests activity particularly good – they liked being able to look at their water usage and one student said “it’s good for people who want to be interactive with their learning and cut down on their water usage” and “It shows them the issues and how to fix them”.

The students remarked, “it’s easy to use” and “all you have to do is click on a button and it downloads to our desktop”. They liked not having to log in each time. They did not like having to sign in every time they used it. One said, “You still have to click on being a student to then get in” “I think you should make I’m a teacher and I’m a student more noticeable”.

Overall they had no problems using SbD with the device but three students said they had had problems with logging in although these were easily fixed. They liked the e-Notebook with one student commenting, “I think it’s really useful because if you don’t have much storage on your

device you can do it on the internet without actually downloading it” and “you don’t have to create a new word document each time”. They all agreed it was better than using their science book saying, “It’s so much better” and “It’s like you’ll never forget your laptop but you might forget your books”.

As the teachers spoke specifically about Stile, the students were asked what they thought about it. They said that Stile is more difficult to use than SbD because it did not provide information but asked for answers to questions. They also agreed that they did not like it because, “it doesn’t tell you your marks”. They closed by saying that “*Science by Doing* is better”.

Suggestions for improvement

Teachers’ perspective

Regarding the navigation of SbD, one teacher said the sequential nature of the units was problematic, comparing it to Stile where the teacher can organise the order in which the students see them. She said that unlike SbD you “have a lot more control in Stile to give feedback and it saves where they are up to”. She suggested that SbD units would be improved if the PDF student guide were linked to the website units to save students “jumping back and forth” between resources. She said SbD has “got good info on student guide” but that it needs to be in one place.

The other teacher agreed that it would be better if the resources were all accessible from a common place as the students need to navigate between different screens. She said, “if it was a printed book that would be fine” and “what’s in it is good but the way they are accessing it that is the problem”. There was “lots of to-ing and fro-ing, looking at resources and the notebook”.

One teacher commented that “the kids love Stile for homework” but these don’t have the SbD unit incorporated. She suggested that the “online notebook would be better as a Stile chapter” and said that it was possible to add content to Stile.

Students’ perspective

The students did not identify any problems with navigating. One student said she has “lots of desktops open and then just swipe(s) between them”. The students said they liked the appearance and could not think of any improvements.

When asked about limitations of the e-Notebook, one student said “It would be nice if the screen was bigger” because “There is a lot of blank space around the edges”. The other students agreed and decided they would like to be able to adjust the display size of the videos – not just choose between small or full screen. They also did not want to be toggling between the resources and one student said, “It would be good to watch the video on half the screen” because “it is annoying to go from one tab and then to another”.

The students could not suggest improvements for the e-Notebook and one student said, “I think it’s really good” and the other students nodded in agreement.

Summary

At this school SbD is supplemented with other resources. All students have a digital device and have no problems accessing the SbD activities. The teachers like the SbD resources and would like to be able to further incorporate them into their more comprehensive online learning system, Stile. The teachers and students commented particularly on the students’ enjoyment of the unit *Enough Water Fit for Drinking*. The students were positive about all aspects of SbD.

Case study 2: QLD Government School

Context

The school

The school is an independent co-educational school in metropolitan Brisbane. It has about 1200 students in grades Prep-12 and an above average index for socio-economic advantage (1100-1200). The school has over 80% of its students performing in the top quartile. Source: www.myschool.edu.au. The school ran an Exceptional Learner Program (ELP). The ELP classes comprise selected students who either show a willingness to learn or are high achievers.

The teachers

A total of six teachers took part in interviews at Case study 2 school (3 female, 3 male). Two teachers (including the Head of Department) had attended an SbD workshop. All were experienced teachers and had taught at the school for more than three years.

The students

One Year 7 and one Year 8 science class were observed and one group of five students (2 Year 7 boys, 2 Year 7 girls and 1 Year 9 girl) took part in focus group interviews.

Technology provision at the school

Use of SbD at this school is limited by the availability of laptops. Students do not have a laptop unless they are in the Exceptional Learner Program program. Teachers would generally book laptops for assessment or if they had a particular Powerpoint they wanted the class to go through. There are three computer class sets for 11 laboratories and the teachers noted they cannot rely on getting a set. One also said that setting homework on SbD is not feasible for non-ELP students as they do not have reliable access to a computer at home. Further issues with SbD related to the internet at the school that could be slow and also to Youtube and Scootle, which are blocked at the school.

Implementation of SbD at Case study 2 school

The use of SbD varied and was mostly used with the ELP students. Two teachers indicated they used it quite often. One said, "If the unit matches up with what I am doing then I may use it once per week". She gave the example that "today I used it for the nervous system". Teachers who did use SbD would display the activity at the front of the classroom and one said he printed out pages from the e-Notebook for the students to write their answers in.

The teachers all agreed it was problematic if the students had their own login. One said, "it was a pain getting all the students to set that up so we just made one email address and one password" and added, "I am getting labels made up that will be stuck on the laptop right next to the keyboard". The strategy of using one email address was common among all the teachers with three noting they had unsuccessfully tried to use individual logins for the students. One said, "If they put their own password in we have no idea what it is" and that having a common login was a "timesaver" for most classes.

