Creating a sustainable STEM Community of Practice

This research is an investigation into the development of a community of practice that nurtures and supports educators through social media.

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The Stem.T4L Project was formerly known as STEMShare Community

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EXECUTIVE SUMMARY

This research explores teachers' involvement in stem.T4L social media groups between January and June 2019. Shortly after the launch of the project in 2018, stem.T4L social media groups were created in Facebook, Twitter and Yammer in order to provide teachers with a collaborative space for professional learning in STEM education. Using a combination of survey data and social media 'postings' (an umbrella term which encompasses users' posts, tweets, replies and comments), we examined the extent to which teacher learning was taking place within this online space and how it served as a community of practice (CoP) for NSW STEM educators. We found that stem.T4L social media was functioning as an effective online STEM CoP, and that the community was already showing signs of being a collegial and productive platform for teachers' professional learning.

Key findings from the research include:

- We observed a total of 2,644 postings on stem.T4L social media (Facebook, Yammer, and Twitter) from January to June 2019, with over 4,500 members and followers. Teachers accounted for the majority of active contributors (59%), followed by stem.T4L admins (21%) and leaders (16%).
- The interaction patterns between social media users suggested that 42% of interactions were *between* teachers and 52% involved teachers and a stem.T4L leader or admin. This suggests that while a teacher-centred community of practice is clearly developing, stem.T4L team members are also playing an important role within the community.
- Thematic coding of postings revealed the use of the stem.T4L social media by the members. 'Socialising' was the most frequent type of use (33%), where members offered each other encouragement or general support. Problem-solving was the second most frequent, indicating that 24% of postings involved members offering solutions to technical problems or responding to requests for creative and pedagogical suggestions. Requesting support (18%) and sharing resources or experiences (13%) were the other professional uses of social media.
- 55% of the total postings could be classified as 'active learning'. This finding suggested that the members used stem.T4L online groups as an opportunity to receive informal professional learning, where they could remotely connect to other educators to solicit advice, share their classroom experiences, and engage in collaborative problem solving. This finding further confirmed that the online stem.T4L community had *a shared practice* as an effective CoP should, and educators were contributing to the construction of STEM knowledge.
- 45% of the postings could be classed as 'networking', suggesting the *community* characteristic of the online CoP, as the members remotely connected to other members to build relationships.

INTRODUCTION

Communities of Practice (CoP) are "groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly" (Wenger, 2006, p. 1). In such communities, learning is facilitated through social interactions as members participate, share information, ideas and resources, observe, provide feedback and refine knowledge (Bernard, Weiss, & Abeles, 2018; Lave & Wenger, 1991). However, the notion of a community of practice cannot be applied to *any* group of people that gather together to achieve certain goals. Rather, a CoP has three unique characteristics that set it apart from any other forms of communities: it has a *domain*, centred around a shared commitment and competence; it is a *community*, in that members build relationships with one another, help each other, share information, and engage in joint activities; and it involves a shared *practice*, where members contribute to a knowledge base (Wenger, 1998, 2006). A CoP that develops these three features can come in different forms. They can be small or very large, local or global, formal and supported with a budget or informal and almost invisible, and finally face-to-face or online (Wenger & Wenger-Trayner, 2015).

Within the education sector, CoP have the potential to develop online and function as professional learning (PL) opportunities for teachers. In fact, there is a large body of research that indicates effective teacher learning can take place in an online CoP (Carpenter & Krutka, 2015; Wesely, 2013). For instance, social networking sites (SNS) such as Twitter and Facebook can engage teachers in "informal", "meaningful", "up-to-date", "just in time", and "personalized" PL with "instant access" to information (Britt & Paulus, 2016; Carpenter & Krutka, 2015; Davis, 2015; Pluss, 2008; Wright, 2010). Social media platforms also play a role in minimizing teachers' professional isolation and burnout (Meyer, 2012). In other words, a CoP that forms through SNS enables teachers to make social connections, engage in shared learning, reflect about teaching practice, collaborate, and receive emotional support (Macià & García, 2016). The increasing popularity of SNS as an avenue for teachers' professional learning can also be attributed to the need for educators and policy makers to eliminate time and space constraints, offer a more participatory way of learning and enable inexperienced teachers to seek guidance and mentoring (Gentry, Denton, & Kurz, 2008; Harasim, 1993; Wade & Fauske, 2004).

Despite their notable contributions, at times online CoP fail to create meaningful professional learning for teachers (Karagiorgi & Lymbouridou, 2009; Xing & Gao, 2018). More specifically, the full potential of an online CoP may not be realized, for instance, when teachers' participation is uneven, meaning a large number of members are observers or "lurkers" and do not actually contribute to discussions (Greenhalgh & Koehler, 2017; Nonnecke & Preece, 2003). Or, when instead of offering active support, teachers contribute only by posting greetings and courtesy tweets (Xing & Gao, 2018). As such, the majority of studies on online CoP examine the nature and quality of the conversations taking place amongst teachers in order to measure the effectiveness of virtual professional learning (De Wever, Schellens, Valcke, & Van Keer, 2006).

One of the objectives of stem.T4L is to "create a sustainable STEM community of practice within the NSW Department of Education". To this end, social media platforms were created in Facebook, Twitter and Yammer to facilitate teacher participation, collaboration and sharing. This research was designed to examine teachers' involvement in stem.T4L social media to ascertain whether it serves as a CoP and, if yes, how teacher learning takes place within this community. It is worth noting that this research is not an evaluation of stem.T4L social media groups per se but rather it explores the extent to which the project has lent itself to an online STEM CoP, where teachers can easily engage, collaborate and grow professionally. The research questions raised in this study included:

Research questions

1. How does STEM learning take place in stem.T4L social media?

2. To what extent is stem.T4L social media characteristic of an online STEM CoP?

RESEARCH FINDINGS

1.1. SURVEY DATA

The dataset used in this research was mainly derived from social media (Twitter, Facebook, and Yammer) postings on stem.T4L groups made between January and June 2019 (Term 1 and Term 2). Additionally, to crosscheck the findings, we investigated teachers' professional use of social media through an online survey. This included open-ended responses on why teachers collaborated through stem.T4L social media or why they did not, in addition to some quantitative data on the frequency of their use. In total, 111 teachers who took the online survey responded to the question: 'did you use stem.T4L social media (Twitter, Facebook, and Yammer) to communicate/collaborate with other teachers?' 71% of teachers (n=79) replied 'No' to this question. These respondents were then prompted to cite their reasons as to why they did not. Through thematic coding we clustered these responses around 6 reasons which describe why some teachers did not participate in stem.T4L social media. Some examples from each category are provided below:

Reasons for lack of involvement in stem.T4L social media

NOT A SOCIAL MEDIA FAN/USER

These teachers cited their disengagement or lack of interest in social media in general (i.e. outside of stem.T4L considerations). They mentioned that they did not have social media accounts or did not use social media regularly, for personal or professional usage. Examples included:

- *I don't use social media*
- *Don't go on social media. Experience through conferences and websites available.*
- *I don't use social media. However I did email with another tech teacher.*
- *Has no value*
- *I don't have social media*
- *I'm not on social media.*
- *Not a big social media user.*
- *I've got my own team which relates directly to the students in my school. I find teachers on these sites just want to show off the amazing things they can do and can't actually provide any help if you needed it.*
- *Because its a waste of time you get bullied*
- *I don't have social media accounts*
- *I don't use social media*
- *Do not use social media*
- *I don't use social media at all and do not have an account for any of the options.*
- *Not something I use much.*
- *I don't often use social media to connect with people that I do not know.*
- *I am not a fan of Social Media.*
- *It is not something I use regularly and was not a priority.*

TIME CONSTRAINTS

Some other teachers pointed out that for them it was "a time factor". Since social media would "take time to search and collaborate", they preferred to use their time to "self-educate".

