Engaging with diverse communities: Analysis of a complex interaction

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One of the roles of a modern university is to engage with community as a co-creator of society’s collective knowledge. Engaging university-based research with diverse communities in such co-creation, however, is a complex task and finding appropriate community collaborators is difficult. This paper reports on one university’s engagement processes in a collaborative project designed to engage the diverse educational community across the footprint of six regional Australian universities. Network analysis was used to examine the complex growth of these collaborations and to determine the interdependence of the factors affecting the progression and effectiveness of project development. The analysis suggested that development of a well-connected network may actually be optimised if pre-service teachers, rather than teachers, were adopters. Continued network analysis appears to be a useful way of prioritising connections for new participants in order that they are connected across a sustainable feedback network.

Keywords: university, community, network analysis

Introduction

Australian-based studies have successfully demonstrated the importance of the ongoing interaction of university researchers and the broader education community, including both university and school educators, as co-creators of society’s knowledge in the area of science, technology, engineering and mathematics (STEM) (e.g., STEM, 2007; Tytler, 2007). Australia, like other industrialised nations, is not producing the mathematics and science teachers and students on which a sustainable economy depends for development (Chubb et al., 2012). The research/education/community nexus may be pivotal in changing this situation, and this type of collaboration nexus has already effected knowledge co-creation in the Australian educational context, for example, through development of educational resources and teacher professional development programs (e.g., Gahan & Lawrie, 2011).

It is difficult, however, using current methodologies to determine progression and effectiveness of any such knowledge co-creation, since the collaboration nexus is essentially a complex system with typically unpredictable endpoints or continuances. Despite this apparent drawback, complexity theory has provided a useful means of examining collaborative interactions in educational contexts, where the complex organisation within groups develops through the internal interactions of members (e.g., Davis, Sumara & Luce-
Network theory has proven useful as a basis for examination of complexity and network analysis, a widely used method based in network theory (e.g., Newman, Barabási & Watts, 2006) may be useful, therefore, in examining collaboration progression and effectiveness.

In this study, network analysis is used to determine whether a collaboration nexus was effective in engaging community by examining the pattern of connections between collaborators based on a series of face-to-face meetings directed at project outputs for a Virtual Centre. This Centre was developed as part of the project, Regional universities network (RUN) maths and science digital classroom: A connected model for all of Australia (the RUN Digital Classroom), a project designed to engage diverse communities in an educational context. The project involved a large number of stakeholders acting together in a dynamic way as the project progressed over a two-year time frame.

**Collaboration and network development**

The primary objective of the RUN Digital Classroom project was to use the research/education/community nexus to co-develop resources for building the theoretical and pedagogical skills of school teachers in order to improve the delivery of mathematics (maths) and science subjects in the regional high schools that lie in the educational footprint of the six RUN partner institutions. The project was built around the formation of innovative partnerships between universities, schools, and other relevant organizations, including partnerships between research scientists and mathematicians and the education community more broadly.

The Regional Universities Network is based in eastern Australia and comprises Southern Cross University (SCU) and the University of New England (UNE) in New South Wales, Central Queensland University (CQU), the University of Southern Queensland (USQ) and the University of the Sunshine Coast (USC) in Queensland, and Federation University Australia (FedU) in Victoria. The partner universities are all headquartered in regional Australia and all have extensive experience in the provision of training and professional development, both pre-service and in-service, in mathematics and science teaching. The following three organizations were also involved in the project; The Commonwealth Scientific and Industrial Research Organization (CSIRO), The Australian Mathematical Sciences Institute (AMSI), and The Primary Industry Centre for Science Education (PICSE). The project partners are all organizations with established track records in endeavors to increase engagement with mathematics and science, including successful professional development and community outreach programs run by AMSI and PICSE.

In order to outline the progression and effectiveness of ongoing collaboration and knowledge co-creation, the focus of this paper is on description of networks that support the progression and effectiveness of the Virtual Centre and the RUN Digital Classroom, as developed at SCU in co-operation with PICSE. Several of the educators and scientists are involved also in the ongoing 3-year RUN project It’s part of my life: Engaging university and community to enhance science and mathematics education (http://scu.edu.au/education/index.php/57/) led by SCU (e.g., see Woolcott, 2015).

Although SCU is a small regional university, it has several science research areas that are rated as ERA 4 or 5 (the Excellence in Research Australia ratings are reported on a 1 to 5 scale, with ERA 5 being well above world standard and ERA 4 being above world standard,
The collaboration network development, therefore, was scaffolded by expert knowledge input from high quality university research scientists. Expert pedagogical input provided by university educators experienced in online education. For the RUN Digital Classroom project, university scientists and educators were initially engaged in discussion, seminars and workshops in order to determine what aspects of science they could bring into a Year 9 or 10 classrooms (middle secondary). A focus that emerged from these meetings was the way that scientists pose and solve problems, and three 5-lesson teaching sequences were developed that combined this aspect of scientific research with regional topics that were deemed engaging to school students and teachers in the region.