Four of the science teachers did not know that SbD had released the e-Notebook before they were contacted to participate in the evaluation. They had been using Education Perfect, which has a document that they said has a similar function to the e-Notebook when it was described to them.

One teacher said, "I do use the e-Notebook but more use it on the board or printing out the e-Notebook sections". In some non-ELP classes she said, "It can take them 15 minutes to get

them onto the computer”. Another said the e-Notebook activities “are not as good as the ones I’ve already got”.

Impact of SbD

Teachers’ perspective

The teachers use a range of resources in science that can include SbD. The teachers generally used SbD, Education Perfect, the textbook and The Learning Space (the school intranet). Teachers are provided with a general plan for the term so that the students do topics in the same order. The teachers take the general plan and then customise it, adding or deleting resources to make it appropriate to their teaching style and class.

Teachers will use the hands-on activities in SbD or the textbook depending on which activity they prefer. They said the activities were quite similar. One teacher said she did not use SbD much but preferred to use other online resources from Youtube and also said she liked Education Perfect. Another noted the videos were good and highlighted a discussion video on inertia and another on DNA that the students found particularly interesting. Some teachers had used the quizzes in SbD.

One teacher said he used SbD in all his classes, but noted that students can “skip the instruction” and need “a lot of verbal instructions”. He said, “I’ve got kids that use it at home”. He said he uses the resources for different year levels and “jumps around a bit” looking for resources appropriate to the level of the students.

The teachers also noted that some students have problems navigating in SbD but one said, “they have a problem navigating anything”. Another teacher added this was because, “the students didn’t follow instructions”. The teachers agreed the layout of SbD was, “not boring” and the students seemed to like it.

One teacher noted that “by the time the kids get on it can be a bit of a strain” and “I don’t get them to use the digital bit” but he gets them to write in their books. He said the students liked looking things up in SbD because “they feel like it’s like Googling” and it “keeps them on task, on topic”. He said, “the language is simplified so it’s good for our low literacy kids” and that “everyone has heard the instructions and some have read it”. He explained that if he just uses the textbook the “struggling readers don’t get it”.

When asked how the teachers could check what students had done in the e-Notebook they said they would get students to write in their books as they could not see what was in the e-Notebook. A teacher said, “that is one of the things about Education Perfect it tracks the students and it marks them”.

Students’ perspective

The Year 7 students were all from ELP classes and agreed that SbD is “a great idea”. One student explained that they “go online and we have a e-Notebook and we either answer questions or fill in stuff”. The Year 7 students had started using SbD a few weeks earlier at the beginning of the semester. They agreed it was easy to access and to use and one girl said she, “enjoyed the games”.

The students used the videos and other activities and thought they were good. One student said, “It answers a lot of questions – even if they’re just like random questions, it helps you understand it”. Another said, “We looked at the videos on it ... it helped us understand how things worked”.

The students said they did not use the PDF student guide and the best thing about SbD was “the accessibility ... instead of having to get to the text book you can just click on your subject and choose”. They said they used the textbook but the group agreed with the student who said, “I prefer the laptop to the text book”.

The Year 7 students had had two lessons of experience with the e-Notebook. One boy commented, “It has a navigation panel so it is easy to find where you need to go”. One student said it was easier to work on your laptop and having it all in one spot and the other students agreed. Some said it was tempting to copy and paste because it was already online but one student said that it was still preferable to be online because, “sometimes people bring the wrong books”.

Overall the students expressed positive views of SbD but use of the e-Notebook was dependent on the availability of laptops.

Suggestions for improvement

Teachers’ perspective

The teachers agreed they would like a shorter teacher’s manual they could print off for each unit. They said the “unit at a glance” is okay in that it is not too long” but that there is “so much stuff” in the other areas of SbD. One said, “sometimes it’s nice to have a core document in your hand” and that he printed out the “unit at a glance”. They noted it would be good to have a broader teacher manual to refer to in class.

One teacher said it would be helpful to have suggested answers to the questions and the quizzes and that “it would be easier for me to mark”. The other teachers said, “yes, definitely”.

One teacher said she particularly liked to use Education Perfect for her ELP students – she liked that the students could do their homework in the program and she could easily track their progress. The school only has funding to use Education Perfect in the ELP classes. Another teacher said he liked a similar function within Mathletics and wondered if there was a way that this was possible for SbD using a common login for all his students, which would allow him to track their progress through the booklet. He said he would like to be able to provide evidence that the students were making good progress in SbD as justification for having priority to use the portable computer set.

Further suggestions were for “something that lists a topic and where it can be found” within the entire SbD resources. For this teacher’s low literacy children he uses SbD resources for lower year levels and would benefit from a master index to find relevant resources. He also said it would be good if there was a way for students to email parts of their work to the teacher so he could look at it later.

Students’ perspective

The students identified some problems with SbD. They said that they found it hard to find things and clearer titles would be good so the teacher did not have to show them how to use it. They did agree that it made sense where things had been put in the website.

