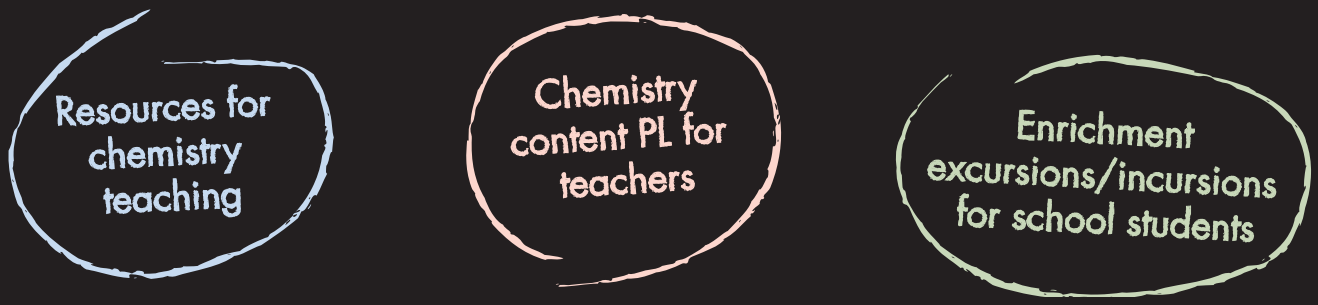

OUTCOMES OF A CHEMISTRY CONTENT PROFESSIONAL LEARNING SESSION: *TEACHERS' PERSPECTIVES*

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

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

BACKGROUND

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

DIVIDE AND ANALYSE PL

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

collective participation (Desimone, 2009), the purpose of Divide and Analyse was to address teacher content knowledge in these new curriculum areas. Teacher content knowledge is evidently important, with Shulman placing it at the top of his teacher knowledge categories (Shulman, 1987). Research into teacher content knowledge has shown that it encompasses more than mere mastery of the subject. For example, content knowledge of mathematics teachers was concluded to be highly specialised in that deep understanding is required to explain concepts to learners, and identify misconceptions (Loewenberg Ball, Thames, & Phelps, 2008). Thus, the Divide and Analyse PL content was not only something that teachers asked for, it had the potential to contribute to the development of chemistry teacher content knowledge.

As demonstrated by Maerten-Rivera, Huggins-Manley, Adamson, Lee, & Llosa (2015), an elementary teacher PL program spanning several years can have a positive impact on participants' science content knowledge. Divide and Analyse is an example of an immersion experience, which is an approach to content knowledge PL for teachers of mathematics and science that involves immersing teachers in content as learners themselves (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2009). Key elements of content PL experiences are that they involve content experts and are aligned with what teachers teach (Loucks-Horsley et al., 2009). Divide and Analyse addressed these elements, being facilitated by chemists (content experts) on new topics in the chemistry curriculum that teachers have to teach.

THE STUDY

The following research questions were proposed to address the aim of learning more about chemistry teachers' PL needs and how we might support them.

1. What influenced teachers to attend the Divide and Analyse PL?
2. What support is available for secondary chemistry teachers?
3. What do chemistry teachers need for their ongoing education and support?
4. How can chemists at Murdoch University help to meet these needs?

Information was gathered by inviting attendees to participate in the research by completing pre- and post-session surveys, and/or joining a focus group discussion. Nineteen teachers attended Divide and Analyse, fourteen completed the pre-survey, nineteen completed the post-survey, and sixteen participated in post-PL focus group discussions. Rating responses to survey questions were averaged and written answers to open-ended survey questions analysed for themes. Three focus groups facilitated discussion during the PL sessions, with participants' thoughts on their own PL needs emerging, as well as how these needs could be met. Discussions were digitally recorded and transcribed for analysis.

Themes in the focus group transcripts were identified using a systematic, iterative process. First, the transcripts were scanned by two team members independently to familiarise themselves with the data in the first cycle of the coding (Braun & Clarke, 2006; Saldaña, 2009). The two coders then discussed their thinking to develop an initial coding scheme based on the first cycle. The initial scheme was used to code one of the transcripts with ongoing comparison and refinement. Codes that reflected the teachers' voices were used to avoid paraphrasing. The iterative process involved revisiting the transcripts to ensure that the teachers' voices were present in the emerging themes. Themes were considered important if there were ten or more occurrences in at least two of the three transcripts. Participant comments from surveys and focus group transcripts are given in italics in the following sections.