- *Social media still takes time to search and collaborate and primary teachers are time poor as it is.*
- *I did not have time to collaborate on Social Media.*
- *Time*
- *Limited time.*
- *Probably a time factor - so much other stuff to do*
- *Didn't have time to and didn't know you could.*
- *We had limited time to use the kit and as it was our first time with this kit we wanted to try it out first. I also do not use social media very much.*
- *Time and access in a school environment.*
- *Who has time to go on social media?*
- *I was using my prep time to self-educate rather than using social media. I had little understanding before I taught the unit.*

PREFERRED OTHER TYPES OF COLLABORATION

A few teachers mentioned that they opted to collaborate via email or face-to-face, which appeared to be easier for some teachers. This might suggest some technical difficulties or unfamiliarity with some aspects of social media – Twitter's hashtag and re-

tweet format, for instance. Some teachers clearly appear to prefer forms of digital communication that mirror traditional forms of communication (e-mail or e-conferences, for instance). One teacher also suggested using a "platform that is part of existing ones like Google/MS Teams" to make communication easier. Some examples include:

- *Most of my collaboration was face-to-face*
- *Found it difficult to engage with and have multiple existing platforms to communicate with. It would be beneficial to use a platform that is part of existing ones. Google/MS Teams.*
- *I emailed any ideas/lessons I completed within my stage and school.*
- *Used face-to-face, initial set-up e-conference and Internet for information.*
- *I find it easier to ask the question via email or call to the STEM leaders*
- *I did email past teachers for assistance*

NO NEED TO COLLABORATE

Interestingly, some teachers reported that they had no reason to collaborate with other teachers because they were confident users of the stem.T4L kits:

- *I didn't need to*
- *Due to face-to-face training and how to videos and learning resource centre, I didn't feel the need.*
- *I do not think it was necessary.*
- *I had no need to collaborate with other teachers from other schools. We are a big faculty and plenty of teachers here to collaborate with.*
- *I felt confident creating a program that would benefit my students.*
- *Focused on my teaching and not collaborating outside the school.*

NOT BEING ENCOURAGED BY THE SCHOOL

School climate was a limiting factor for some teachers in their decision not to use social media. They said they were not being encouraged by their school to join stem.T4L social media and, in one instance, a teacher commented that social media use was "centralised" in their school "for privacy". Other examples included:

- *Our school does not tend to use social media.*
- *Centralised in school for privacy.*
- *We are not encouraged to communicate using social media*
- *Not encouraged to use social media*
- *No access at school*
- *Our school does not use social media to collaborate with other schools.*
- *We post things on our own Facebook page*

UNAWARE OF STEM.T4L SOCIAL MEDIA

Finally, some teachers were simply unaware of stem.T4L social media.

- *Because I was not given information about any groups on social media platforms that may be relevant. The only group I am aware of was in Microsoft Teams.*
- *Did not know was option*
- *Was unaware.*
- *I did not know about connecting with STEM share using social media.*
- *Did not know we could or should.*
- *Did not know it was needed*
- *Never really thought about it.*
- *Didn't occur to me*

Frequency of using stem.T4L social media

29% of teachers (n=32) indicated that they used social media sites to connect to other teachers. Within this group, we measured the frequency of professional use of social media, with a response range of *frequently* (once a day to several times a week), *occasionally* (once a week), *sometimes* (once every few weeks to once a month), and *rarely* (once every few months). As Figure 1 shows, in most cases the users posted either sometimes (37%) or occasionally (34%).

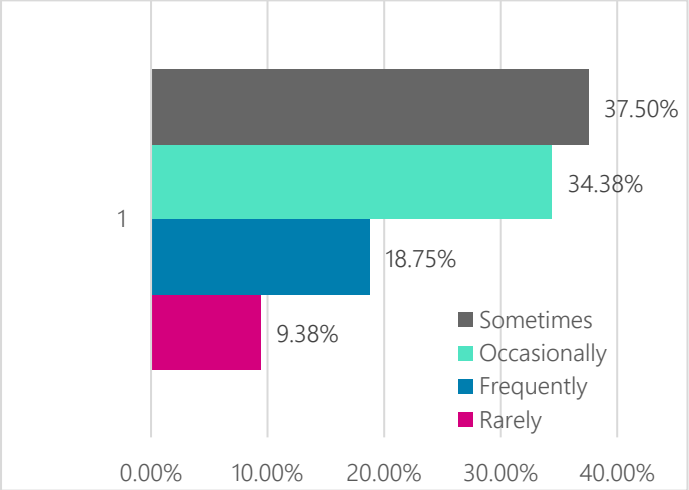


Figure 1. Frequency of using social media

Teachers' uses of stem.T4L social media

In order to distinguish mundane activities from those associated with professional learning, we asked teachers to identify the purpose behind their use of social media. We found that the primary reasons centred around (1) Seeking support/ideas and (2) Sharing (classroom) experiences. Teachers explained that they used social media to "see what other schools were doing with the equipment", "find lesson ideas", "learn about problems other teachers encountered, "seek assistance", and "share what [they] learnt in class" (see the examples below). From the 32 examples that teachers provided to show how they benefited from stem.T4L social media sites, only 2 were categorised as "socialising". The majority of responses were clear examples of collaboration and sharing of resources and information, which are directly linked to teacher learning in an online space. Some examples of teachers' professional uses of social media included:

SEEKING SUPPORT/IDEAS

- *Teaching Ideas.*
- *Find interesting lesson ideas etc.*
- *Ask questions.*
- *To gather units/challenges for students along with activities that I could complete to support my understanding.*
- *Seeking information and learning ideas.*
- *To look for resources and teaching ideas.*
- *Networking with other teachers, getting ideas for lessons and things to share with students.*

- *Get ideas and see what other schools were doing with the equipment, ask questions and collaborate.*
- *Finding activities and trouble shooting.*
- *To improve knowledge, share ideas and resources, and to manage challenges.*
- *Teaching ideas.*
- *Watching how other schools were using the kit, and to find lesson ideas. I asked a couple of questions to see if other teachers had ideas but the response was limited.*
- *To learn about problems other teachers encountered and ideas.*
- *How to setup. Issues with 3D printing*
- *; looked online at other non-stemt4l resources - lifting of the 3D print from the surface….*
- *To seek assistance.*
- *See what activities other schools were doing successfully.*
- *For keeping up to date as to what other educators where using the kits for.*
- *To answer questions that I cannot answer using YouTube or google.*

SHARING (CLASSROOM) EXPERIENCES

- *Posting activities of students using the kits. Sending resources that I generated to people who were interested in what the students were doing.*
- *To share experiences and offer advice.*
- *Used Yammer, Twitter and Facebook to share lesson ideas and share technical knowledge of the equipment.*
- *Sharing of resources, ideas and experiences*
- *Posting about students using the kits. Looking at what other teachers were doing*
- *Communicating use of kit in school with our community*
- *To share what we learnt in class*
- *Share ideas and questions.*
- *To show what we were doing with the kit.*

1.2. SOCIAL MEDIA DATA

To promote teacher collaboration and active participation in stem.T4L, social media platforms (i.e. Facebook, Twitter, and Yammer) were created in the early stages of the project, which as shown below, now has over 4,500 members (June, 2019).

