# Peer Learning Beyond the Curriculum in University Statistics Courses

## Aprendizagem entre colegas para além do currículo em Cursos de Estatística Universitária

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**Abstract**

*Peer learning in statistics can occur in a variety of settings, including class collaborations and assessment in the form of group projects. Most reports indicate that it has positive effects on learning. However, peer learning can also be organised by students themselves outside course requirements, to similar positive effect. In this paper, we investigate this second form, sometimes referred to as 'peer learning beyond the curriculum'. The parameters of the project were derived from a similar study in the discipline of music, conceived as an action research collaboration between students and academics. A series of focus group interviews was carried out with students in a range of university statistics classes, introductory and later-year, majoring in statistics or studying statistics as a component of another discipline. These were arranged and run by a group of statistics students participating as researchers and peer learners in a 'vertical' research team that also included more experienced academics from statistics and other disciplines. The team found that first-year students were well aware of the academic and social benefits of forming study groups to support each other's statistics learning, and they gave clear advice to future students to do so. By contrast, peer learning in later-year classes played a more nuanced role that seemed to depend on the major discipline in which statistics was being studied – possibly due to the particular aspects of statistics that were in focus. Comparisons with peer learning in other disciplines shed more light on the various ways that peer learning in statistics can be utilised in different contexts, and suggest various implications for improving statistics pedagogy.*

*__Keywords:__ Statistics learning, peer learning, study group, vertical research team, focus group, action research, community of practice*

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**Resumo**

*Aprendizagem de estatística com interação entre pares pode ocorrer em uma variedade de maneiras, incluindo colaboração entre colegas durante as aulas e avaliação sob a forma de projetos em grupo. A maioria dos relatos indica que tem efeitos positivos sobre a aprendizagem. No entanto, a interação entre colegas com esta finalidade também pode ser organizada pelos próprios estudantes mesmo não sendo requisitada no curso, com um efeito positivo semelhante. Neste artigo, investigamos esta segunda forma, às vezes referida como "aprendizagem com interação entre pares em atividades extra-curriculares". Os parâmetros do projeto foram derivados de um estudo semelhante no curso de música, concebido como uma pesquisa-ação entre estudantes e acadêmicos. Uma série de entrevistas com grupos focais foi realizada com alunos universitários de uma classe de estatística, dos anos iniciais e dos anos finais, em cursos de estatística ou estudando estatística como uma disciplina de outro curso. Estas entrevistas foram organizadas e executadas por um grupo de estudantes de estatística que participaram como pesquisadores em uma equipe com estudantes de diferentes níveis, incluindo também acadêmicos dos anos finais em estatística e outros cursos. A equipe identificou que os alunos do primeiro ano estavam bem cientes dos benefícios acadêmicos e sociais de formar grupos de estudo para apoiar a aprendizagem de estatística e aconselharam os futuros alunos para fazê-lo. Em contrapartida, a aprendizagem entre colegas nas classes dos últimos anos desempenhou um papel mais moderado, que parecia depender do curso no qual a estatística estava sendo estudada - possivelmente devido aos aspectos particulares que estavam em foco. Comparações com a aprendizagem pela colaboração entre colegas em outras disciplinas, abriram caminho sobre as várias maneiras que sua utilização pode ocorrer na aprendizagem da estatística em diferentes contextos, e sugere várias implicações para melhorar seu ensino.*

**Palavras-chave:** *Aprendizagem estatística, aprendizado entre colegas, grupo de estudo, equipe vertical de pesquisa, grupo focal, pesquisa-ação, comunidade de prática.*