Lesson development was facilitated by subsequent meetings of scientists and university educators with secondary science and maths teachers from five high schools in the SCU educational footprint. These teachers were involved in several discussions and workshops dedicated to gauging student interest, the appropriate educational level at which to pitch the digital lessons, and the relationship of the lesson material to the curriculum. Teachers involved had recently developed teaching programs for Science and Mathematics based around Stages 3 and 4 of the revised NSW Syllabus, based on the new Australian K-10 Curriculum. A particular feature that arose from this collaborative interaction was a desire to portray scientists as dedicated but vibrant personalities who lived full and interesting lives outside of science. The collaborators agreed that a focus on community interests across the region would be advantageous in engaging school students.

The project outputs developed from these interactions were three lesson sequences, each consisting of digital resources for five lessons, based around the following three areas of community interest.

- When I am not surfing I do research on elements.
- How fast do humpback whales travel up the east coast of Australia?
- Going with the flow? Water across the Richmond catchment.

Production of these sequences involved further collaborations between university educators and teachers as well as with video producers. Although each of these lesson sequences took different approaches, depending on the scientists and video producers involved and their expertise and expectations, each sequence was accompanied by an introductory video involving scientists and research that embraced elements of the themes in each of the five lessons. As an illustration, the lesson sequence, When I am not surfing I do research on elements, showed how four scientist could enjoy their life in the region while at the same time solving scientific problems of interest to the education community in the SCU region. Collaboration with all parties confirmed that this was a positive approach to the agreed focus of the project.

Method

This paper reports specifically on the development of knowledge co-creation networks during development of the lesson sequences, with a view to examining the key features of the networks formed, across the SCU educational community, between research scientists, university educators and high school teachers as well as the video producers. The methodology is based in network theory, which concerns itself with understanding how the features of a complex system arise from their underlying network structures, rather than with specifics of the features and interactions. This theory is typically applied as network analysis (NA), where the system is reduced to a set of objects called nodes and a set of relationships called edges that link the nodes together (e.g., Newman et al., 2006). NA is a powerful and
well-tested tool for representing and examining relationships in terms of system connectivity, and follows a well-established analytical methodology that allows qualitative mapping and quantitative analysis of the edges and nodes (Newman et al., 2006). Network analysis has been applied across a number of differing disciplines, largely because the rules governing network relationships remain independent of the nature of the subjects being linked (Hanneman & Riddle, 2005). NA is used here to complement the description of the development of the collaboration provided above and to provide insights into the future development of the collaborative network. In particular, the analysis is used to examine project progression and effectiveness and to outline the potential future interface of outputs with end users.

NA is used here to examine the following research questions.

*What indicators can be used to determine progression and effectiveness based on analysis of face-to-face meeting of project participants?*

*What members of the education community would best maintain project sustainability as project adopters within the co-creation network?*

The network analysis used a matrix of coded data generated from records of project-related face-to-face meetings of participants during project development (see exemplar matrix in Table 1). There were 40 meetings recorded for this analysis, with a total of 41 participants. In this connectivity matrix, participants were coded ‘1’ if they attended a particular meeting, and as ‘0’ if they did not attend that meeting. This matrix was subjected to a process of network analysis to produce graphical representations and associated network metrics in the software package UCINET (Borgatti, 2012). The network maps generated (e.g., Figure 1) consisted of participants functioning as nodes, with edges (connections) determined by face-to-face meetings between participants. Network representation follows Woolcott, Chamberlain, Scott and Sadeghi (2014) and the network metrics of Density and Centrality, indicated to be key metrics in NA (Hanneman & Riddle, 2005), were applied here to the undirected network data following Woolcott, Sadeghi and Chamberlain (2014).

<table>
<thead>
<tr>
<th>Participant (code)</th>
<th>Meetings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
</tr>
<tr>
<td>Scientist 1 (S1)</td>
<td>1</td>
</tr>
<tr>
<td>Scientist 2 (S2)</td>
<td>1</td>
</tr>
<tr>
<td>Educator 1 (E1)</td>
<td>1</td>
</tr>
<tr>
<td>Educator 2 (E2)</td>
<td>1</td>
</tr>
<tr>
<td>Teacher 1 (T1)</td>
<td>0</td>
</tr>
<tr>
<td>Teacher 2 (T2)</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 1. An example showing the format and coding in the matrix used to record participation in the first 40 face-to-face meetings of the project.