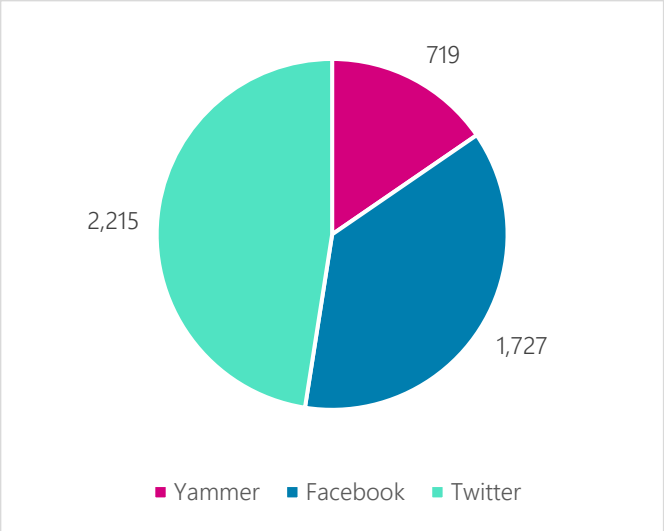


Figure 2. stem.T4L social media followers/members

To examine the nature of the conversations happening within this semi-structured virtual community, we retrieved all comments, postings, tweets, re-shares, and tags posted during Term 1 and Term 2, 2019 in Yammer, Facebook and Twitter. The dataset we built was comprised of a total of 2,644 postings (Facebook=1,047; Twitter=584; Yammer=1,013). Given the substantial volume of data, we analysed data from each site separately using coding frames that were consistent across platforms and then aggregated the overall findings to present in this report. Looking at the data, the first question that we asked ourselves was: who were the key contributors of the postings in each site? Teachers, stem.T4L leaders or any other stakeholder groups? Also, we wondered when a teacher raised a question in order to obtain ideas and support, who volunteered to reach out to them (i.e. interactions *between* contributors)? Was it other teachers who provided them with information, or was information provided by stem.T4L leaders and project staff? In other words, did teachers consider themselves a member of the stem.T4L community and as such felt incumbent on them to support each other, or was there a heavy reliance on the stem.T4L leaders to contribute? The answer to these questions would help us measure the extent to which NSW teachers were active members of the stem.T4L online community and considered it as an opportunity for informal professional learning.

Equally important was the percentage of postings that could be grouped as "cognitive and interactive" or "social" (i.e. use of social media). When teachers engage in the mutual construction of knowledge by sharing information, clarifying ideas, strategizing, showing agreement, testing and modifying proposed ideas, and finally applying newly constructed knowledge, they are in the cognitive and interactive domain, where learning takes place (Henri, 1992; Benbunan- Fich, Hiltz, & Harasim, 2005; Gunawardena, Lowe, & Anderson, 1997). However, when teachers are more inclined to use social media to socialize through facilitating, community building, and showing support, they remain in the social domain. Although this domain does not generate content-related ideas and therefore is not directly related to learning, it can encourage a sense of belonging (Henri, 1992). What was desirable was to see teachers' strong presence in the cognitive and interactive front, which could be indicative of the learning that was taking place within the community. The following section summarises key findings of this research, which carry significant implications for the stem.T4L project.

Contributors of social media

As the first step, we recorded the number of unique contributors who had made postings from 1 January to June 30, 2019 (the set timeframe used in this research) in each site. In total, we found 462 unique contributors that had posted at least once[1]. As depicted below, Facebook had the highest number of contributors (n=212) and Twitter, despite attracting the largest number of members (n=2,215), had a lower number of contributors (n=152).

Given the total number of members or followers across the three social media platforms (n=4,661), it appeared that a large number of members apparently lurked (i.e. read postings but did not post or comment). This dynamic was also evident when we compared the number of viewers with the number of comments received for particular posts. For instance, in Facebook, the highest number of comments recorded for a post was 21. However, the very same post had 1,087 views. Similar patterns emerged in Yammer, where the most commented post generated 25 comments (from 5 unique contributors) yet was viewed by 114 users.

This finding is consistent with prior research into online CoP: online discussion spaces often involve a disparity between a large volume of observers and a smaller group of active members (Nonnecke & Preece, 2003; Xing & Gao, 2018). For example, Greenhalgh and Koehler (2017) found that less than 11% of their participants posted original tweets and the rest only retweeted or "liked" posts.[2] Similarly, our research showed that the 2,644 messages posted across the three sites were generated by 17.64% of members and 82.36% were only viewers of the posts. However, we tend to agree with those researchers who believe these "silent readers" still benefit from the discussions through this passive form of engagement (Lantz-Andersson, et al., 2017). Also, they are likely to make contributions to the communities eventually, as peripheral participation is just one step away from posting and becoming more deeply engaged in discussions (Seo & Han, 2013; Zuidema, 2012).

Now the question was: who were the 17.64% that posted on stem.T4L social media? To answer this question, we looked at the contributors in each platform separately and found that there were three main groups: teachers, administrators, and stem.T4L Leaders. Admins and stem.T4L leaders were the moderators of the online community and their role was to provide constant support, guidance and encouragement. We also found a small group in Twitter and Yammer that we labelled as 'Other'. This group consisted of businesses that partner or collaborate with stem.T4L (such as developers or manufacturers of technology used in the stem.T4L kits), Department of Education users who are external to stem.T4L, or parents of students (usually via a school tweet). Another small percentage of postings in Facebook and Twitter originated from schools. Figure 3 below describes the proportion of contributor types across the 3 platforms. Teachers accounted for the majority of contributors in each site. Put differently, out of 2,644 messages, teachers contributed 1,565 postings (59%), admins were the second largest group of contributors (565 postings or 21%) followed by leaders (433 postings or 16%).

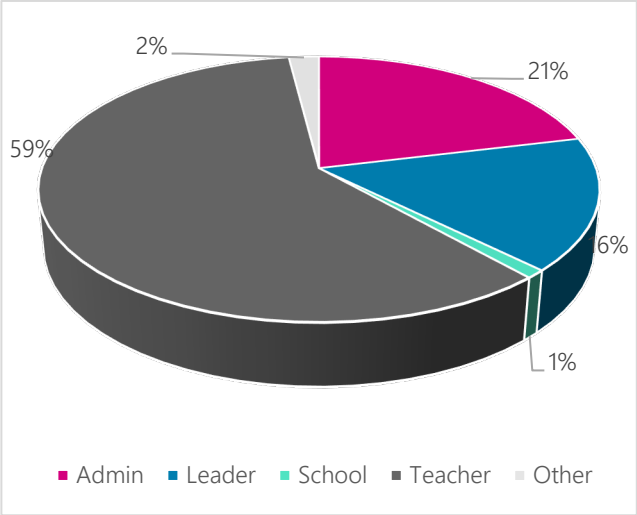


Figure 3. Contributors of stem.T4L social media: Total

[1] The total figure of 462 unique contributors is not a sum of the three platforms. Some users posted on more than one platform, so the total figure was adjusted for these duplicates.

[2] In order to focus on more detailed engagements between users, we have limited our analysis to verbal comments or tags, and did not record details on the number of 'reacts' (e.g. likes, re-tweets) a post received.

When we compared the contribution of each group across the sites, we observed that although teachers were the main contributors overall, in Facebook and Yammer they played a much more substantial role (65%) compared to Twitter (38%). Also, 'admins' had a stronger presence in Twitter (34%) than in any other site. This finding can perhaps be attributed to the overarching dynamics of Twitter as a social platform: the character limit on tweets can direct discussion into a more abbreviated form, while the hashtagging and tweeting format is arguably less user friendly for more infrequent social media users. The higher proportion of 'other' users on Twitter is due largely to it being an open community, compared with the Facebook group (where users request membership) and Yammer group (which is accessed using a DoE account).