## Introduction

Learning in statistics, as in most other disciplines, is not a solitary activity. It takes place socially, in a context that usually includes not only a teacher and other learners, but also a wider network of people who are involved in its various aspects. Traditionally, the social space of learning is a tutorial room or lecture theatre in which the learners are, to a greater or lesser extent, under the control of a tutor or lecturer. Contemporary pedagogical approaches incorporate an awareness that students can learn from each other and derive significant benefits from collaborative work (ROSETH, GARFIELD e BEN-ZVI, 2008; SISTO e PETOCZ, 2012; PORCIÚNCULA e SAMÁ, 2014). The tutorial room, and sometimes even the lecture theatre, is modified into a social learning space where group activity and peer assessment can be included to enhance the learning (BOUD, COHEN e SAMPSON, 2001). With the development of technology, learning management systems provide an extension of such spaces in which students can work collaboratively at any

time and from any physical place. The tutor or lecturer control of such spaces is still an essential feature of the learning. However, there are – and always have been – other collaborative learning spaces that are set up and controlled by students themselves, beyond the standard class or lecture rooms or their electronic extensions. Our focus in this paper is to investigate learning in statistics that takes place in such spaces; we refer to this as peer learning in statistics 'beyond the curriculum' (using a phrase introduced by Havnes, 2008). The paper builds on an earlier report of such peer learning in introductory statistics classes (PETOCZ et al., 2014), representing the first phase of our project, and extends the investigation to students studying higher levels of statistics from different majors. We make comparisons with peer learning in other disciplines as a way of understanding the variety of ways that students utilise peer learning in statistics. Finally, we discuss the implications of our findings for statistics pedagogy and make suggestions for further research on student-organised peer learning.

A natural theoretical foundation for any study of peer learning is to be found in Wenger's (1998) notion of 'communities of practice', defined by the three essential features of mutual engagement, joint enterprise and shared repertoire. Peer learning, particularly that 'beyond the curriculum', contributes to the community of practice that develops around the learning activities. Students move from an initial marginal involvement – described in the theory as 'legitimate peripheral participation' – to a central role of full participation. We could say that they start as 'novice students' at the beginning of their university studies and move towards the role of 'expert students' as they become familiar with the requirements and expectations of student life, a trajectory that is built on a range of experiences including the important aspect of learning with and from their peers. In a sense, this represents a prior step to the movement 'from expert student to novice professional' that is the subject of the investigation by Reid, Abrandt Dahlgren, Dahlgren and Petocz (2011), and shares much of the same theoretical basis, including the importance of their conceptions of their discipline and of studying (and working) in that discipline.

From the viewpoint of the individual student, their 'personal learning environment' (DABBAGH e KITSANTIS, 2012) is strengthened by the peer learning network, which may include technological aspects such as mobile devices that bridge the gap between physical and online communication.

Such personal learning environments are beyond the control of an institution, go beyond university-mandated technologies, allow for wide-ranging exploration of material and

provide flexible environments. They are self-directed spaces where students have the autonomy to choose learning collaborators, topics and methods of working, and preferred learning outcomes. The notion of 'personal learning network' (WARLICK, 2009) adds an emphasis on social learning and connectivism, with material accessible via mobile devices, bridging the gap between analog and digital, between physical and online communication.

There seems to be widespread consensus on the beneficial effects of peer learning, most obviously through the increased levels of engagement that it provokes (see the chapters in Boud et al., 2001, for example). Most reports are based on studies of peer learning organised for students by academic staff, such as group assignments or organised study sessions in 'peer assisted learning' (or PAL) programs. Some reports derive from the US tradition of engagement research. For instance, Krause (2007) surveyed undergraduate social science students at an Australian university about their peer interactions outside class. Such activities included discussing assignments, meeting socially with course members, borrowing course materials, and group study for a test or examination. She concluded that students' engagement with learning was closely related to their participation in learning communities within and beyond the classroom. She recommended the development of community through collaboration in class and by stimulating students intellectually through peer interaction and contact with the broader research community. Roseth et al. (2008) give practical suggestions for how to achieve this in introductory statistics classes, while Sisto and Petocz (2012) and Porciúncula and Samá, 2014 (2014) describe particular case studies that illustrate the development of such engagement. Using a questionnaire with both open and closed questions, Stenberg and Carlson (2015) reported on an investigation of Swedish student nurses' perceptions of peer learning in clinical practice. They found that although the majority of students seemed satisfied with the peer learning experience, the final-year students were somewhat less satisfied than the first-year students, maybe because the former had moved beyond the structured experiences that had been developed for them in the peer learning program. Fewer studies investigate the operation and effectiveness of peer learning organised by students themselves beyond the reach (or control) of academic staff. Nevertheless, it is this literature that is most pertinent to the current study. One of these is the study by Reid and Duke (2015), who noted that musical identity for music students was enhanced by out-of-class peer activity. Coffee shop conversations, breaks between rehearsals, and informal music making contributed positively to students' musical identity, and ideas