INFLUENCES TO ATTEND THE DIVIDE & ANALYSE PL

Answers to the first research question regarding factors that influenced teachers to attend Divide and Analyse were gleaned from pre-PL survey responses. Responses related to teachers wanting to learn and obtain resources to help their students, their gaining experience with the instrumentation and analytical techniques that they teach, as well as the alignment between the PL content and the new curriculum topics that they have to teach. Survey responses also indicated lower levels of confidence in teaching new areas of the curriculum. The following written comments articulated teachers' concerns that the new curriculum contains content that is not accessible to them.

- *New sections in the course and schools don't have this sophisticated equipment.*
- *Understanding how these analytical abstract concepts can be applied to teaching in a high school context.*

Written responses about influences to attend introduced other themes that were further evidenced in the focus groups. Participants voiced motivation to refresh and expand their chemistry content knowledge and improve their teaching. These written responses show that teachers also wanted to attend the PL to investigate partnerships with the university.

- *See if I can obtain more links between my students and Murdoch University with the curriculum content.*
- *To develop a relationship between Murdoch Uni and [my school]. Potential collaborations between Uni and a SHS.*

AVAILABLE SUPPORT FOR TEACHERS' CHEMISTRY PL NEEDS

Responses to questions in the pre-PL survey gave clear answers to the second research question about available support for chemistry teachers. In summary, there is PL available for chemistry teachers related to the chemistry curriculum and general science teaching, but not chemistry content. Divide and Analyse clearly addressed a need in the area of chemistry content PL for teachers, and post-PL survey responses provided insight into the support it delivered. Participants gave high average rankings to most elements of the PL. The lowest ranked items were 'Real-world applications of analytical techniques' and 'How information could be applied in the classroom setting', indicating that the PL did not deliver as much as participants might have expected with respect to information that would actually help them teach chemistry. This was reinforced in some written responses to the post-survey item about the least valuable aspect of Divide and Analyse. Responses showed that participants perceived changes in their own interest, ability, knowledge and confidence to teach particular topics as a result of attending. The majority of comments about the most valuable aspect of Divide and Analyse related to seeing analytical instruments in operation. The direct relationship between the PL and the curriculum, with application to the context and hands-on experiences, was also seen to be of value.

WHAT CHEMISTRY TEACHERS NEED AND HOW UNIVERSITY CHEMISTS CAN SUPPORT THEM

The focus groups provided a wealth of answers to research Questions 3 and 4, which represents the major findings of the study. In describing these findings, we have made extensive use of the participants' voices from the focus group transcripts. These comments are shown as quotations in italics throughout the following sections. Previously identified as an influence to attend, desire to refresh content knowledge was also expressed in focus group discussions. However, it became very clear through the focus groups that teachers need support for their chemistry teaching as well as refreshment of content knowledge. They are enthusiastic about chemistry and want to make the subject relevant to their students, possibly encouraging more of them to continue studying towards achieving chemistry or STEM careers. There is tension between enrichment and ensuring that students are prepared for the exam. "*I think there's [sic] two issues as I see it … you've got the exam and then you've got the real chemistry where you'd love to get that interest [from the students]*". Teachers know that students could be interested, but they express frustration that they lack time to go into depth; "*You know the interest level and you haven't got time for the interest level*". At the same time, there is acknowledgement that "*… it's a balancing between ticking all the boxes and actually engaging the kids and actually getting them to take up a science career and saying, you know this is exciting …*"

Teachers told us they could enhance interest and make chemistry relevant to their students by including stories and contextual examples in their lessons, because "*… by telling a story you're actually opening up a wide vision …*" Teachers needed: "*… just basic real-life stories …, … the connection between their world and the world of chemistry. The relevance, relevance, yeah …*" Without this "*… you're just teaching theory to the kids and it's meaningless*". Divide and Analyse helped with this because "*… I've got no, you know, storytelling*", and "*... it [the PL] makes it more real for me and now we have to try and work a way of making it more real for our students*". One teacher said: "*So I think if we're able to come to these PLs, get our own experiences so we can tell the stories …*" Another explained how interaction with chemists helped with storytelling, "*we need to have relevant people that are actually doing it now ... that are researching it … its applications so that we can link into their knowledge …*". If teachers have relevant and contemporary stories to share with students,

they may be better equipped to balance the need to prepare students for the exam and make studying chemistry interesting.