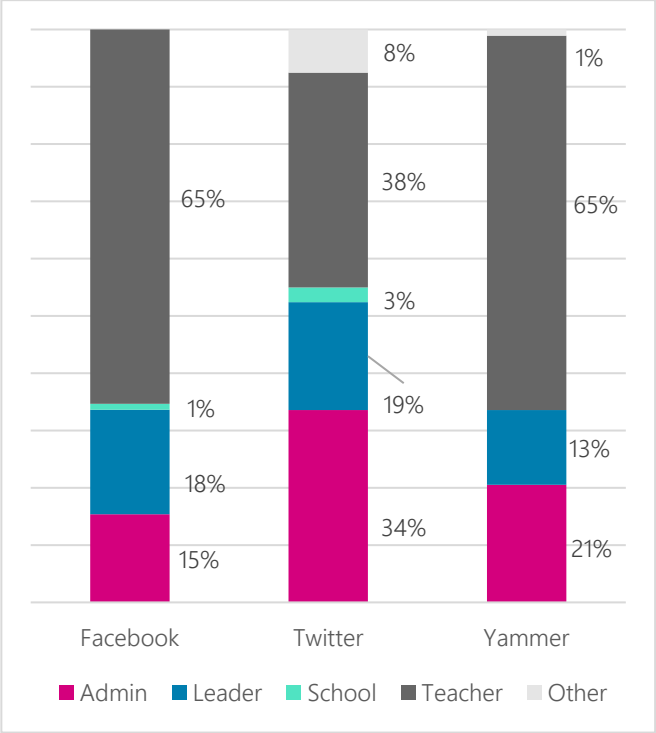


Figure 4. Contributors of stem.T4L social media by platform

As discussed above, CoP members have a shared commitment to contribute to the knowledge base so that a shared repository of resources can be built (Wenger, 1998, 2006). Based on the number of contributors we can conclude that teachers had an active involvement in the stem.T4L online community and were core participants in online discussion. But the question remained: did teachers contribute to the construction of knowledge in stem.T4L online professional learning?

Interactions between contributors

One of the characteristics of a CoP is that it is a "community", suggesting that the members "engage in joint activities and discussions", help each other, and build relationships (Wenger, 2006 p.2). It is through these connections, collaborations and conversations that learning develops within a CoP (Vygotsky, 1978). In this study, we examined the interaction patterns between the contributors to ascertain the extent to which peer-relationships and collaboration were established between teachers. Figure 5 below describes interactions between the stem.T4L contributors. Five interaction patterns emerged from the analysis: (1) interactions between an admin and another admin or a leader (admin-centred); (2) interactions between leaders (leader-centred); (3) interactions between two or more teachers (teacher-centred); (4) interactions between a teacher and an admin or a leader (teacher-admin/leader); and (5) interactions involving 'other' types of contributors. We found that more than half of the interactions (52%) occurred between teachers and admins or leaders. In other words, when a conversation was initiated by a teacher, (e.g. asking for technical/pedagogical support, sharing resources or classroom experiences, etc.), about half of the time it was replied to by an admin or a leader, or vice versa (e.g. when a teacher replied to an administrative announcement about kit bookings or PL opportunities). Teacher-teacher collaboration, however, was also clearly established within the online community as teacher-centred interactions accounted for 42% of the total.

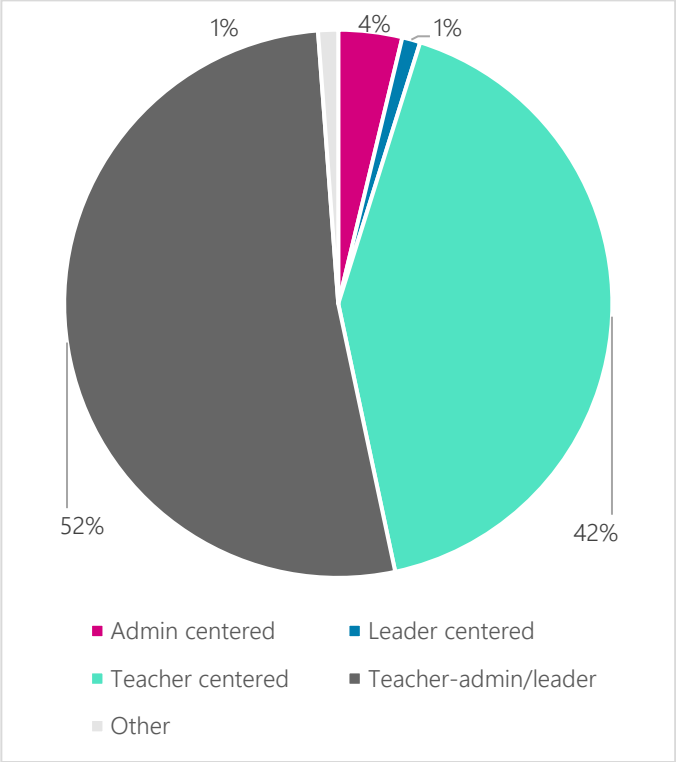


Figure 5. Interactions between contributors in stem.T4L social media: Total

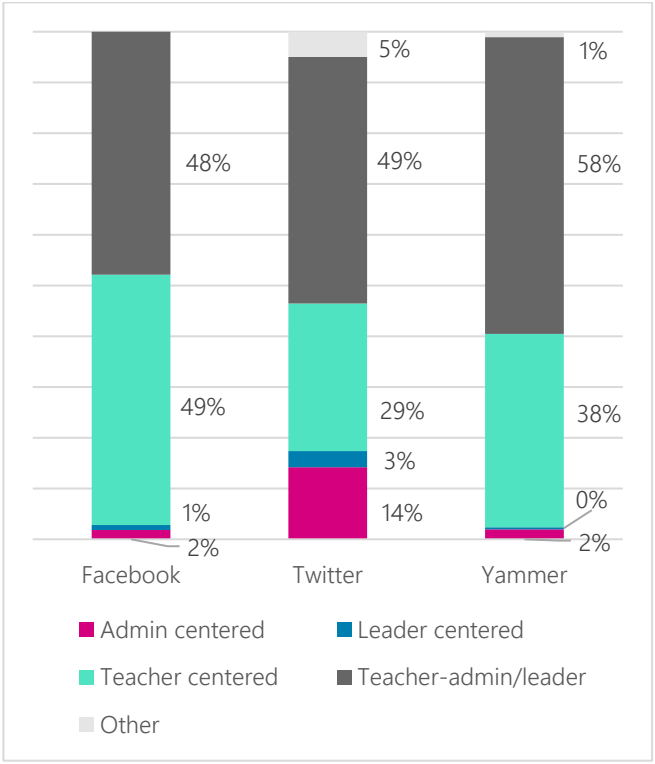
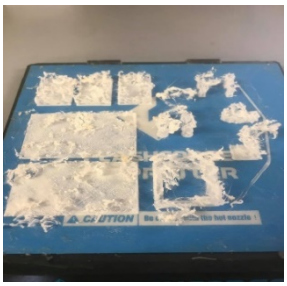


Figure 6. Interactions between contributors by social media sites

We also examined the interaction patterns in each site separately (Figure 6, below). We observed that teachers provided the highest volume of peer support in Facebook, where 49% of interactions were amongst teachers. In Yammer, teacher-admin/leader interactions were more dominant (58%), compared with the proportion of teacher-teacher interactions (38%). Similarly, 49% of interactions in Twitter were between teachers and admins or leaders, whereas teacher-teacher collaboration accounted for 29% of the total. In online teacher professional learning what is desirable is a gradual stepping back of the moderator to encourage self-reliance within the group and stronger collaboration amongst teachers (Casey & Evans, 2011; Chapman, Ramondt & Smiley, 2005; Vratulis & Dobson, 2008). This argument aligns with the Facebook observation, when the moderators (i.e. leaders and admins) took a back seat in the conversations, stronger peer-support grew and teachers contributed more.

Below we present three conversation threads from Facebook to demonstrate how teachers and leaders engaged in conversations to resolve issues and challenges faced by other teachers. As the excerpts show, teacher and leader participation was essential to generating engaged discussion, which facilitated a strong support network on stem.T4L social media.

THREAD 1: PARTICIPATING BY REQUESTING TECHNICAL SUPPORT AND PROBLEM-SOLVING



Teacher 1 (T1): Help!! Our 3D printer has been working perfectly but the last few prints have had a few glitches! Name tags which were reprinted - some fine, some not so good! The last print was a disaster! Nothing stuck! I have checked designs and they seem fine!! Any ideas?

