CriSTaL
CRITICAL STUDIES IN TEACHING & LEARNING

2022, Volume 10, Issue 2
DOI: 10.14426/cristal.v10i2.590

Hybrid approaches to teaching: Re-imagining the teaching of a foundational science course during a global pandemic

Daniel M. Parker[1]#, Jo-Anne Vorster[2], Lynn Quinn[2], and Margaret A.L. Blackie[2]*
[1]*School of Biology and Environmental Sciences, University of Mpumalanga*
[2]*Centre for Higher Education Research, Teaching and Learning, Rhodes University*
#Corresponding Author: daniel.parker@ump.ac.za
* @mags_blackie

(Submitted: 7 September 2022; Accepted: 24 November 2022)

Abstract
Access to scientific knowledge, and teaching in the sciences, is believed to be about training because scientific knowledge is, generally, specialised. However, for students to gain full epistemological access in the sciences, they also need to be inducted as scientists and learners of science. We use Bernstein's regulative and instructional discourse to engage with the notion of epistemological access and effectiveness of a foundational science course. We examine how the course can cultivate scientific identities amongst first year students at a recently established South African university. Our analysis assesses the impact of the forced shift from contact teaching to Emergency Remote Teaching due to the COVID-19 pandemic. We demonstrate that the course was able to begin to facilitate the cultivation of different kinds of knowers in science. However, several gaps remain. Thus, we argue that foundational science lecturers should focus on hybrid teaching approaches to promote enhanced learning amongst students.

Keywords: COVID-19, Emergency Remote Teaching, flipped classroom, hybrid teaching, mixed pedagogy

Introduction
The COVID-19 pandemic suddenly thrust all universities into what has now become known as Emergency Remote Teaching (Council on Higher Education - CHE, 2020). The choice of nomenclature was deliberate because the pandemic resulted in an emergency situation where most universities, and academics, had to transition rapidly from face-to-face, contact teaching to remote, online teaching (CHE, 2020). Significant adjustments to teaching and learning needed to be made quickly to ensure that the 2020 academic year could be successfully completed. It is not pertinent to our purposes here to discuss the full range of constraining and enabling factors during the transition and subsequent phases of Emergency Remote Teaching and this has been done in more detail elsewhere (for example, Kraft, et al., 2020). In this article we critically analyse

the pedagogic approach to the teaching of a foundational science course at the newly established University of Mpumalanga in South Africa (established in 2014). Our aim was to demonstrate, not only an innovative approach to teaching in the sciences, but also to show that learning in the sciences can be more than just the transmission of knowledge for the sake of knowledge.

Knowledge and knowers

Morrow (2009) suggests that to become a participant, or a knower, in a particular discipline requires an individual to learn the appropriate ways of working, and understanding the disciplinary-related knowledge/canon, and the logic of the field. Morrow (2009) refers to this participation as epistemological access, with such access being underpinned by discipline-specific norms, standards, and rules. Significantly, for students to gain epistemological access to a discipline, they not only need to learn the knowledge or content, but also need to learn how to actively participate in the discipline's normative processes and practices (Morrow, 2009). Epistemological access is, in many ways, analogous to access to specific academic discourses, or ways of being, and making sense of the world, which are secondary to our primary social discourses like our home backgrounds and prior socialisation (*sensu* Gee, 2012). Lave and Wenger (1991) take the concept of epistemological access further with what they call Legitimate Peripheral Participation (LPP). LPP describes the process of students becoming part of communities of practice in their learning to transition from being newcomers or novices to mastering the discipline (Lave & Wenger, 1991). Crucially, Lave and Wenger (1991) underscore the importance of including the social-cultural practices of a discipline for achieving LPP. Moreover, empirical work in the South African higher education context supports the notion that early socialisation practices and past education experiences serve to either enable or constrain access to higher education discourses (Volbrecht & Boughey, 2004; Boughey & McKenna, 2016).