They agreed they liked the overall appearance but would like fewer words and more pictures and diagrams. One girl said, “People would rather look at pictures and diagrams than read”.

Summary

This school mainly uses SbD with its higher ability students (ELP program). These are the only students with their own laptops. A shortage of class sets of computers is one of the main reasons why SbD is not used more widely in the school. The e-Notebook has only recently begun to be used at the school. The students were positive about the SbD resources. Teachers

who had experience of programs that made use of learning analytics, mentioned that they would like to see that feature within SbD.

Case study 3: NSW Non-Government School

Context

The school

The school is a Catholic Co-educational Regional High School in New South Wales. It has about 600 students in Years 7-12. The school has a slightly below average ICSEA (Index of Community Socio-Educational Advantage) value with approximately 10% of its students performing in the top quartile. Source: www.myschool.edu.au.

The teachers

Four teachers contributed to the data collection, the Head Teacher Science and three science teachers who had been teaching with the SbD resources. Teacher 1 was an experienced teacher who had been at the school for some years; Teacher 2 was an experienced teacher, who had recently returned to teaching and had been at the school for less than a year; and Teacher 3 was a beginning teacher who had been at the school for less than a year.

The students

One Year 7 science class was observed and seven students (3 girls and 4 boys) from that class took part in a focus group interview.

Technology provision at the school

All students have their own Acer or Toshiba notebooks. The teachers project lessons onto a whiteboard. The head teacher enters all the science activities for each year, including SbD, into OneNote for teachers and students to access. If students ever log in to SbD they use the teacher's login because the teachers find that there are too many passwords for students and they forget them.

Implementation of SbD at Case Study 3 School

The school began using SbD as a resource because it suited the inquiry-based focus of the new science syllabus. Prior to that science had been taught mainly from textbooks. The school took on SbD without making any modifications to SbD. They found that they were not able to complete all the work in the units. This was a problem as explained by the head teacher: "you start at the top and you work your way down and so that was a bit disappointing because we didn't quite get to the wrap-up point in those last sections". The school now uses some SbD resources supplemented by other resources. Because all their science activities are accessed through OneNote, students are not able to distinguish between SbD resources and materials from other sources.

There are 5 year 7 classes and the same number of Year 8s and they all use SbD but Year 8 had not used new units as they had just become available. Year 7 students have completed activities from Doing Science Investigations, Enough Water Fit for Drinking, Science of Toys and Earth and Space.

Parts of the student e-Notebook are copied and pasted parts into OneNote for the students to complete. The teachers want students to be able to keep all of their work together. Teacher 3 explained: "When we are just using this as a tool with other resources it would be too hard to

have some notes here, some in their books, some in OneNote, they would have no idea where anything was”.

Impact of SbD

Teachers' perspective

The teachers like SbD because it is inquiry-based and helps teachers to understand inquiry-based learning, and also because it is context-based. They commented favourably on the quality of the interactives and videos in SbD. They also found that navigation was improved in the updated units. Teacher 1 commented: “There used to be like three things you had to look at to teach a lesson. Now you have the teacher’s guide all in that one spot and I think that is probably the best new feature”.

The teachers have had difficulty fitting all the SbD unit activities into the time available and rather than adjust the unit they left out the later activities. The head teacher commented: “The valuable things about SbD are getting kids to have an informed opinion and getting their literacy up. They are all the things that come towards the end of the unit that we were missing out on. Those are the things we don’t do as well as we could because we run out of time”.

The head teacher described the impact of the updated units as follows: “I found a big difference between the old units and the new ones. They fixed a lot of problems that I found, which is really good. I found [in the old units] that there was [not sufficient depth of coverage of the science subject matter]. Parents, kids and teachers want content. They want to know what they’re teaching. There wasn’t a piece of information they could go to and teach from and that’s been fixed up a bit. It’s friendlier in that respect. There’s a bit more background information to help you carry out what to do. So I think [in the past] it was pitched the wrong way – do your activity and then find out – and that’s been fixed up. In year 7 we’re using it more this year than we have over the last few years”.

Students' perspective

The students have enjoyed using SbD because the science ideas are clearly explained, the activities are enjoyable and there are a lot of hands-on practical activities. Comments included: “The work’s easy to understand. It explains it in a good way” and “This one (Science of Toys) is pretty fun. The experiments and tug of war has been really fun and the writing has not been as boring as some of the other work has”.

Suggestions for improvement

Teachers' perspective

The teachers suggested the following improvements to SbD:

Learning analytics – All the teachers interviewed commented on how valuable a learning analytics capability within SbD would be. They all agreed with the head teacher, who explained, “In year 8 we use a program called Education Perfect – an online tool where you have a dashboard and assign tasks to classes. There are stimulus and activities and once assigned there is feedback, which is really valuable. You can see what each student has done and how they have done. It helps with auditing, giving evidence of [learning and] providing students with feedback. With SbD having all that feedback in it would be brilliant. If it had those capabilities you wouldn’t do much else”.

More guidance on condensing units – The teachers would value more direction on how to fit SbD into their limited time with the students, without leaving out vital parts of the 5Es process.

The head teacher noted: “The length is the big issue, I know there are optional topics but that is not enough”.