Leader 1 (L1): I would relevel the printer and use glue stick on the print bed. Check how the filament is feeding through, remove filament tube if too much tension on filament, I've found I can get errors when there is too much 'drag' on the filament.

T2. Also consider adding a raft to your prints. It provides a more stable base and easily removed from the main print.

T3. I second the glue stick on the print bed. And check that the filament has not got too much tension on the spool.
T1. Thanks all!! I'm thinking the tension may be the issue! Using the glue, and levelling regularly! I will also try the raft!
T3. Call me if you need to….we have 3 at school that have all sorts of issues at times.
T1. I have looked at the filament - unloaded/reloaded! Same issue! Is there anything else I should do to check the tension? It seems to be feeding fine! I've just read about environmental issues - does anyone have experience with any factors like temp?
L1. Sometimes if there is a lot of moisture in the air that can effect the filament. Do you have another roll you could try? There is also a factory reset in the menu options just in case it's being really silly

The above conversation is initiated by a teacher (T1) and involves three additional participants: two teachers (T2 and T3) and a stem.T4L leader (L1). T1 requests technical support for the problem she has encountered when using the 3D printer, while sharing a photo of the problem in question. The first comment is made by L1 where she offers an immediate solution. From this point on, a collegial collaboration starts to establish between teachers. While the leader's intervention spurs further discussion, teachers offer additional solutions – taking on the role of knowledgeable facilitator themselves. T3 even volunteers to provide further personal assistance – suggesting either an existing professional connection, or just an altruistic offer of further help ('Call me if you need to'). We can see that T1 takes advantage of the opportunities that online PL offers by trying out the ideas introduced by the peers in her own time and coming back to the group with feedback. However, the response by T1, asking for additional support, suggests that the problem still persists. It appears that the final comment by L1 helps resolve the issue as there is no further follow up on this conversation.

THREAD 2: PARTICIPATING BY ACQUIRING IDEAS AND GIVING TIPS

T1. Hi all, our school has the 3D printing kit for term 2. Just looking for any ideas, tips, resources etc from those who have previously used it! Thanks.

T2. Me too! I do know that there is a trick to logging in to tinkercad that saves a lot of mucking about. St must be logged into det and have email open to get into tinker.

T3. What year levels will you be working with?

T2. St 2 and 3. You?

T1. Same!

L. Have you started with the library ? There are videos explaining log ins and how to use tinkercad. If possible I would get students to use the same computer each time as the program remembers the log in.

T4. Definitely this!!

T1. Yes I've used the library to watch the tutorials on how to set the printer up and I'm using the PL on Tinkercad to hopefully teach the students how to create a key chain first. There are only 2 learning challenges that I can see so far in the library for the 3D printer… will there be more added?

L. There will be more added as people use them and hopefully teachers like yourself can add as well.

T3. We did a snowflake challenge for Stage 3… linking maths in. About to embark on a bag tag challenge next.

T1. Awesome, do you happen to have any step by steps for that? 😊

T5. Check out makers empire

T6. Following to get some ideas also.

T7. I would say that printing takes a long time.

L. did you place multiple objects on the bed so you could press and forget? I play Tetris to get things to fit and instead of going back and foward for 1 print every hour, I can get 4-5 done in a shorter time.

T3. We did that too.

T8. You can set up a 'class' in Tinkercad. Makes it easier to download the .stl files.

This conversation occurs around pedagogical lines and problem-solving through offering tips. The initial post attracts nine members (eight teachers and one leader),

with each either sharing their ideas and experiences or just joining the conversation to learn something new. The first teacher (T1), casually solicits advice from other members about how to make the best use of the 3D printing kit – presumably as part of pre-term lesson planning. While a leader joins in (L1) to direct teachers towards the professional learning materials provided by the stem.T4L Project, most of this conversation is teacher-centred. One teacher (T2) forewarns of potential technical challenges with software, and some socialising ensues around the age groups they will be teaching. A third (T3) then outlines some potential lesson ideas, citing the syllabus that student learning is directed towards. Additional teachers then join in the conversation: some to share external lesson planning resources (T5), to share some prior experiences (T7), to provide advice as to making lessons easier to plan (T8) or simply to add themselves to the conversation, so as to acquire pedagogical ideas of their own (T6). This example shows how conversations develop in an almost circular manner, with collaboration detouring into socialising and eventually returning to collaboration – all of it taking place with the informal and collegial tone afforded by social media.

THREAD 3: PARTICIPATING BY ACQUIRING IDEAS AND GIVING TIPS

T1. Hi team - just wondering if there are any recommendations on what is a top quality green screen to use for filming? I am looking to get one for school - is the one in the stem.T4L Film kit the go? Is it hard to crease? Or something heavier the go?

T2. Make sure you think about what colour your students will be wearing. A green screen didn't work that well with our green uniforms!

T3. Excellent point! Perhaps a blue screen might work better for you!

L1. The ones in the kit are amazing because they are so easy to put up and down and transport from room to room. Any flat coloured wall will work with TouchCast Studio though.

T4. We purchased the whole filming kit for our school (all on procurement). The green screen is so easy to set and pack up and is really mobile. I highly recommend.

T5. Just poking my nose in to ask: does anyone have trouble with fuzz or 'noise' when using backgrounds/green screen in touchcast? I am not having any luck ….

L1. It's all got to do with shadows. If you can get the lighting right to remove the shadows, the fuzz will go away.

T6. We painted the whole wall of our tech room green

T7. What paint and specific green did you use?

T6. We went to Bunnings and got chroma key green, if you ask at the paint counter if they have the specific code for a green screen they should have it. If not Message me and I can send you the specific code for it.

In this example, the conversation occurs amongst seven teachers and a leader. T1 kicks off the discussion with "Hi team", clearly indicating a sense of belonging to the community. In other words, although she is positioning herself as a teacher learner, she is reminding everyone and herself that she *is* a teacher and belongs to the community or team. T1 raises a question about top quality green screens for filming, and T2 responds. This response is not directly related to the question posed – however, T3's response illustrates that a direct 'question and answer' format is not needed for the contribution to be helpful for other practitioners. Moreover, it highlights the "community" characteristic of this group. As mentioned, Wenger (2006) specified that "community members help each other" (p.2). This characteristic is evident here as T2, who might not have a recommendation for T1, tries to help the other member by drawing upon her lived experiences and the lessons learnt. This comment is immediately confirmed by T3 ("excellent point!"), suggesting the importance of the tip given by T2, which can circumvent further problems faced by T1. The contribution of L1 seems to solve the problem as T1 leaves the conversation. However, the thread continues and leads to further discussions related to green screens between new members (T5, T6, T7).

The excerpts provided above showed the interaction patterns between a few members of the stem.T4L Facebook group, and the manner in which discussions evolved from initial posts. We can make some important overall observations. (1) Teachers who participated in the discussions believed they were co-constructors of knowledge and equally responsible for the professional learning of other members. They did not sit back to let the leaders problem solve; rather, they drew upon their experiences and offered concrete examples to share and collaborate within this space. (2) The three threads started with a repertoire of requesting ideas and technical support and then finished with giving tips and problem-solving ideas. This implied that when a member required assistance, they received it through the dialogue and discussions. We could thus identify the practice characteristic of a CoP, which connotes doing (Wesely, 2013), in the stem.T4L Facebook group as the members put into practice the proposed ideas and learned from each other.

Use of stem.T4L social media

Researchers that study online discourses tend to analyse three interrelated dimensions critical to learning in an online space: cognitive, interactive and social (Benbunan- Fich, Hiltz, & Harasim, 2005; Henri, 1992). As discussed above, the cognitive dimension involves generating and sharing ideas, clarification, inference, and brainstorming. The interactive dimension is characterised by relating multiple ideas to one another and building upon previously mentioned ideas, for instance. On the other hand, the social dimension mainly focuses on community building such as expressing gratitude, offering further help, or connecting people to each other. It has been discussed that when teachers are active in the cognitive and interactive dimensions, they are more involved in collaborative and problem-solving processes, which eventually can lead to the acquisition and application of new knowledge and skills (Booth & Kellogg, 2015).