Boughey (2002) argues that to acquire a discourse, and thus enable epistemological access for becoming a knower of a discipline, the focus should be on making the norms, standards, values, ways of thinking, acting, speaking, reading, and writing in that field explicit to students through curricula and teaching. In other words, it is not enough to foreground disciplinary knowledge in a curriculum; more needs to be done to mould and shape students as knowers or to make explicit to them *how to be* in a specific discipline. In the natural and physical sciences, *what* one knows (strong epistemic relations) is deemed much more important than *who* one is (strong social relations) (Maton, 2014). These strong epistemic relations can result in a form of 'knower blindness' which is a distorted notion of scientific objectivity (Blackie, 2022; Hlatshwayo, et al., 2022). This focus on *what* to know can further result in content-focused, and overloaded science curricula that may not promote student learning (Ellery, 2018). Yet, recent research has shown that South African academics can be resistant to focusing on the knower (Adendorff & Blackie, 2022a, 2022b). Blackie (2022), therefore, calls for the development of 'knower awareness' in science education; that is the recognition that the person of the scientist – the knower – is essential to the development of scientific knowledge. The focus of this paper is on the development of the 'knower'.

Science knowers

Knowers in any discipline can be distinguished based on who they are (kinds of knowers) and how they know (ways of knowing) (Maton, 2014). When a discipline foregrounds how someone knows, it requires the knower to see and do things in particular ways and involves acquiring an understanding of the discipline through prolonged participation and apprenticeship. Knowers, in these cases, can be said to have a cultivated gaze, where a gaze refers to a particular way of recognising and understanding what is valued by the discipline (Bernstein, 2000). By contrast, when a discipline emphasises who someone is, the kind of knower is important, and legitimacy stems from knowers' social positions (e.g., race, class, or gender), they can be said to be in possession of a social gaze. An individual is said to have a born gaze if they simply have naturally 'born' talent in a particular discipline or can master the knowledge and processes of a discipline without any additional learning. Disciplines that are dependent on knowers acquiring specialised knowledge, legitimate what is known as a trained gaze.

In the humanities, a cultivated, a social, or a born gaze is normally foregrounded. In contrast, in the sciences, a trained gaze is usually legitimated (Ellery, 2018). Since becoming a knower in the sciences is considered to entail training, Maton (2014) suggests that anyone, regardless of their social background, can be successful in science provided that they can acquire the appropriate disciplinary knowledge and skills, and acquire the trained gaze of a scientist.

Empirical research conducted on a foundational science curriculum at a South African university demonstrated that in addition to students needing to acquire the trained gaze of a scientists, students also need to take on the identity of being science learners (Ellery, 2018). Ellery argues that if students are to acquire epistemological access to the sciences, then curricula, teaching, and assessment methods need to ensure that students are explicitly taught how to be science knowers (or scientists) as well as how to be science learners. This explication of how to be is particularly important in the South African context where many students' home and educational backgrounds have not prepared them for working and learning in a scientific context. Ellery (2018: 31) shows that to become science learners, students require 'knower dispositions, values and attributes such as being engaged, critical, reflective, confident, independent, proactive, responsible, and autonomous'. By contrast, for students to be become scientists

> they would be expected to develop practices and knower dispositions based on scientific epistemic values linked to knowledge generation and claim-making, such as being rigorous, curious, reliable, and objective, working accurately and precisely, estimating appropriately, observing carefully, seeking simple solutions, and thinking analytically and critically. (Ellery, 2018: 31)

Our study attempts to provide some insight into how the advent of a global pandemic prompted a critical re-examination of the kinds of knowers (scientists and science learners) that are being legitimated in the curriculum of a foundational science course.

The context of the study

Since democracy in 1994, one of the structural mechanisms employed by the South African government to promote student access to higher education has been to promulgate the establishment of two new comprehensive universities – the University of Mpumalanga (UMP) in the Mpumalanga province, and the Sol Plaatje University in the Northern Cape province. Comprehensive universities in South Africa are universities that offer a range of programmes and attempt to balance the provision of formative and professionally oriented degrees (e.g., Bachelor's programmes), with vocationally and technologically oriented teaching and learning programmes such as diplomas (CHE, 2016).

One of the programmes offered by UMP is a Bachelor of Science (B.Sc.) degree. This qualification focusses on the biological, earth, and environmental sciences. In the first year, students take a fixed curriculum in which they do a full year of biology and earth or geographical sciences, and a semester of integrative environmental science. These courses are supported by a semester of chemistry, a semester of computer science, and a semester of mathematics. In second year, there are separate, year-long courses in ecology, environmental science, geography, geology, entomology, and integrated water management. Students select any three of these courses, contingent on the university rules for progression. In third year, the same courses from second year are offered but at level 7 of the South African Higher Education Qualification Sub-Framework (HEQSF). Students select two of these year-long courses which represent their major subjects. All combinations of majors are designed to prepare students for further studies, or employment in a wide range of fields and it is expected that as UMP grows, additional elective options will be made available. Nevertheless, throughout the three years of the programme there is an emphasis on independent research, and third-year courses include credit-bearing research projects.