Professional learning – The teachers indicated that they would like more PL opportunities. The head teacher explained: “It would have been good to access some PD on SbD. Nobody has done SbD PD. We have run our own PD from the resources [available in SbD]. [But] access [to PL] is a problem. [If] would have to go to Sydney and there is a cost involved. If you could get somebody to come here for the day it would be great. There is a lot of PD stuff. We did staff meetings on how to flip the classroom but I found it quite difficult to change people’s habits, really, really difficult because it’s unknown. You don’t know where you’re going”.

Syllabus mapping – The teachers appreciated SbD’s alignment with the Australian Science Curriculum but would find it helpful if units were mapped to the NSW syllabus. Teacher 1 suggested, “It would be good to have each lesson mapped to the syllabus. There’s a lot of buoyancy in the Toys but no dot points [related to] for the [NSW] syllabus”.

Communication – The teachers indicated that they would like more communication from the SbD team. Teacher 1 stated, “I don’t get anything by email from SbD even though I have the school login for it. I didn’t even get notification that the units were being updated. Teachers do not have time to monitor web sites”.

Technical issues – Teacher 3 suggested, “A small thing but I don’t like how it doesn’t keep you logged on. So, you have to log on every time and that’s confusing for the kids. You have to log in and start again navigating to where you were. It’s time consuming”.

Students’ perspective

The students’ suggestions for improvement centred on them wanting more practical work. “More practicals”, they chorused. We have a lot of writing in lessons. Their main criticism was directed at the Earth and Space unit. “All we did was write”, they claimed. “We did one prac, which was you had to get one of those white foam balls and a flashlight, but you still had to write heaps of information down”.

Summary

This school initially adopted SbD as a resource to help them to implement the new Australian science curriculum. It has since become integrated into their science programs, with selected SbD activities delivered via an online learning management system. The Year 7 students who were interviewed find the SbD learning activities interesting and easy to understand. The teachers find the updated units more user friendly and they like the balance of activities. The teachers’ experience with a program that gives them access to feedback on their students’ online learning prompted them to comment that a learning analytics facility combined with the SbD learning activities would constitute an ideal science program. They would also appreciate guidance on how to optimally condense SbD units to fit the limited science teaching time available.

Case study 4: Tasmanian Government Boys’ School

Context

The school

The school is an all-boys Government high school in Tasmania, and caters for boys from Years 7 to 10. It has about 775 students. The school has a slightly below average ICSEA (Index of

Community Socio-Educational Advantage) value with approximately 10% of its students performing in the top quartile. Source: www.myschool.edu.au.

The teachers

Four teachers and one pre-service teacher contributed to the data collection. The Head Teacher Science (HTS) and an experienced science teacher were interviewed and others shared their views in informal discussion.

The students

A Year 7 science class was observed and six students from that class took part in a focus group interview.

Technology provision at the school

The school is not well equipped with devices for students but classrooms have data projectors. A previous BYOD policy at the school was not a success and currently science classes very occasionally use the school's computer lab.

Implementation of SbD at Case study 4 school

The HTS described SbD as 'the backbone' of the school's science program with other resources added. The school uses SbD extensively in Year 7 and 8 and less so in Year 9 and 10. Teachers mainly project their SbD lessons onto a whiteboard at the front of the classroom, although all students have an individual log in. The material in the student e-Notebook is either projected for students to copy into their exercise books or printed out for students to complete.

Impact of SbD

Teachers' perspective

The teachers are very happy with the updated Year 7 and 8 units. They commented that explanations have improved. They like the simulations and find them more 'user friendly' in the updated units because they can be accessed within the SbD site and so are always available and don't "disappear" like other web-based resources. They think there is a good balance between hands-on activities and science information. They like the consistency in building on student inquiry skills year by year throughout SbD. They noted that SbD's adherence to the Australian science curriculum very advantageous. Comments included,

SbD beautifully matches the curriculum and the Unit at a Glance and Teachers Guides are fantastic.

I really like the new interface for teachers (Unit at a Glance) and we've found it useful in creating a scope and sequence for the school as it matches the Australian curriculum.

Student literacy levels are a concern at the school. So, differentiation in Science is important for the teachers. The teachers reported that the literacy demands of the Year 9 and particularly Year 10 units are pitched at a level too high for their year 10 classes. Comments included:

Even with technology I would still use the school login for SbD as there are a lot of students with literacy issues and students with English as a second language so anything I can do to make it simpler ...

A lot of the language is inaccessible to some of our students. Most students can access the language in the Year 7 units but only about 50%, max, of students in Year 10 can access the language in SbD units so we need to simplify it. The upgraded units are pretty good. We refer to the Glossary a lot and we find it useful.

The teachers find that there is “too much to get through” in the SbD units and that they would appreciate more guidance in condensing the units. As a teacher explained,

We only have three lessons a week with the students and we cannot get through the activities that are provided. The units are too long and, even when you take out those optional activities, it’s still too much work. And often when you look at the optional ones, we think that they are the ones that the students would enjoy the most so it’s a really tough call what you do.