gleaned informally had a large impact on individual performance practices. Havnes (2008) noted the same phenomenon with students taking a course in philosophy of science. He concluded that students' problems seemed to be focused on the broader concerns of their work and interactions, or as one of them said, "the real problem is being a student" (p.202). Other studies published by Vines (2010) in the context of a law course and by Orsmond, Merry and Callaghan (2013) in the discipline of biology also investigate peer learning 'beyond the curriculum'. When we first set up our own project we wondered how informal peer learning in statistics would be manifest, and we will return to this discussion after describing the current study and presenting some of its results.

## The research project

Investigating student-organised peer learning in statistics is a challenge for statistics educators, not least because they may not be aware of aspects of how students learn with and from each other when they are outside their classes. The earlier investigation of peer learning in music (REID e DUKE, 2015) provided a possible research approach. A collaboration between academics as researchers of pedagogical approaches, students as researchers of their own learning practice, and (more traditionally) students as research participants seemed to be an appropriate methodological approach to investigate the problem. The project encouraged students as researchers to make their own plans to investigate each other's learning through an exploration of what peer learning meant to them. The research analysis of the results of their deliberations was carried out by student researchers themselves, working with their older peers – the members of the academic research team.

In the initial phase of the project (in 2012) we advertised for 'student research leaders' and focus group participants in a range of statistics lectures and selected two research groups with two leaders each at the first-year level from members of an introductory statistics class for students of psychology. A second-year group and a third-year group were also set up, but for various reasons did not complete the project. In the following academic year (in 2013), we had a second attempt, forming another group of three student research leaders from members of a third-year capstone class in statistical consulting for students completing a statistics major. This time, the group successfully carried out the project. The results from the first-year groups have been described in Petocz et al. (2014); they will be summarised here for completeness and extended by results from the third-year group.

The student research leaders were paid as research assistants and identified as members of the research team. They recruited the remainder of participants from their own and other statistics classes. The student research leaders were briefed by the academic team members about the aims and approaches of the project. The briefing was deliberately open-ended so that the student researchers could lead the investigation without being influenced by pre-existing biases from the academic team members. They were asked to arrange two or three semi-structured focus groups with volunteers from their classes (we had a list of e-mails from interested students) to discuss various aspects of peer learning. There were eight participants in the first-year psychology groups and a further 15 participants in the third-year group, completing their statistics studies across four disciplines: actuarial studies, business, science and psychology. Each participant took part in at least one of several one-hour focus groups discussing various aspects of peer learning. The following questions were provided to start the discussion:

- How would you typically learn statistics in an individual study session?

- What about a group study session in class (lecture or tutorial)?

- How would you typically study statistics with a group of friends from the same class?

- Are your ways of learning different from each other's?

- How would you explain to others your approach to learning statistics?

- What would you say about your statistics learning if you were with a group of friends who were not studying statistics?

Unstructured discussion followed; the complete sessions were recorded and relevant sections were transcribed. We asked the student research leaders to crystallise each group's discussions into a short video that would be appropriate and useful to show to future cohorts of students. Each research group planned out and recorded their own video; focus group participants were invited to act in these videos, and several of them did so. The first-year videos can be seen at http://tinyurl.com/PeerLearn1 and http://tinyurl.com/PeerLearn2. The third-year group produced four short video clips that can be accessed from http://tinyurl.com/PeerLearn3. A final meeting for each phase was attended by student research leaders and academics; these meetings were also run as focus groups led by one of the academics, and were also recorded. The artefacts of the project

– the recordings, transcripts and video clips – formed the raw material for the subsequent analysis by the project team, including the student research leaders. The research was approved by Macquarie University's ethics committee, and all participants were aware of the details before they consented to be research leaders, focus group members, participants or actors in the video clips.