Theoretical and analytical framework

We used Bernstein's ideas of instructional and regulative discourse to engage with the notion of epistemological access (Bernstein, 2000). Bernstein (2000) was interested in how power and control influenced student learning. He was curious about the ways in which the classroom perpetuates (or disrupts) social stratification.

Bernstein (2000) argued that there are two kinds of processes (discourses) which reveal what counts as 'legitimate' within the social structure of the classroom. We are used to thinking about the 'instructional discourse' which comprises the skills and knowledge which we are trying to teach. But this is embedded in a 'regulative discourse' which implies a 'way of being' and gives strong messages about who 'belongs' in the space. Thus, in Bernstein's terms, a course which is proclaiming inclusivity through the knowledge in the instructional discourse can remain a place of deep alienation for some students by virtue of the unspoken regulative discourse. For example, if participation in class is primarily through the raising of hands and articulating a question, then this strongly favours middle class students who are confident in speaking English. Although the regulative discourse can refer to the social order of the institution or society, the social order (i.e., how to act, speak and conduct oneself) of the discipline is arguably more important for regulating both staff-student interactions in the classroom, and the conduct of students as science learners. This regulation requires students to become more autonomous, critical learners who are responsible for their own learning (Ellery, 2017). The discipline-specific rules are also associated with regulating the conduct of students in the classroom, requiring them to attain the requisite knowledge, skills, norms, and values (Ellery, 2017).

Embedded within the regulative discourse, the instructional discourse pertains to the actual curriculum content and classroom activity – what is taught and how it is taught (Bernstein, 2000). The instructional discourse is underpinned by the rules of the discipline, and these regulate the selection, sequencing and pacing of knowledge, and the evaluative rules which define what is considered legitimate knowledge and learning (Bernstein, 2000). The regulative discourse can enable or hinder access to the instructional discourse. Using multiple methods of encouraging student participation in class and with one another lowers the threshold to actively engaging with the knowledge through conversation. Such activities enable epistemic access affording students a (relatively) safe space to ask questions and test understanding. Importantly, through 'speaking' science the student also begins to take on the identity of a knower of the science.

Empirical work has demonstrated that one of the many ways that lecturers can promote epistemological access in their courses is to employ a mixed pedagogy (Lingard & Mills, 2007). A mixed pedagogy is sometimes referred to as a mixed methods or flipped approach to teaching and learning (Simmons, et al., 2020; Aziz & Islam, 2022), whereby students are introduced to learning material outside of the classroom prior to engagement with the teacher and/or to learn through multiple methods (Simmons et al., 2020; Aziz & Islam, 2022). Within a mixed pedagogy approach, one can choose where to place the emphasis and where to hold strong boundaries and make clear connections, and where one can allow for a more dialogic, responsive approach. While this balance of strong boundaries and responsive teaching can be achieved in several learning contexts, Ellery (2017) suggests that the mixed pedagogy approach can better enable epistemological access of all groups of students. In the context of a foundational science curriculum, Ellery (2017) proposed strong boundaries and clear connections in the selection and sequence of knowledge acquisition, but weaker boundaries and fluid connections in terms of pacing and relationships with students (Ellery, 2017). In other words, students are aided when teachers drive the selection and sequence of what is taught but are flexible in terms of the pace of their teaching, and actively attempt to build meaningful relationships with their students.

We are of the view that the enforced move to emergency remote teaching by the COVID-19 pandemic forced new pedagogic approaches and practices which may well prove a beneficial augmentation of teaching practice. But this will only happen with careful reflection. We wished to analyse to what extent a remotely taught curriculum succeeded in ensuring that students were given opportunities to acquire foundational science knowledge and were beginning to acquire the dispositions of science learners and scientists as described by Ellery (2018). We used student and peer feedback on one foundational B.Sc. course at the UMP (see details below), to analyse the effects of the Emergency Remote Teaching activities on student learning. Specifically, we wished to interrogate how course processes facilitated the cultivation of different kinds of knowers in science. Our discussion represents a reflection of the patterns that emerged over the two years of Emergency Remote Teaching in the course.