The lack of digital technology provision at the school has influenced to a great degree how the SbD resources are used. However, teachers find the resources worthwhile and so have adapted their use to the school context by projecting lessons, printing out parts of the student e-Notebook and differentiating the activities for students with low literacy levels. They commented,

If everybody had an amazing laptop, oh my goodness, it would be fantastic and you wouldn’t change a thing. We’ve weighed up the problems but it’s such a worthwhile program that we are battling through regardless. And we are ready to go with technology when it appears magically and it will be fantastic when it does.

I like the content of the e-Notebook but I don’t like that the students don’t have devices so they don’t use it. The one student who has a device and uses the e-Notebook on that is a student with a disability and he loves it.

Switching over to the e-Notebook, I think we would always want to keep the written one as well. I wouldn’t let go of the hand written notebook, especially when there is a focus in the school on improving handwriting.

The teachers recognised the differentiated learning and independent learning opportunities afforded by students using their own devices. They argued that if SbD provided access to learning analytics for their classes it would make it worthwhile having all their students log on individually. However, this would mean every student would have to have access to a device and the teachers at this school thought that this was unlikely in the next few years, mainly because of cost.

Students’ perspective

The students enjoyed using SbD and said that it was easy to understand. They liked the games and found the site easy to navigate. They also appreciated that it was a trustworthy source of scientific information. Although they do not use the digital version often at school, some have used it at home, at a public library and on a smartphone to help with assignments. Their comments included,

It uses multiple forms of media like the videos that make it more interesting and engaging for us and makes us more interested in learning about it.

Has a good organisation system so it’s easy to find everything.

Helps to learn science by putting everything in the one spot and cuts down on the time you have to spend searching for individual bits of information.

The website is designed for younger minds so it’s made it a lot easier to understand.

Suggestions for improvement

Teachers' perspective

The teachers' suggestions for improvement mainly concerned the facility to differentiate and condense units. Their suggestions included,

It would be helpful if there was a button for students to be able to access different levels of language for a task so that the language is differentiated.

If they had individual logins and could access differentiated versions. That would be great.

Or the school could have logins at 3 levels to cater for students of different abilities.

It may be helpful for us to be able to modify the Student Guide to differentiate learning for the school context.

With the idea of cherry picking, with a differentiated class you could say do lessons 1, 4, 9 and 12 and when you go onto that the first page is the simple version and then the second page is the more complicated version. If they (the students) see the simple version there is more chance of them staying with me.

The teachers recognise that science knowledge changes quickly and that SbD resources must be kept up to date. They also noted that some of the practical activities require materials that are no longer permitted in schools due to OH&S rules. Teachers said,

SbD needs to stay up to date (with safety restrictions).

The Tasmanian education system requires that Learning Intentions and Criteria for Success be identified for all learning activities, so the teachers would find it helpful if SbD units identified these.

Students' perspective

The students suggested that a zoom feature would be useful so that the material is visible to all students when it is projected onto a whiteboard. They would like more feedback from the program and to be able to check their progress and understand how much they have learned so that they know what they have to revise. One student suggested,

Maybe a very easy to find and easy to access and very visible record of what units you've been onto, what you've completed and which ones you've been all the way through so you know whether you have to go over anything or complete anything. Because if it's been a few days since you've used it you may not remember and you might waste time by going into the same thing twice.

This prompted other students to suggest potential useful features that may be described as a learning analytics capability, e.g.

That feature might help teachers if they can check what all the students in their class have been up to, if they've been into what they are meant to be doing. So you can check and if they haven't been doing it they get a detention.

Maybe a system where a teacher can assign a topic to a class and put in all the names from the class and then when they log in it will come up as the first thing on their topic bar, so they know what to click into.

Summary

Both the teachers and students commented very favourably on the updated SbD units. The teachers were happy to adapt their use of the program to overcome literacy and technology challenges in their school context because they found the program worthwhile.

Their suggestions for improvement mainly related to updating Year 9 and 10 units in similar ways to the current updated units while ensuring literacy demands decreased compared to past units. They have limited time to teach science; consequently, they would welcome a guide to condensing the units to optimise science learning in meeting requirements of the Australian Curriculum; Science. They also wanted more ability within the program to differentiate for students with different capabilities, particularly to cater for variations in student literacy levels. They considered this to be important in order to maintain student interest in learning science.

Case study 5: Tasmanian Government School

Context

The school

The school is small government high school in a semi-rural area of Tasmania. There are about 280 students at the school. It has a below average ICSEA (Index of Community Socio-Educational Advantage) value with none of its students performing in the top quartile. Source: www.myschool.edu.au.

The teachers

The only two teachers who teach Years 7 and 8 Science at the school were interviewed.

The students

One Year 7 and one Year 8 science class were observed and two groups of six students from each of these years took part in focus group interviews.

Technology provision at the school

The school is not well provisioned with digital devices for the students. Teachers book their classes into a computer lab if they want them to do digital activities. The computer lab has a class set of laptops. Bookings are rare for Year 7s and occasional for Year 8s. Teachers often prepare lesson materials in PowerPoint and project them onto a whiteboard.