Our research methodology combined the approach of action research with thematic analysis. Action research (McNIFF e WHITEHEAD, 2002) is based on using the experience of participants in a learning and teaching process, the students and lecturers, to find practical solutions to a pedagogical problem. Such 'vertical' research teams have been successfully used in academic contexts (for example, the study of student engagement by Taylor, Wilding, Mockridge e Lambert, 2012). Peer learning, particularly in contexts outside the standard lecture or tutorial, is more powerfully investigated by blurring the distinction between student and teacher, subject and researcher. Our analytic method was for all research participants, student researchers and academics, to read independently and iteratively through the transcripts, and review the video clips, in search of the important themes. The themes each reader identified were discussed collaboratively to construct a combined list, and supporting quotes for each of these themes were identified. Since the project was carried out in two phases, the themes identified in the first phase were already known by the time the second phase was carried out. Such thematic analysis is a fundamental form of qualitative analysis (BOYATZIS, 1998). It aims to identify common ideas from the emphases and concerns raised by participants, and to use these common ideas to investigate the phenomenon of 'peer learning beyond the curriculum'.

## Students' approaches to peer learning – first-year groups

Themes identified from the focus group discussions and video clips illustrate peer learning in statistics beyond the curriculum from the viewpoint of the participants in a first-year course in statistics for psychology. Three themes were identified:

**[1] Peer learning as one form of support**
Peer learning was one form of support for statistics learning – others included the lecturer and tutors, the prepared lecture notes, textbook and online materials, formal 'peer assisted learning' classes, partners with knowledge of statistics, and private tutoring both

individual and group. The discussions highlighted the diversity of support available to students, and the fact that they seemed happy to utilise a variety of them in their learning.

> *I think [support from tutors and from peers] definitely complement each other, because there's a real difference in being told something and being taught something and two people not really knowing but then finding out the answer together.*

> *I don't actually have a study group, but when we have the practicals, like the one we just had, me and two other friends will just go direct together.*

> *I'm quite fortunate. My boyfriend is…, loves doing assignments. So I will actually do some of my work and then tell him about what I'm doing and he's…, he did economics at university.*

Peer learning allowed members of the group to combine their strengths and expertise in order to face the problems of navigating sometimes complex and confusing material.

> *I study with another two that I've met through the course and so we get together on weekends and go over stuff and look at the quizzes and the answers and everything and just try to…, but it's worked really, really well for me, because they always know…, I know something that they don't and they know something that I don't. It's really great. It's really been helpful.*

Some participants said that they preferred to start the work on their own and only get together with their peer learning group after this initial effort.

> *I find it much easier to study by myself, because I get far too easily distracted when people talk to me. So I might, I really have to, yeah, work by myself, but then we'll ask questions.*

Nevertheless, the feeling from the group was that self-arranged peer learning, most often described as 'study groups', was the single most important component for success in the course.

> *You know with this, one of the most important things is the best thing has been just having someone you can call up or email and say, I don't know what on earth I'm doing.*

**[2] Benefits of peer learning**

Most participants in this servicing statistics course did not have much background in numeracy, let alone any further mathematics, and their general feeling was that they were doing statistics only because it was a compulsory part of their psychology course.

> *I think it's probably because it [statistics] is not a subject people are really wanting to do. I'm sure there are people who actually genuinely enjoy it and are doing it for their own reasons. But yeah, I think because it's a subject we're all doing as a pre-requisite, it's not something we're very excited about.*

Many comments described the statistics course as challenging, particularly due to the constant presentation of information about various aspects of statistics.

> *But with this unit I'm so glad I've got this study group, because I feel that it's just a lot of information coming in. There is not a lot of discussion or anything. You don't really get a lot of answers. You don't clear up doubts very much. It's just every week more information, more information, more information.*

> *But when you're there [at lectures], for me, it just gets overload at some stage. Like, I'm getting it, getting it, getting it, getting it, and then I just go, oh, my God. Then there's something new, something else, something else, and like, oh, too much, too much.*

The regular quizzes and assignments provide plenty of material for group discussion and learning, and indeed, students feel that their study group provides a good format for tackling the assessment.

> *Yeah, and we focus on the, yeah, the quizzes a lot, because the answers from that are sort of, we think are pretty fundamental. So if we can understand that well, that's going to help us in the exam and further down the track.*

The peer learning group assists students to counter their negative feelings about statistics, and provides a balance to the usual focus of university courses on individual work as opposed to group work. Participants reported benefits from discussing and sharing ideas with their peers and contrasted this with the experience of others who had not participated.