To determine NSW teachers' engagement in each of the above-mentioned dimensions and to explore the learning occurring in stem.T4L online platforms, we coded the 2,644 postings in social media (January to June, 2019) into discrete themes related to use of social media. As depicted below, five core themes emerged from the data: (1) Requesting support; (2) Sharing resources; (3) Problem solving; (4) Socializing; and (5) Administrative. Examples of each code are presented below.

	Descriptions
1. Requesting support	Raising questions Acquiring ideas (creative/pedagogical) Requesting technical help Obtaining stem.T4L events information
2. Sharing resources	Sharing classroom experiences Sharing external links and resources Sharing creative/pedagogical ideas Sharing stem.T4L resources (e.g. Learning Library)
3. Problem solving	Offering suggestions for technical support Collaborating on specific creative/pedagogical ideas
4. Socialising	Tagging someone following a post Brief pleasantries (incl. emojis) Affirming someone's post, offering emotional support
5. Administrative	Announcements of PL opportunities Administrative announcements about kits (e.g. booking opportunities, kit return dates) Surveys Promotion of related events (e.g. education conferences)

Figure 7. Use of stem.T4L social media

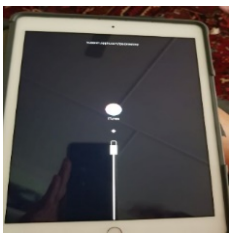
Examples:

REQUESTING SUPPORT

- *Hi All, we had a the 3D printer last term, I need to create an assessment for Tinkercad to report on for this semester's reports. What/how are you using Tinkercad for assessment and what parts in the new syllabus are you assessing on? Thanks.*
- *Having trouble connecting iPhones to our det Wi-Fi for Primary VR kit. We have iPad but iPhone don't respond... please please help.*
- *Has anyone used the VR kit or tablet robotics kit to do lessons around the Stage 3 History unit Australia as a Nation? I'm thinking of activities around mapping sites in Canberra...*
- *Should the PC robotics kit have come with chargers for the LEGO EV3?*
- *Do you know if this online workshop will be recorded?*
- *We have the 3D printer at our school at the moment and can't seem to find the flashgorge software for printing. We tried to download but*

need admin details. Does anyone know how to do this or where to find this software on stem.T4L computers ?

- *I am working with a colleague from stem.T4L to plan for our Professional Learning Day on Day 1 of Term 2. I was wondering if I could contact anyone who has used the resources in the Secondary Mathematics curriculum to identify where the resources could be used in the curriculum. Most of us have very little experience in using the resources and I am hoping to plan a day that is hands-on and linked to our curriculum. Thanks in advance.*
- *Hi STEM sharerers - have just recently unboxed our 3D printer to use at our school and when trying to print the test file it seems to be getting stuck/jam in the corner and not print. Any ideas how I can troubleshoot? Thanks.*
- *Hi everyone, We are looking to purchase some filming equipment to support our involvement in a film festival this year. Currently we have a small set of IPADs in the school. What are some of the essential items to purchase that you might recommend? Where do you access them from? Thanks in advance.*
- *Hi, can anyone tell me if there are any written instructions on using VR and AR in the classroom. Something simple that teachers can use as a reminder as they set up???? Cheers*
- *HELP! Does anyone know why I don't have the option to guide an expedition for the VR kit? It was there a couple of days ago? All the downloaded expeditions are in library. Thanks in advance.*
- *VR kit- Could someone please help me and tell me why this is Wi-fi hub device is always turning red. The iPods can't connect to it as it's constantly disconnecting. It starts off being blue but then turns red in a matter of minutes. Due to this students can't connect to the Wi-Fi. Thank you for the advice in advance.*



- *Can anyone help me? I've managed to reset 4 Ipads but the other 6 keep showing this screen.*

- *Check out some of the great creations our students came up with in the last week of term using LEGO WeDo 2.0 from the STEM share kit. I think they're genius.*

- *Year 8 English write blackout poetry. Taking a page from a novel, they choose words or phrases, blocking them in with conductive graphite pencil. The graphite extends the connection from the word to the Makeymakey. Students use Scratch to record phrases to match their chosen words. They had fun using different intonations and expressions. They then write a program so that when a word is touched, it plays the recording for that word.*
- *Highly recommend you use the 'Can I Fly There?' app by CASA, tells you where you can fly etc.*
- *We created a collaboration folder for students to save Tinkercad designs in (using their name as the file name) and then ordered the folder by date and time. We then printed up to 6 designs at once and often were printing before school, all day and then after school! It's hectic but so rewarding!*
- *FYI any schools purchasing WeDo highly recommend paying bit extra for rechargeable units as have had experience chasing lots of 2x AA batteries and it is much easier to simply recharge.*

- *Our school has had the filming kit and tablet robotics kit. We decided to make movies about our small school. Yesterday, we showed cased some of the student's completed movies at our whole school assembly. All the video footage was shot by the students using the iPads from the kits. The students decided what camera angles and shots to include. Some*

SHARING RESOURCES

video footage was candid while other scenes were staged…

- *We did a snowflake challenge for Stage 3… linking maths in. About to embark on a bag tag challenge next.*
- *Year 7 Science students program Microbits and build electrical gates to time the journey of a match box car down a slope in their forces topic. Students are investigating the relationship between slope angle and the time of the journey.*

PROBLEM-SOLVING

- *Watch the videos and play around… A tip I would give is to put glue (just with a glue stick) on the printing bed before each print, just a little. This will stop the print sliding.*
- *There is a google wifi box in the kit. Connect that and then connect all the iPhones to that wifi.*
- *Make sure you think about what colour your students will be wearing. A green screen didn't work that well with our green uniforms!*
- *Use the iPad on the det network to download vr google expeditions the switch it's wifi over to the google wifi box in order to run a guided session.*
- *"Check the date and time on the phones. If they are wrong you will need to manually reset them. It is something iPhones do if they haven't been online in a long time, strangely this inhibits net connection, possibly a security thing.*
- *You could have students make their own virtual excursion to Canberra using CoSpaces Edu and then view it in the VR goggles! We did that with Asia last year for stage 3. Was awesome!!*
- *You need to click on the small blue writing that says sign in with social, choose the google icon and students sign in with their email address.*
- *A paint scraper has been useful for getting prints off the bed.*
- *I would definitely recommend an iographer case and or set with a manfrotto tripod. I bought mine through iographer and got the start up type pack which included a fluffy mic, lighting and case (from memory) I also purchased two small clip on microphones from jb hifi and two extension leads for them.*
- *If you use LEGO blocks, pre-sort them into egg cartons to make them easier to distribute.*
- *There is an app called kodable… also use the 'drive' function for the Sphero… and make mazes to drive the spheres through… discuss direction and speed… also play some of the already made apps on the sphero edu site… hot potato etc…*

SOCIALISING

- *What a wonderful video! Congratulations to all the kids involved!*
- *So my 10 year old wanted a green screen for her birthday. Looks like we will be learning together … and maybe a tax deduction* 😬
- *What amazing prints! I love that you have printed for a purpose!*
- *That's great news that you are getting a printer after trialling this one. Well done!!*
- *Well done! Looks fabulous!*
- *Dash is excited to meet Happy Healthy Harold today. They had a lovely chat.*
- *Hi, we haven't received any as of yet but having lots of fun learning how to design, test and print our ideas*
- *We've tried so many different people on staff to have a go… no luck so far but we won't give up. The kids are having a great time playing and developing ideas on Tinkercad, it'd be disappointing if we don't even get to see one thing printed* 😬
- *Thanks … for an awesome day today. Our staff are now pumped! Hope to see you again soon.*
- *I'm seeing more and more schools with the tablet robotics equipment purchased. Dash Bots are becoming more popular (for good reason).*
- *If anyone is attending STEMX this week in Canberra. Stop me and let me know how your stem.T4L journey is going and what I can do to help you while I'm here. Teachers collaborating from all over Australia- what could be better than learning from each other.*
- *Proud of the students who did these all by themselves!!*