A frequently occurring theme in each focus group was the need for quality chemistry teaching resources. Teachers had also expressed concern in the pre-PL survey about the accessibility of new curriculum topics in school classrooms, and how content areas involving laboratory instrumentation were to be taught. Teachers told us that videos and experiments on the topics of Divide and Analyse would be particularly useful in addressing the issue of covering this content in school classrooms. Development of video resources on Divide and Analyse topics is a way for university chemists to support chemistry teachers and work on this has commenced. If resources for chemistry teaching were to be developed, then a repository for making them available would have to follow. Various models for housing and dissemination of teaching resources were discussed in the focus groups and this will be pursued in future work.

It was also suggested that university chemists could support the teaching of new curriculum topics by having groups of school students experience a modified version of Divide and Analyse on excursion to campus. However, not all participants were in favour of this, citing various barriers to the organisation of excursions. These participants suggested support for teaching these topics through incursions, such as chemists visiting schools. The ideal support proposed by some teachers was a combination of incursion and excursion.

Chemistry teachers want content PL and Divide and Analyse addressed a gap in this area. "*So this is the first PL that I've actually been on in WA that has been content specific".* For one participant, the focus on content was "*really refreshing"* and another said, "… *I think it is the first one that's actually content specific"*. Teachers also want content PL to be facilitated by chemists because it allows for "… *being able to bounce off ideas off the actual experts it helps us even further our own understanding of the areas".*

Three themes of support for chemistry teaching emerged as the major findings of this study. University chemists can support chemistry teachers through collaborating to develop a repository of quality teaching resources, facilitating content PL, and excursions/incursions. These three themes contribute to teachers providing enhanced relevance to the study of chemistry through inclusion of examples and applications that facilitate context and storytelling in chemistry lessons.

COMMUNITY OF PRACTICE PARTNERSHIP

The idea of a partnership between chemistry teachers and Murdoch University chemists originating in the pre-PL survey was reiterated in focus groups. As one participant said, "*I just think I would like a relationship, a personal relationship with [the] Murdoch community … possible things that we can do, some collaborations …"* A focus group facilitator noted that participants were describing what sounded like a community of practice, and we started using the terms 'partnership' and 'community of practice' to describe the interaction between chemistry teachers and university chemists that developed through Divide and Analyse. Since a community of practice is a group of people with a common mission in what they do, and through their interactions the members learn more about how to approach what they do (Wenger-Trayner & Wenger-Trayner, 2015), we concluded that a community of practice partnership has evolved from Divide and Analyse. It is a community of practice because members share the goal of being effective teachers of chemistry who want to show that chemistry is interesting and encourage more people to study the subject. Through the partnership we learn together about how these common goals may be achieved. Further work to investigate the extent to which our partnership is a community of practice is planned. How this study contributes to previous work on community of practice is the subject of ongoing literature review and research.

The major findings of this study are brought together in the model shown in Figure 1, which describes the community of practice partnership, its members, outputs and flow-on effects. It is based on what participant teachers told us and is supported by literature. It illustrates how the themes of support for chemistry teaching identified by teachers in this study emerge from the partnership formed, and how these themes provide opportunities to build relationships. For example, the interactions that occur when community

members (chemistry teachers and university chemists) come together for PL sessions or excursions/incursions will maintain and enhance the partnership. The model also shows how the themes of support for chemistry teaching may contribute to the shared goal of enhanced participation in studying chemistry. Lack of student interest is one of many factors contributing to the acknowledged decline in studying science beyond the compulsory level at school (Lyons & Quinn, 2015). Student experiences of science classes as irrelevant, boring, and lacking in links to their own lives have also been reported (Lyons, 2006). Teachers told us that chemistry could be relevant and interesting for their students with stories and context. To facilitate storytelling and contextualisation, teachers want resources for chemistry teaching, content PL, and enrichment opportunities through excursions and/or incursions. This study has shown that there is scope for collaboration to produce fit-for-purpose resources to support teaching particular curriculum topics, with work towards this already beginning.

University chemists can work with chemistry teachers to provide content PL and this may contribute to enhanced student interest in the subject, as shown in a recent study where improved student perceptions towards science learning for primary students was linked to effective content PL for teachers (Smith, 2015). Therefore, Divide and Analyse will be offered on an annual basis. Other content areas where PL was sought were identified in participant feedback. A session on amino acids and protein structure has already been held and this will also be an annual event. Through the partnership, we will learn about other topics teachers need and refine PL offerings accordingly. Excursions and incursions desired by teachers can be facilitated through collaboration between university chemists and chemistry teachers. Collaborations of this type are pursued for a number of reasons, including the exposure of school students to real science and scientists, and encouraging the uptake of science careers (Cripps Clark, Tytler, & Symington, 2014; Lyons & Quinn, 2015). So collaborative excursions/incursions are a vehicle whereby the community of practice partnership can work towards the goal of enhancing participation in studying chemistry. A modified version of the Divide and Analyse PL course has already been provided for groups of Year 11 students on excursion to Murdoch.