> *I did have a conversation with somebody who hadn't been going to classes and they sat next to me and asked me questions on this stuff, and I was like, this is basic stuff, and they just hadn't really been going to most of anything, so I think that's kind of like the whole…, once you reach the end of the semester and you realise that you just missed out on all the peer learning and stuff, all the time you could have been doing this!*

**[3] Method of working with peer learning**

There were interesting descriptions of how students identified potential group members and how they set up their study groups. Approaches included attending the first few tutorials and actively looking for likely people (such as fellow 'mature-aged' students). Others reported eavesdropping on other members of the class to check whether they would be compatible members.

> *I think statistics is something you have a lot of questions for, so you're all sitting there at the computer, say to the next person, 'how do you do this?' and then everybody sits next to each other, just start with that.*

> *Being a mature-age student it helps as well, because as soon as you walk into the first tutorial or prac [practical class] you look around and go, okay, there's one [likely partner].*

Study groups often utilised the common free time between lectures. They arranged regular meetings, and had a strong incentive to come well prepared to these meetings.

> *With our study group we don't turn up just not knowing anything. We all want to help each other, so the idea is to go through it all, learn as much as you can, so we can actually contribute in the study group. So I do as much as I can, I understand it as best as I can, before I go and meet up with these other two, so when we turn up we can just discuss those couple of things and help each other with it, which really helps so much. I wouldn't like to be doing this without the study group. It's really, really good.*

Groups often used social media, such as a Facebook page, to post questions, suggestions and comments within their group. They were very comfortable using technology for such academic reasons, rather than asking lecturers or tutors. They didn't make a big fuss about the technology, but just used whatever was available and useful; this is also shown clearly in the video clips.

> *What I have done in our study group, is that they just added their ongoing message, if they had a question, they'd just post it because they're a group of specific people, rather than going to the lecturer.*

The focus group transcripts clearly showed the approach taken by students as they discussed specific problems in statistics and particular ways of learning in statistics. At one level, the research focus group was also a peer learning group for statistics. This is illustrated in a comment from one of the student research leaders on the process of carrying out the focus groups:

> *I think the main thing that I found out was like how important peer learning is. For me personally, I usually suffer in silence a little bit more. When I'm talking to other students, it seems like everybody does the same thing and they talk to each other and are able to realise that everybody is in the same boat and not feel like they're not getting, that they're the only one that's having a hard time with the class. So just seeing how other students go about that is a good experience.*

## Students' approaches to peer learning – third-year groups

The analysis of the textual material from the third-year groups was carried out a year later. Although we were open to the possibility of different themes emerging with the groups of students in later-year classes, and even expecting them, it turned out that essentially similar themes were identified, despite the study being undertaken with different student research leaders and participants. These similarities with the first-year results will be illustrated with quotes from the participants before moving on to highlighting the ways in which the third-year groups thought differently about peer learning beyond the curriculum.

### [1'] Peer learning as one form of support

In their discussions about study approaches and methods, students again commented on a wide range of support services and structures – including lectures and tutorials, online forums, formal peer-assisted learning [PAL] and the numeracy centre. Self-organised peer learning was one component of this palette of support for learning.

> *I'm not sure about peers but, like definitely, I think the idea of the numeracy centre… that would be really awesome… Yeah, like you study by yourself but the minute you don't know a question or you don't know something, there's someone to refer to.*

*Actually it depends on the difficulty of the course. 'Cos [because] last year I took a course and it was difficult so a lot of people went there [online discussion forum] and discussed in the forum. But this semester it's not, like, the subject is not too difficult so they just do it themselves.*

*I think it does help a lot when you have a tutor that is engaging and wants to be involved and make sure you understand things properly, not just that you take away how to get the answer but know that you can get there yourself.*

*I was going to PAL to supplement my tutorials as well, not to address particular questions but to get a better understanding, but the timing was a bit of an issue.*

*I'd definitely recommend it [peer learning] but just don't jump on the Facebook to try and get everything, all your answers, just try to be an active student when you are doing statistics. To be an active student is important, and peer learning is one of the ways towards that.*

## [2'] Benefits of peer learning

Students seemed aware of the benefits that could be obtained from self-organised peer learning, including the development of confidence, ensuring that they had not missed anything essential, and the important aspect of 'learning by teaching or explaining'. They were generally able to articulate these benefits convincingly.