Implementation of SbD at Case study 5 school

SbD is used at the school to frame the science scope and sequence and each year level from 7 to 10 uses the four SbD units across the four school terms. Teachers use the units as a framework and cut and paste activities from SbD into PowerPoint because the school's technology is set up for that method of lesson delivery. The students initially had trouble generating individual student logins in the SbD system. The teachers have set up a generic login that every student uses. To do student digital activities it is necessary to access the computer lab but the teachers generally project the activities onto the whiteboard and work through them. As the science co-ordinator explained, "It would probably be better for each student to have their own device but there is just not enough money for that. We are not a private school so we don't do that".

Impact of SbD

Teachers' perspective

The teachers consider that SbD supports an inquiry approach to teaching very well and is very helpful in the implementation of the Australian science curriculum. The school has a number of new teachers and finds that the SbD framework gives them a series of lessons to follow and a good starting place for unit and lesson planning. They also use SbD because there are a lot of

hands-on activities and more concrete activities suit the students at this school. The teachers like it because there is little written text in Year 7 and 8 and because “it’s more learning through observation, learning through looking at a video, through discussion and through activities and a lot of these students engage that way”.

The teachers found the new units easier to navigate for teachers and having everything accessible on the left hand side of the screen is very useful. The appearance of the new units appeals to the students and the balance between hands-on and theory in the Year 7 and 8 units is about right but more short practical activities would be very popular with students and teachers. Compared to previous units, they reported that the sequence of activities in the updated units are easier to follow and more logical. They also stated they there were more good activities that can be used for assessment, e.g. mind mapping activities.

One of the teachers interviewed had no science teacher training and he found the SbD materials a good starting point. He used the materials last year and has found that the students are much more engaged with the new content this year. He said, “The biggest thing I’ve noticed is it’s a lot more hands-on. They have a lot more just simple practical activities for the students to be involved in, for them to see science in action kind of thing. That’s really good”. He is not ‘science trained’ and claimed that SbD was critically important to him in providing resources that allowed him to teach science.

The teachers find it easier for students to use a generic login because, as one argued, “Unless they are tracking the students there is no point in them having individual logins”.

The teachers don’t use the student e-Notebooks. As the science co-ordinator explained

I have no use for it. Because we are not fully digitised and they don’t have computer laptops with them every lesson, they would have to print it so I’d rather they wrote in their workbooks. The thing is with an e-notebook, it doesn’t give you the ability to draw. So if you want to draw a diagram, you can’t. Also, it enables kids to cut, copy and paste so that’s part of the reason I like them to write their own answers down in their workbook. They can draw an answer or they can just write their own”.

Students’ perspective

The students found the units to be pitched at the right level for them, commenting, “We can understand it. It’s at our level of learning”.

They liked the interactives and videos and found them useful for their learning because “you can visually see it and it goes in your brain so you can remember it”. They thought that “the different media’s good like watching the videos and then the worksheets as well so, say if you are more of a visual learner, it’s easier to watch them and say if you work better on paper it’s easier as well”.

They also said that SbD “looks good and it’s easy to find your way around”.

Suggestions for improvement

Teachers’ perspective

Since teachers at this school transfer the SbD activities into PowerPoint presentations they would like to be able to do this more easily. The science co-ordinator said:

What I would find really useful is to have just some PowerPoint slides for each of the activities that teachers can use as a backbone for their PowerPoints that they use in the classroom. We are a PowerPoint school. We have a distinct structure to our lessons (common instructional model) and it’s all done on PowerPoint. We can’t just put the Student Digital up and run with that. We have to have a certain structure to the lesson”.

With respect to being able to track students' progress, the teachers felt that "it depends on whether what we're tracking is directly linked to the curriculum and whether we can use it as an assessment tool. If it was possible to have some sort of indicator, not just whether they had done the activity, but have it as part of an assessment, that would be very useful". "If we were able to get the results of some of the quizzes and able to use some of those results as part of our, even formative, assessment or summative assessment, that would be useful".

The teachers also thought that it would be useful to have pre and post assessments. A comment from a teacher:

I know there are post assessments but not any pre assessments. In Tasmania there is a program called *Improve* where students answer a bank of questions before they study a topic and again when they have finished and their answers are tracked so that they can see how much they have learned. It would be good to have that for SbD.

The teachers also thought that differentiation in the SbD activities would be very useful to cater for students with lower literacy levels. Furthermore, because SbD is mostly projected onto a screen, it would be useful if the unit window could be made to project full screen to make it visible to the whole class.

Students' perspective

The Year 8 students suggested that using simpler words in the experiments would be helpful and "explanations of scientific words" (a glossary) would be useful. These students have not had very much experience with the updated units that incorporate this feature.

They would like more interactive media activities and videos. They thought that "learning on computers is a lot easier because it's individual and you can do it at your pace".

The students would like the program to give them feedback on their progress and they would like the teacher to be able to see what they were doing online. The students have used *Manga High* in maths and they liked the competitive element. They claimed that competition motivated them to try harder, commenting that something like this with a leader board or gold medals would be a good thing for SbD.