**Results and discussion**

Network analysis enabled the development of indicators of project progression through examination of a sequence of visual overviews (snapshots) of the interconnectivity (face-to-face meetings) of the participant interactions. An example from the suite of 40 network maps produced is given as Figure 1, a snapshot taken near the end of output development (after meeting 40), but before dissemination across the broader community.
The advantage of visualizing these interactions as a suite of network maps is that key people, those found at hubs in the collaboration network, are readily apparent at each stage of the project. Hubs are nodes where a large number of edges meet, and which are important links across the network – the network is easier to traverse (it involves a shorter number of nodes, on average) from any single-connection node by going through one of these hubs. As may be expected, the two key people were the two project organisers, educators E1 and E2, and they became more important as the project progressed. The map shows that some scientists, however, also became key people, largely because they had direct involvement with a number of teachers. The connections between certain of the participants is also an important feature of this network, where some high school teachers (T) are linked to a small group of educators (E) and scientists (S) who had prior contact with each other. There are stronger links across some such groups, and members of these groups had contacts with one or both of the video producers (V).

Network analysis enabled also the development of indicators of project effectiveness through examination of how to sustain the network as well-connected. Effectiveness was measured through determination of how relationship across the network facilitated the knowledge co-creation nexus being extended to an increasing number of participants in the education community, and determination of whether the developing network allowed feedback to reach all participants. Teachers may be considered to be the apparent choice as output adopters, since they would initially be able to have contact with university scientists and educators. The network visualisations indicated, however, that the network would need to be developed so that the key people did not remain as hubs, or even as important nodes. If this was to remain the case, then all of the adopters would need short path connections to particular university educators and scientists and this is not sustainable in terms of university researcher and educator involvement with large numbers of teachers.

The analysis at this stage of the project suggested that, in order for the network to remain well connected and, therefore, effective, a potential direction for progression of the collaboration
nexus is to look for alternative adopters. This meant that network expansion should be less reliant on the hubs of key people and network theory suggests that one way to do this is to create weak links. Weak links are known to be important in network stability and they are a crucial addition, therefore, as a network grow in size (Hanneman & Riddle, 2005). Such weak links in this collaboration network would allow information to move across connections, in either direction, without necessarily involving hubs. On this basis, project sustainability, since it is based in community interaction, would be more effective if participants are added at nodes so that weak network links (connections) are formed.

Although this project was developed with teachers considered as the primary target adopters, the NA suggests a surprising change in progression—the ideal target adopters may be, in fact, pre-service teachers. This group within the education community has contact necessarily with university educators and researchers, but there is a limited, and hence sustainable, number of such pre-service teacher contacts each year. These pre-service teachers, as new nodes in the collaboration, could act to form weak links in the developing network, but, over time, would also be able to form links with teachers during and after their practice teaching experiences. Thus, the network could be expanded in a sustainable way that facilitates feedback and obviates hubs.

The need for this innovative development is supported by the network metrics, as the Betweenness score (related to how important the node is in traversing the network) of two of the educators E1 and E2 became much higher than other participants with network expansion, as would be expected. Additionally, as the network expanded the Density dropped off, as would be expected also in such an expanding network. The progressive development of a well-connected network, however, may actually be optimised if this was not the case. For example, if the pre-service teacher group was utilised as adopters they could form an interface between the educators and teachers which decreases network Density and Betweenness of E1 and E2. Importantly, the network metrics and visualisations indicate that the network will not be de-stabilised as it develops if key people are replaced by other scientists and educators. Continued network analysis would be a useful way of prioritising connections for new participants in order that they are connected across the network as weak links.

**Conclusion**

The university collaboration nexus described for the Virtual Centre aimed to engage teachers, and their students, in an expanding knowledge co-creation network that involves information transfer across the entire collaboration nexus, including feedback to university partners from the broader education community. The use of network analysis to examine the collaborations at SCU provided insights into project development. The analysis at the pre-dissemination stage of development suggests that project effectiveness may benefit from ensuring that the current hubs become less important distributors of information as the project progresses across the SCU educational footprint. The analysis suggests, therefore, contrary to the project’s expected progression plan, that new participants in this particular collaboration nexus should be added as weak links that circumvent hubs. Pre-service teachers are a potential source of such links.

The findings from this study suggest that development of the SCU Virtual Centre project, as influenced by the network analysis, may be a model for development of the collaboration nexus at each of the partner universities – the development of these collaborations has so far
been similar in many ways. Network analysis may prove useful, therefore, in examining project progression and effectiveness for other components of the project. On a broader scale the model used here has potential for assessing the RUN collaborative networks as a whole as the outputs are combined within the Virtual Centre. In the longer term, therefore, the process outlined in this study suggests a method for optimizing project dissemination so that it facilitates feedback across the network.

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References