*I think that with stats, you're just looking for reassurance as well. Like, with other subjects you won't be so collaborative 'cos you're like 'oh yeah, that's my thing, that's what I can do', and in stats 'cos it's one simple answer, if you've got the same one then it's most likely that.*

*I would study to be prepared for the study sessions that we had and then we wouldn't do all that much study but we would sometimes quiz each other on areas that I might not have thought, and just in general as well, and that's the good thing as well about having some aspect of group study, that means that you do end up often touching on areas that you might not have thought were important or that you might have missed.*

*And you can listen to their questions and think about it. 'Cos from my experience answering questions is very helpful, you have to think a lot. Sometimes I think I understand this problem and then another guy comes to me and asks a question and I think 'ah, I know nothing'.*

*I think also when you are in a group study session and if do understand something and someone else hasn't, trying to explain it you can realise your own limitations to what you know.*

## [3'] Method of working with peer learning

Students talked about a wide range of ways in which they utilised some aspect of peer learning, from simply checking results with colleagues before or after submitting assessments, through to studying with another person or in a group (even if the other students were not taking the same subjects), to setting up a Facebook page for discussion of course problems.

> *I usually do it individually but particularly during [the course] I would have Helen, 'cos we were both kind of on the same level as well, so we would go and meet in the library and she would be able to teach me things and I'd be able to teach her things, and that teaching process was really constructive.*

> *The other thing that happens a lot in psych [psychology] stats is that people create pages for their units. People all go on there and freak each other out with all their answers to all the quiz questions. So there's that, so whenever you're not sure of a quiz question you can check on that, but usually it makes it worse.* [*]

> *What I did do, when I got an assignment result back, I would compare with other people to see whether they got the question right and I didn't and I'd just swap. I'd go alright you got the right solution, I'll copy your one down, but if you want to look at mine you can copy that too.*

> *Honestly, I don't do a lot of group study. But generally I will do more group study if I am unsure about something which is usually when an assignment or exams are coming up.*

> *I guess it's when you feel unsure about what you're going to submit and you know your friend's really good at something, then you might be, like, 'hey, what did you do for question three 'cos I'm not sure if this is right?'.*

> *I study with my friends but they are all doing different courses. I just feel that being with them is more productive. Having someone to study with even if they are not doing the same unit.*

## Differences between third-year and first-year peer learning

While some of the themes identified in the third-year statistics students paralleled the themes from the first-year groups, there were also some important differences. Firstly, it appeared to be much more common to express a preference for working individually, and sometimes to justify that preference in various ways. While this study was exploratory and qualitative rather than quantitative, the frequency of such statements was quite apparent. Here is a selection of them:

*I did biology – everyone works together in biology… I find in stats I like to study by myself though.*
*The thing is, it's like at the end of the day I know that – it's gonna [going to] sound weird – but I know that I study best by myself. So at the end of the day I know I'd probably, if I got stuck I'd probably only ask one or two questions but I'd still go back and go by myself.*

*Well I think, yeah, often when I ask a question and someone tries to explain it to me, like I won't understand it at all, and yeah, it just doesn't help me. I think self-study is the best way to understand.*

*We tried [to study with friends] but progress is very slow. And you need to explain the things to the others… At uni [university] you spend a lot of time explaining things and so progress is very slow.*
*I tend to do more group work outside stats. 'Cos it's just a different feel to stats so you just have to do it by yourself, and even if I need help I'm just not sure where to go and look for help, even consultation time isn't that helpful.*

One common reason given for not making use (or greater use) of peer learning was the perception that statistics wasn't the sort of subject that needed discussion.