The course, its processes, and effectiveness at facilitating knowers in science

Biology 102 is a course which was designed and developed by the first author upon arrival at the UMP in 2016. The first author (DMP) has also been the sole lecturer for this course since then. The course is a second semester module (July to November) in the first year of the B.Sc. It is usually only offered in person (face-to-face), and normally takes 14 weeks to complete. The course has been allocated 15 credits of the total 120-degree credits required in first year and is at the NQF level 5. Because the course is also a prerequisite, foundational module for two other programmes at the UMP, it did not assume that all students taking it will have taken Life Science in Grade 12. The course is intended to provide the foundational building blocks of cellular biology for further study at the undergraduate level in the biosciences, and relevant elective modules in the B.Sc., B.Sc. (Agriculture), and B.Sc. (Environmental Science) programmes. In face-to-face mode teaching, there are normally four (50 minute) lectures and one (3 hour) practical/laboratory class per week.

Knowledge of cellular biology is foundational for any biologist because it is, in essence, the first principles upon which all other life science disciplines build (Zupanc, 2008). The course description, specified in the course documentation and developed by DMP, clearly articulates the importance of these first principles:

> The cell is the basic unit of life and cell biology is the branch of biology that studies the structure and function of cells. Cell biology is concerned with the physiological properties, metabolic processes, signaling pathways, life cycle, chemical composition and interactions of the cell with its environment. This is studied both on a microscopic and molecular level. The history of cell biology dates back to the 17th century when the term cell was first used. We now recognize cells to be the building blocks of all living organisms. The discovery of DNA by Watson and Crick in the 1950s provided the world with a new way of understanding cellular function at the molecular level which led to our understanding of patho-physiology of diseases, cancers, microbe structure and the discovery of many important drugs and their associated treatment pathways. The purpose of this module is to introduce students to the essential topics of cell biology. An understanding of the structure of cells underpins our understanding of how they function. Cell biology provides an important foundation for all science students. In this module we aim to provide you

with a framework that will allow you to fully appreciate how unicellular and multicellular organisms are structured and how they function.

Since Biology 102 is a second semester course, DMP had significantly more time than lecturers in the first semester of 2020 to plan his teaching after the announcement of the National State of Disaster and subsequent lockdown on 15 March 2020 (Declaration of a National State of Disaster, 2020) in South Africa. Crucially, this extra time allowed DMP to ensure that the course documentation foregrounded and included knowledge (the *what*) and *how* to become a science learner and a scientist. In addition, he was able to use his enrolment in a Postgraduate Diploma in Higher Education (PGDip (HE)) for academic developers at Rhodes University as a way of learning by doing (Stewart, 2012). Being taught under Emergency Remote Teaching conditions allowed DMP to think, feel, and experience how many of his students might be thinking, experiencing, and feeling. For example, DMP's first PGDip (HE) module was face-to-face, but the remaining five modules all had to be taken remotely. Because the remaining modules needed to be completed remotely, DMP had to balance domestic/household responsibilities with work and academic responsibilities. This situation allowed DMP to empathise with the challenges experienced by his own students. The experience of being taught remotely was crucial in promoting DMP's flexibility in terms of the pace of his teaching and intentional relationship building with his students.

DMP began the process of planning for the teaching of Biology 102 by firstly revisiting the exit-level outcomes for the B.Sc. programme and then the specific outcomes for the course (Barnett, et al., 2001). DMP then reflected on what he believed was important to teach in the module (the selection of knowledge), when it should be taught (the sequence of knowledge), and how to pace the teaching (Bernstein, 2000). In addition, through both of these initial processes he was cognisant of the issue of epistemological access as outlined above (Morrow, 2009).