Summary

The teachers feel that SbD is an excellent vehicle to deliver the Australian science curriculum and have framed their science scope and sequence around the SbD units for each year level. The students at this school do not have their own devices and the school uses a particular lesson structure and method of lesson presentation that affects the way that SbD is utilised. The teachers and students reported that the updated SbD units laid a foundation for science teaching and learning at the school. They said they were engaging and easy to use. However, they do not make use of the student e-Notebook at the school. The lack of digital devices means that, in their view, there is little benefit in having a digital notebook. Both the teachers and students would like SBD to provide feedback on the students' progress in learning science as they work through activities.

Case study 6: NSW Non-Government Girls' School

Context

The school

The school is an independent Catholic girls' Secondary School in a regional city in New South Wales. It has approximately 1100 students in Years 7-12. The school has an above average ICSEA (Index of Community Socio-Educational Advantage) value with approximately 45% of its students from backgrounds that locate them in the top quartile. Source: www.myschool.edu.au.

The teachers

All of the teachers on the Science staff contributed to the data collection, the Head of Science and five Science teachers who have been teaching with the SbD resources. The Head and another experienced teacher shared the Year 7 class in which the lesson was observed. Five of the six teachers had used the e-Notebook with their students.

The students

One Year 7 science class was observed and six students from that class took part in a focus group interview.

Technology provision at the school

The school has introduced a BYOD policy and all students in Years 7 and 8 have their own Apple iPads, while laptops are brought to school by students in Years 9 and 10. The teachers project lessons onto a whiteboard.

Using SbD at Case Study 6 School

The school introduced SbD about 5 years ago, when the new NSW *Science* Syllabus provided a catalyst to shift the approach taken to teaching and learning Science. Led by the Head of Science, the staff has focused on increasing the emphasis on guided inquiry. All Science teachers are encouraged to use the 5Es to inform their programs in Science. The school implements the Middle Years Program (MYP) of the International Baccalaureate, which also emphasises inquiry. Staff and students use the Learning Management System, *Sector*.

There are approximately 120 Year 7 students at the school and all Year 7 Science classes are mixed ability. In 2017, they have completed activities from *Enough Water Fit for Drinking* and *Circle of Life* before *Science of Toys*. Year 7 classes do not have a textbook for Science; each student has a Science workbook (an exercise book) which has notes that they make in class, including some photocopied worksheets and proformas that they have glued in. The photocopied worksheets come from other sources (not from SbD).

During Science classes, Year 7 students shift between the lesson materials (including videos) on *Sector* and the lesson materials from SbD, including the e-Notebook, which the teacher links to the *Sector* lesson by adding screenshots of the SbD guide. Students log-in and out of SbD independently, although one student commented in the focus group that this can be time-consuming during a lesson. In the Year 7 lesson observed, the teacher gave the students a choice as to whether they wrote their responses to the e-Notebook questions in their exercise book or typed them directly into the e-Notebook. The students who chose to type their responses said that they then download them from the SbD website and save in *Pages* on their iPads. If the teacher wants to mark their work, then the students upload the saved response to *Sector*. The Head of Science commented, "I definitely don't think we'd ever be a complete e-Notebook school for SbD; you just pick and choose when you need it".

Impact of SbD

Teachers' perspectives

The teachers like that SbD provides a structure and organisation for supporting the process of guided inquiry, promoting active student engagement in learning and deeper thinking. One teacher commented:

It's got the resources there, like videos, where students can go and gather their own information and then group activities where they can talk about ideas and discuss things. So rather than just listen to the teacher out the front explain things, and then copy notes down from the board or whatever, they're actually gathering information and discussing ideas themselves. So it gets them thinking about things.

The teachers reflected that the new and updated units are much more streamlined and "less clunky", with improved ease of use as resources are "located in one place and you know what it's about". One teacher commented that the Year 8 students have said that they prefer the new units, while another said in relation to the *Toys* unit, "I think there's been a big improvement to that. The way it starts off has changed ... The activity about making a paper helicopter reinforces the scientific method, the fair test. And it's a just a fun activity for Year 7 students to do. They enjoyed it and learnt a lot at the same time".

The teachers were not particularly enthusiastic about the e-Notebook, although it must be noted that there had only been limited use over the previous 6 weeks of the term, prompted by the invitation to participate in the research evaluation; "I really think the girls still prefer just to write things down still. Like, the e-Notebook doesn't allow them to draw diagrams". There was discussion during the focus group interview about the strengths and limitations of templates, which included the following exchange:

Teacher 1: "The e-Notebook is guiding you into a structure that is somebody else's structure, therefore you're taking away the skill from the student to organise their own thoughts in some way. And then they don't learn that skill if they're using an e-Notebook. With writing it down, as you saw today, some students decided to draw a table, some used sentences – I think discovering your own way to organise your notes is important".

Teacher 2: "It's taking the creativity away".

Teacher 1: "And the thinking about how to do that. It's like here the question, now the answer, here the question, now the answer – without that structure, they haven't learnt anything other than, 'Here are the facts'".

The teachers did not seem to be modifying or tailoring the e-Notebook to suit their students' needs, despite the editable format.