*You don't really just learn by just discussing things with your peers. Statistics isn't that kind of subject, it's not like English or philosophy, some things you just have to read it and get it yourself.*

*I think in subjects like law you need ideas from people, you need to share your thoughts… In stats there's one way to do something, well there are different ways but usually there's one obvious way. So, yeah, there's not much we need to discuss.*

*You could say that, like, a statistics degree isn't designed to be collaborative at the moment, if you think about it.*

Another reason was the problem of sharing misconceptions and mistakes rather than correct ideas and solutions. Continuing the earlier quote about the psychology Facebook page [*]:

*[But how would you know if someone's wrong?] Well that's the thing, people go on there [Facebook] really needing an answer and they just don't know. Sometimes I go on there and I'm, like, 'what are you doing? That doesn't even make sense; why would you do that?' But that's why students monitor each other and people do go in there and go 'That's not the right way to do that.'*

But the essential reason seems to be that students have developed their skills and approaches to the extent that they feel less in need of peer learning.

> *At the moment you're getting people who are established, not like fresh students… Like, if you were to start from the start and you were to do assignments like coding and stuff that required that you had to share and talk to other people, then you would learn to quickly, like, come together.*

> *If you got more people that [know] the end result but don't know how to get there, you'll get more collaboration. 'Cos at the moment you're getting people that are coming in three years later and they've already worked out how to effectively study.*

## Discussion

The overall picture that emerges from the participants, both the first-year and the third-year groups, is that they are aware of peer learning as a source of support for their studies, and they are familiar with ways of arranging and carrying out peer learning and its range of possible benefits. The first-year psychology statistics groups made extensive use of self-arranged peer learning, to the extent that some of them described it as an essential component of their learning. By contrast, the third-year group, as more experienced students, have developed their individual learning approaches so that they are less dependent on help from peers or even tutors. Amongst these students there is little evidence of the 'emergency' study groups that were described by the first-year students without which they would be completely lost and may even give up their studies.

From the theoretical viewpoint, many of the first-year students are still on the fringes of the university community, building their personal learning networks and experiencing the 'legitimate peripheral participation' described by Wenger (1998). They are 'novice students' learning to survive in the university environment and broadening their conceptions of their discipline and their learning, and their future use of statistics in professional contexts (REID et al, 2011). On the other hand, many of the more mature third-year students are no longer on the fringes, but have moved into full participation in the community of practice of learners, attaining the status of 'expert students'. They are able to work individually or with teachers and fellow students, and they can utilise the resources of other members of the community of practice – including peer learning – as and when they need them.

The participants in this study belonged to different disciplines: psychology, actuarial studies, business and science. It was apparent in some of their statements that the different aspects of and approaches to statistics that they were studying had an influence on their attitudes towards peer learning. Actuarial students require the strongest mathematical background and seem to focus in their units on the technical aspects of the discipline. The third-year actuarial students in this study were least interested in working collaboratively in statistics. Business and science students take third-year elective statistics units out of an interest they have developed during their studies. Several of them stated that engagement with peers was not a necessary component of statistics study, though it was often useful. Psychology students, on the other hand, are required to take statistics units in each year of their undergraduate degree. Statistics is a core part of their degree structure, but not the main focus. It is interesting to note that the psychology students were the only group that talked about regular involvement with peer learning in third-year statistics, though their approaches seemed more mature than those of their first-year colleagues, some of whom viewed their peer learning groups as lifelines.

The philosophy of science students in Havnes' (2008) study were all in their first year of studies. Nevertheless, Havnes describes various 'trajectories' of peer-mediated learning beyond the curriculum, including one where teachers advise students to set up colloquium groups and meet weekly with them, and at the other extreme, students forming groups with a social dimension to reconcile and recontextualise the course content in terms of their daily lives. It would be interesting to study such trajectories during a complete three- or four-year degree in statistics in various major studies. The less frequent use of peer learning in third-year statistics is contrary to the findings of Vines (2010) in a Norwegian law course. However, that course incorporated a strong promotion of peer and networking skills, formally in the first year, and then handed over to student arrangement and control in later years, with continuing staff support in the form of learning resources. Indeed, students in that study valued their informal peer-mediated learning opportunities and actively opposed excessive staff involvement. On the other hand, the study by Orsmond et al. (2013) of biology students' social learning found results similar to those of our statistics study:

> It was noticeable, however, that third-year students were more focused on self-assessment. These students spoke more in terms of developing personal knowledge compared to first and second year students. (p.899)