ADMINISTRATIVE

- *Attending or still thinking of going to EDUTech? stem.T4L communities will be hosting many teachers and students to share their school stories in the DoE Stand. Here's a schedule…*
- *Do you have a stem.T4L Kit in Term 2? We need you to fill in our Survey as soon as you can. Our Surveys help our research team to see…*
- *What are our Boards and Cards in the Learning Library about? Check out this video…. sharing some tips and tricks on discovering, creating and sharing boards and cards.*
- *Still spots available for the following workshops in Sydney's South. Join me for a fun and informative day.*
- *Robotics in the classroom in Armidale! For full details, go to…*
- *This video was captured with the stem.T4L 360 camera by one of our Environmental Ed teachers on his recent trip to Antarctica!*
- *This is a full day stem.T4L Regional School Professional Learning Event. Come and explore all aspects of the stem.T4L kits with guidance from stem.T4L Leaders. All teachers are welcome.*
- *Online Workshop - Curious to learn with the PC Robotics Kit, Wednesday, 6 February, 3:30 pm – 4:30 pm*
- *Wow!!! 80,000 visits in 6 months! How wonderful to know we can support every child in every public school across NSW to build the skills they need to solve the problems of tomorrow.*

In the second phase of the analysis, we calculated the frequency of occurrence of each code in each platform separately and then collectively. Figure 8 shows that, across the three platforms, socialising (33%) was the primary reason for using stem.T4L social media. Problem-solving (24%), requesting support (18%), and sharing resources (13%) were the next most common use of social media. The smallest category was related to administrative posts (12%) made by stem.T4L leaders and admins (note: where admins contributed to problem-solving and sharing experiences, these were considered distinct from 'administrative' contributions).

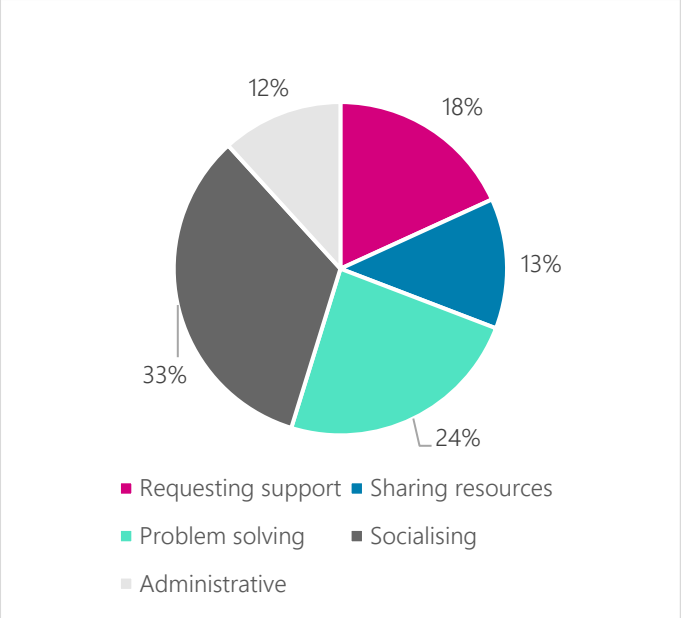


Figure 8. Percentage of professional use of stem.T4L social media: Total

The data from each site yielded further interesting findings. It became clear that while the majority of conversations in Facebook and Twitter were around socialising (38% and 43%, respectively), in Yammer they were on problem-solving (32%) and requesting support (25%). In other words, it appeared that Yammer users considered this platform as an extended professional learning opportunity, where they could go to learn through participation and collaboration. Twitter, meanwhile, was found to be on the other end of the spectrum, where users participated mainly to network, encourage each other and offer emotional support (i.e. socialising).

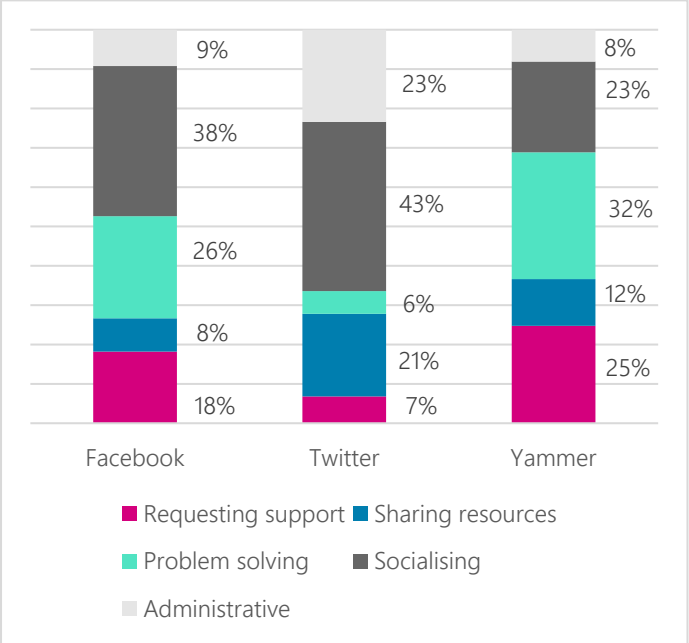


Figure 9. Percentage of use of stem.T4L social media by site

As the final step, these thematic codes were aggregated into larger categories. The postings related to "requesting support", "sharing resources", and "problem solving" that belonged to the "cognitive and interactive" dimensions were clustered as 'active learning'. In our view, members who used stem.T4L online platforms for any of the above-mentioned purposes were actively engaged in the learning process through discovery. This entailed exploration of different ideas, sharing of content, creating, questioning, and implementing new knowledge. These members did more than "tinkering around the edges" (Brown & Munger, 2010 p.566), as their collaboration with other members promoted a deeper understanding of practice. After calculating the total number of postings, we found that more than half of the conversations (55%) that occurred during January and June 2019 in stem.T4L social media engaged members in active learning (Figure 10, below). Interestingly, we observed that although active learning took place in all social media platforms, the intensity of learning varied in each site (Figure 11), with Yammer generating the highest level of teacher learning (69%) and Twitter the lowest (34%).

The fact that a majority of the total postings fell into the active learning category, especially in Facebook and Yammer, bodes well for the future of the stem.T4L community of practice: members are clearly using the online community to receive informal, self-directed STEM professional learning. We also merged 'socializing' and 'administrative' codes to form a category called 'networking'. Postings in this group (45%) did not directly contribute to the learning process; however, the users who made these contributions can be considered pillars of the online community as their ongoing emotional support and encouragement fostered a sense of community among the members. They shared the same values and objectives and invested time in community building by tagging someone, affirming their posts, promoting events, and so on.