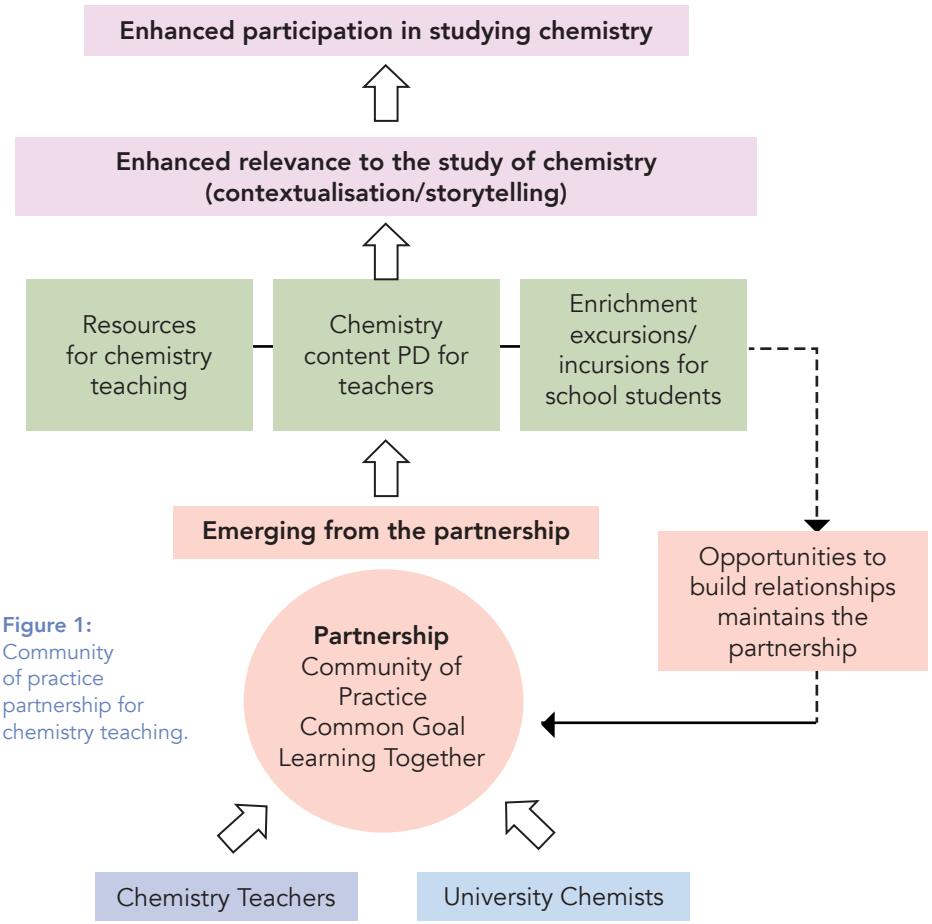

Figure 1: Community of practice partnership for chemistry teaching.

CONCLUSIONS

Teachers were motivated to attend Divide and Analyse by a desire to refresh and expand chemistry knowledge, as well as obtain resources and contextualisation examples to support their teaching. The need for PL related to new curriculum topics and lower levels of confidence in teaching these areas were also noted. Teachers also wanted to establish a relationship and collaborate with the university. There is support available for chemistry teachers, but Divide and Analyse addressed a gap in PL available for chemistry content. Furthermore, it was clear that teachers wanted more from the PL to support their teaching of new curriculum topics

as well as content knowledge and this will be considered in the design of future PL. Teachers want to make the study of chemistry interesting and relevant to their students, perhaps inspiring them to pursue further study or a career in the subject. They told us they could do this by including relevant stories and contexts in their teaching. Through partnership, university chemists can support chemistry teachers by developing resources for chemistry teaching, content PL, and excursions/incursions. These may help teachers with making the study of chemistry more interesting and relevant for their students, and this may lead to more students continuing to study chemistry. The model developed from the major findings of this study can guide outreach and collaboration between universities and schools. It highlights to universities what teachers need and want for their own learning and that of their students. It shows teachers ways in which support for teaching and their students can be facilitated through partnership with universities. While the model developed through this study is in the context of chemistry, it could be applied to any science discipline and thus serve as a model for how partnership between science teachers and tertiary scientists can contribute to enhanced participation in STEM.

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