Students' perspectives

The students really like the practical lessons and experiments that characterise SbD units. In relation to the *Science of Toys* unit, students commented that they like "the prac lessons, and learning about forces, and actually putting them to the test" and "getting to experiment with different toys, testing them out and the forces they use". Others stated, "I didn't really know there were that many forces in toys" and "I think about a rubber duckie in the bath differently now". They have found the *Toys* unit easy to navigate and they like the colours used. The students really like doing the pracs and playing the interactive games themselves, rather than watching teacher demonstrations or having whole class participation in games on the whiteboard. They like using the e-Notebook, as they can check spelling accuracy and easily copy and paste the questions they don't understand into the Google search engine when they need help. Typing their notes in the e-Notebook makes Science different from other subjects. Organised students have created a Science folder on their iPad and then sub-folders for each Science unit, so that they can locate their e-Notebook notes. They don't use the e-Notebook when there are only a few questions to answer or a diagram to draw, as it's faster to write responses in their exercise book because logging in can be a "hassle". Some students indicated

that they like having all of their notes for a lesson in one place, so sometimes they prefer to write their response in their exercise book.

Suggestions for improvement

Teachers' perspectives

The teachers suggested the following improvements to SbD:

The nature and presentation of questions in the e-Notebook – “I think the questions themselves, some of them are a little bit dry, they’re just a straight question with no stimulus. Not all of them. I notice there’s one thing we’re doing in Year 7 at the moment on levers, and they have little diagrams of wheelbarrows, hammers, things like that. And that’s good, just to give those visuals, the graphics”. Another teacher commented that the template box sizes could be deceptive for students as to the length of answer expected. This teacher suggested that extended answers should be indicated by having a larger box, while short answer questions are indicated with smaller boxes, to guide the students as to expectations. Furthermore, some of the teachers said that the questions can be too difficult, such that even they sometimes have trouble answering them themselves, and are uncertain about where they’re leading. A final comment in relation to the e-Notebook questions was that these are not necessarily linked to the SbD guide, and seem “to go off on a tangent” at times.

Compatibility of interactive games and videos with iPads – There was a request to make interactive games and videos ‘iPad friendly’, as students cannot access videos and games that use *Flash* which results in whole class playing of games on the whiteboard, limiting active participation. One teacher commented that when the roller coaster one worked, the “vibe in the room with the girls playing was different” to whole class use. The girls do sometimes use other devices at home to access games, especially leading up to assessments.

Syllabus mapping – The teachers at this school already need to coordinate the NSW Syllabus, school-based programs, the MYP and SbD in planning units and lessons. They would really appreciate lessons in SbD being clearly linked to the NSW Syllabus, not just the Australian Curriculum. This would help them to identify outcomes that have been missed if they miss or leave out an SbD lesson. One teacher also observed that optional activities in SbD sometimes could be related to the test, so cautioned about the need to flag optional activities included in assessment so that teachers are careful to include them.

Differentiation – There was agreement amongst the teachers that it would be helpful to have options related to task differentiation, given that they teach mixed ability classes and students have diverse prior knowledge and experience.

Issues with Chemistry units – While the Physics and Biology SbD units were regarded as strong for Years 7 and 8 students, the teachers commented that they found aspects of the Chemistry units problematic. One teacher found that the order within SbD units does not always make sense to her, and her experience was that sometimes, a unit launches into something quite complex without the necessary lead in or background lessons; “They (students) need the literacy of Chemistry to be able to engage and explore”. There were comments that some of the experiments are too long to conduct in a lesson, and if stretched over two lessons, then it becomes impossible to fit the unit into a term. The same teacher advised that there are also pracs requiring some chemicals not permitted in schools in NSW (lead nitrate, potassium iodide).

Appearance of the new units – One teacher commented, “I think less is best. Some of the new units have too many words, are too busy and too splattered all over the page. Where do I start?” However there was some disagreement about this issue. Another teacher remarked that the

new units reflected visual literacy in the modern world, and suggested that the units be designed with awareness of increasing demands on visual literacy.

Casual teachers and unit delivery – “The girls love that they’re doing pracs every day in the SbD program, but when there’s a substitute teacher, then I have to skip ahead to a lesson that is more research-based and not hands-on, or find another resource or lesson”. This teacher commented that this can disrupt the intended learning sequence and impact on the flow in students’ learning.

Students’ perspectives

The Year 7 students have experienced problems when trying to go forwards and back on different pages in SbD, with the need to re-login. Some experienced difficulty downloading the e-Notebook, with one student sharing that she saved it in iBooks on her iPad but then has to go back onto the website to login again to access the questions. It can be frustrating not being able to access interactive games on their iPads.

Summary

The Head of Science’s enthusiasm for SbD appears to drive the use of the program in this school; “I love SbD ... I know SbD is a life saver for people who’ve come into the Department and they don’t do Science, they can pick that up and it’s got all the detailed notes and things for every lesson”. Another teacher commented, “I love the resource as a resource, not as a sole way of teaching”. The staff and students alike at this school appreciate the inquiry focus that SbD gives to Science teaching and learning, engaging students actively and promoting discussion and deeper thinking about Science.



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