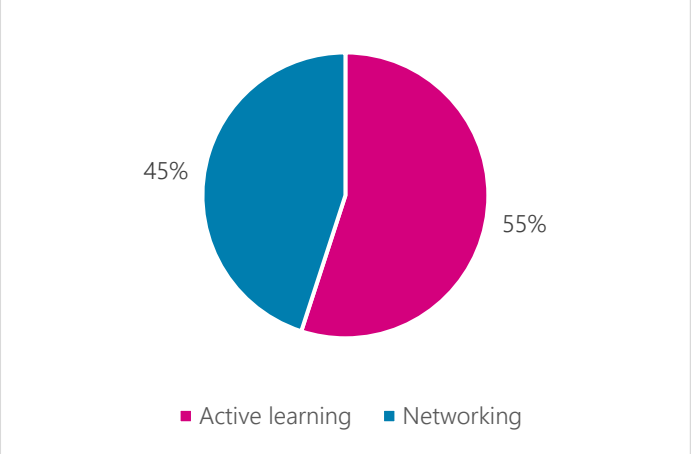


Figure 10. stem.T4L social media contribution to teacher learning: Total

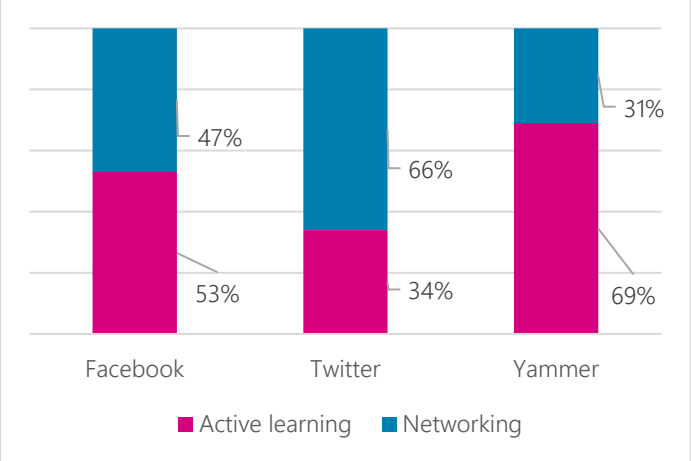


Figure 11. stem.T4L social media contribution to teacher learning by platform

CONCLUSION

In the introduction of this report we explained that to be characterised as a community of practice, stem.T4L should possess three features: have a domain, be a community, and have a shared practice. We examined survey and social media data to learn if the stem.T4L groups served as a community of practice for teachers who chose to collaborate online and, if yes, how they used this platform for informal professional learning. We found that the members and followers of stem.T4L social media (n < 4,500) created 2,644 postings (comments, posts, tweets, tags, and re-shares) from January to June 2019. We concluded that stem.T4L social media had a *domain*, because the members showed a commitment to STEM teaching and learning by voluntarily joining this online group and embracing a shared vision and identity as NSW STEM educators. When we analysed the conversations that occurred during this timeframe, we found that 45% of the postings could be classed as 'networking' – this underscores the *community* characteristic. A community of practice does not come into existence unless the members build relationships with one another and help each other. In fact, one of the main differences between an ordinary group and a CoP is in the very sense of community, where "members invest in and contribute to" the community itself (Wisker, Robinson & Shacham, 2007 p. 306). The stem.T4L online community proved to be a *community* as the members remotely connected to other members to build relationships. To this end, they regularly offered emotional support, and affirmed other members' posts which cultivated a sense of community. Another key finding that signified the presence of the *community* spirit was teacher collaboration that suggested 42% of the total interactions were between teachers. In other words, leaders and admins were not the only problem solvers in the community when a teacher faced technical or pedagogical difficulties but other teachers chipped in and offered solid support.

Did the members of the stem.T4L online community contribute to a knowledge base – was there evidence of a *shared practice*? In other words, did teacher learning take place in this online group? The answer is yes. We found five main uses of social media by members, three of which (55%) engaged teachers in 'active learning'. More specifically, through posing questions and requesting additional support (18%), some members generated ongoing discussions, which fostered increased participation by members who had a higher level of expertise in using STEM technology. This group directly contributed to the repertoire of knowledge by drawing upon their experiences either to problem-solve situations (24%), or share resources, ideas, links, and photos of classroom activities (13%) to collaborate and contribute to the repertoire of knowledge.

Based on the above findings, we conclude that a stem.T4L online community of practice is well underway. The broader stem.T4L project was only implemented in 2018, and social media is clearly playing an important role in establishing the foundations of a self-sustaining community of practice. More than just a space for socialising, this community has created an additional space for STEM professional learning.

The key findings of this research and recommendations for future practice are summarized below:

- The postings on stem.T4L social media (n=2,644) were generated by 462 contributors. This implies that 82.36% were observers and did not make contributions or fully engage in conversations. However, this observation should not be taken as a limitation, because these members could have been learning from stem.T4L online CoP in various ways. In other words, a range of contributions could have benefited the 'silent readers' and encouraged them to remain in the community and, perhaps, one day be a more active part of it. These include: the frequent up-to-date information on stem.T4L events posted by the leaders and admins; the tips and problem-solving ideas shared between members; and even the collegiality and collaboration amongst members that promoted a sense of belonging for those only reading postings.
- Facebook had the highest number of contributors (n=212), with active participation on the part of teachers (65%). 53% of postings in Facebook cultivated active learning (problem solving 26%; requesting support 18%; sharing resources 8%). As such, we argue that this platform was a site of learning as teachers negotiated meaning by engaging in reflective dialogues, and collaborated and shared ideas and resources. Also, the teacher-teacher collaboration (49%) showed that teachers did not assume that teacher learning was the responsibility of the moderators but they were in change of the learning process and contributed as fellow learners/teachers.
- Twitter, despite attracting the largest number of followers (n=2,215), consisted of a small number of contributors (n=152) where teachers accounted for only 38% of the total contributors. It appeared that this site was mainly used for networking (66%) by admins (34%) and leaders (19%), leading to a smaller engagement of teachers in the active learning process (34%). Teacher-teacher collaboration was also found to be lower (29%) than other sites.
- Yammer had the smallest number of members (n=719), however, like Facebook, teachers accounted for 65% of the contributors. Interestingly, the highest level of active learning occurred in this platform (69%), suggesting that Yammer users considered this site as an extended professional learning opportunity, where they could go to get an expert opinion. However, although teacher-teacher collaboration was higher in Yammer (38%) than in Twitter (29%), teacher-admin/leader collaboration was very dominant (58%) in this site and left little room for teachers to collaborate.

- In total, more than half of the interactions (52%) occurred between teachers and admins or leaders. Teacher-teacher collaboration, however, was also clearly established within the online community and accounted for 42% of the total. This finding suggests that foundations for a self-directed CoP have already been established. However, educational research into online CoP has noted that – in order to be considered self-sustaining – community interaction needs to be weighted toward members facilitating their own professional learning and that of other members, with formal moderation or guidance gradually

tapering off (Casey & Evans, 2011; Chapman et al., 2005). There is already evidence of this taking place on stem.T4L social media. To further enhance the three groups' value as a space for self-directed learning and collaboration, admins and leaders of the online groups could intentionally 'step back' from providing instant support and give teachers the opportunity to provide peer support. They can also encourage further collaborative dialogues through introducing new ideas and raising context-specific questions to challenge educators' perspectives and opinions.

- The survey data indicated that 71% of teachers (from a total number of 111) had not used stem.T4L social media during Term 1 and Term 2, 2019. Some of the reasons for their lack of participation in the online community included: being ambivalent towards social media in general, having time constraints, and having no need to collaborate, for example. The remaining 29% pointed out that they used social media to share classroom experience or request ideas and support. However, among this group only 18% posted frequently (once a day to several times a week). Researchers suggest that the frequency of participation in online communities can influence teachers' learning, where greater benefits accrue with those who make regular contributions and follow discussions consistently (Brown & Munge, 2010). Although we did not attempt to pinpoint the frequency of posting by individual members of social media, this research suggests that further promotion of stem.T4L social media could be warranted. These promotional messages could also be accompanied by 'how to' guides for using social media for professional learning (Stenger, 2017). Doing so might enable teachers to balance the potential benefits of using social media for PL against any negative perceptions they have (e.g. time costs, cyber-bulling or ambivalence towards social media). One-on-one mentoring, multiple exposures to the online communities, running introductory sessions, and offering online CoP with other forms of professional learning (Wesely, 2013) are effective ways to further facilitate teacher participation in stem.T4L social media groups.

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