Sometimes the discipline of study includes crucial requirements for peer learning. The saxophone players who participated in the music study by Reid and Duke (2015) had essential requirements for learning by playing together in chamber ensembles, and their overall learning was dependent on every member of the group carrying out their part. The pianists had a greater focus on individual work, but many of them were also involved in ensemble music. The peer learning of student nurses in Stenberg and Carlson's (2015) study could also be characterised in this way. Health professionals are most often working in such team contexts, and so peer learning is not only an effective path to skills and knowledge, but is also a way of developing the generic teamwork skills on which the profession is based.

## Conclusion – lessons for statistics pedagogy

The results of these studies may have important messages for statistics educators. Firstly, despite some comments from students, particularly those later in their studies, most participants were well aware of the value of collaborative work with their peers, and particularly in situations outside their formal classes. Indeed, some students in first year viewed their 'study groups' as their key to success; one student stated:

> *I mean, if there was no one that…, if you didn't know anyone and you didn't have anyone to ask, I don't know what you'd do. If I didn't have that, if I was just by myself trying to do it, it would be…, I think I'd give up the course. I don't think I'd try.*

This is an important point for lecturers to bear in mind. There are at least some students early in their studies who would not survive without the support of their peers.

On this basis, it may be tempting for an academic to try to oversee the process of peer learning, to arrange formal peer learning situations to avoid problems such as students promulgating incorrect approaches. However, there seems to be an important aspect of identity development that is only available if students themselves are in charge of at least some aspects of the process. By their third year, most students had worked out how to be effective learners, in part because of their experiences with collaborating with their peers. Instead of seeking to take over more aspects of peer learning, academics could provide explicit suggestions and even training for novice students in how to manage their own learning, including the cooperative as well as individual aspects. It would be beneficial to

provide time in the first few classes, particularly tutorials but also lectures, for students to get to know each other, to set small but regular early assessment tasks as an incentive for cooperative work, and to encourage and help shy or disinterested students to form or join a study group.

A particular aspect of relevance is the way that the statistics units and degrees are constructed: for some students, seemingly not conducive to or requiring student collaboration or peer learning. It seems a pity that many statistics students have developed a perception that statistics is a solo activity, and hence that peer learning is unnecessary. Comments such as *"a statistics degree isn't designed to be collaborative at the moment"* and "*in stats there's one way to do something ...there's not much we need to discuss"* indicate a particular conception of the discipline that seems to be at odds with the collaborative nature of much professional work as a statistician.

It is important that students' conceptions about statistics, learning statistics and professional work in the discipline should also be incorporated into the pedagogy. This could be done at the expense of some of the content; many students (particularly those in the first-year psychology group) found the constant focus on more content very dispiriting: *"every week more information, more information, more information."* As academics, we often plan our courses in terms of material that needs to be 'covered', but learning can more efficient if students have space to consider the nature of the discipline, the way they learn in the discipline, and the role that the discipline will play in their future professional work. This is true in more mathematical subjects such as actuarial studies as well as in more applied subjects such as psychology and business.

These ideas and suggestions are not new, and a more theoretical and wide-ranging discussion is given in Reid et al. (2011). However, it is pleasing to see how the students in this study implicitly supported them.

The fact that students who participated as research leaders or subjects were a self-selected sample of those who were particularly interested in peer learning could be seen as a limitation of the study. Discussions amongst participants included several comments about other students who had not made the same commitment to their studies. Nevertheless, such an introductory and qualitative study of the phenomenon of peer learning beyond the curriculum has given overall information on the views of students from several specific classes at a particular university (Macquarie University in Sydney). In terms of research design, it is a most appropriate first step in investigating a topic whose boundaries are unknown to teacher-researchers. The information gained from this study

is vital for the next stage of the research – to investigate the role and extent of such peer learning in broader contexts. This could be carried out quantitatively utilising more traditional approaches. Two of the authors (GB and PP) have already begun this process, developing a questionnaire of 'Student motivated peer learning in statistics' and trialling it with a larger group of around 300 students. The results are currently being prepared for publication, but in the meantime the questionnaire is available from either of these authors.

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