The result of this reflection was a reconsideration of the instructional discourse, and a complete restructuring and presentation of the course on UMP's Learning Management System (Moodle). Given the circumstances, he elected to reorganise the course into weekly blocks, using a philosophical question to serve as inspiration for each week. The themes were linked to the overall theme for the course, "a voyage of scientific discovery", using the fundamental concepts of cellular biology as the theoretical framework. In addition, to begin to induct students into the discipline (Barnett, 2009), he chose to start the semester (the first three weeks) by posing two broad, provocative questions to the students; "Why am I here?" and "Who needs science?". His reason for posing these questions was to start introducing students to the dispositions they would need to become both science learners and scientists. The student evaluations in both 2020 and 2021 demonstrated that this critical course process was most likely having the desired effect. Specifically, students commented:

> The module got me so interested as it teaches scientific writing, presentations, posters, etc. It made me to be a biologist in upcoming years. (Student respondent 79, 2020)
>
> This module gave me an easy way to get information which is researching. (Student respondent 97, 2020)
>
> It wants you to [be] active and always doing research while learning more new things. (Student respondent 7, 2021)
>
> Learning all about the important scientists that played a huge part on our future. (Student respondent 19, 2021)

In these responses, it is evident that the students are beginning to grasp the importance of scientific skills like writing and some of the dispositions of a science learner, such as autonomy and curiosity. They are also beginning to see themselves as legitimate ‘knowers’.

The importance of the initial induction phase of the course was also identified as being useful by one of DMP’s peers in 2020:

> I can see that the students are generally responding well to his approach and that is also encouraging. His ability to keep his formats simple, clear and well-structured demonstrates the value of working smart and not just working hard in his teaching that is very beneficial to the students. (Peer evaluator, 2020)

In the first week of the course, students were also required to join a peer group for the semester since collaboration is one of the key dispositions of a scientist (Fox & Faver, 1984) and learning to work with others is one of the critical cross-field outcomes of the programme. Rather than allocating students to groups, arbitrarily or otherwise, DMP used the group function in Moodle to allow students the freedom to select their group members and their group names to empower them and promote inclusivity. This approach gives the students agency through participating in the development of one aspect of the regulative discourse. This process, and the group learning, appeared to have been appreciated by the students:

> Group assessments [in the context of what the student enjoyed the most during the course], it is because they brought us together as students even in trying times (Student respondent 53, 2020)
>
> We had an individual and a group task for every week which kept us studying😁. (Student respondent 112, 2020)

> Group tasks, having to discuss a topic with my group members, hearing different point of views. (Student respondent 55, 2021)

> Taught us how to work in groups and to do research as a team. (Student respondent 122, 2021)

Although autonomy and independence are two of the cornerstones of a successful scientific disposition (Fox & Faver, 1984), so too is the importance of instilling a culture of collaboration and teamwork in science learners from early on in their careers (Fox & Faver, 1984). In addition, the desired effect of enabling epistemic access through 'speaking' biology does appear to be afforded by the regulative discourse. Indeed, one of DMP's peer evaluators, who is an active scientist, also touched on the significance of group work in his evaluation:

> … the integration of group tasks into the Moodle sessions is commendable because this aligns neatly with social constructivism, i.e., learning is greatly enhanced when students work collaboratively with one another and when they are engaged in the construction of knowledge. (Peer evaluator, 2021)

Throughout the 14 weeks of the course, students were given one group task and at least one individual learning task for completion each week. In addition to speaking to the dispositions of science learners and scientists, the other core purpose of these tasks was to reassure the students that they were in this together with the lecturer and that he was available at the other end of the virtual line. The group tasks were set to try and promote more collaborative learning (Stewart, 2012) and feedback was formative. One student noted:

> The fact that we were given space to actually process and understand the content bit by bit instead of being a whole lot of work at the same time. (Student respondent 52, 2021)

This student's response highlights how DMP's mixed pedagogy was visible to the students. His intention was not to overwhelm the students but to carefully pace the tasks to promote student learning. Thus, his attention to the instructional discourse was shown to be valued by the students.

The individual tasks also provided a mechanism for DMP to monitor online engagement by the students (i.e., identify if any students were having connectivity issues or struggling to access the material), and to provide students with important opportunities to practice assessment tasks in the course (Ellery, 2017). Importantly, some students were able to see the value of this assessment practice, with one student highlighting:

> The weekly quizzes that train us to get used to how questions may be asked in the tests. (Student respondent 97, 2021)

To further promote more autonomous learning by the students, DMP required students to complete weekly tasks which were designed as scaffolded exercises (Wood, et al., 1976) building on the ideas and learning each week. For example, the group tasks moved from answering single questions in a *wiki* during the first week to submitting a detailed, written task about nanotechnology and the role of cell biology in the fight against COVID-19. This approach is at least a step in the direction of the contextually relevant engagement called for by Cross and Govender (2022) and Madondo (2021). These tasks were deliberately designed to be relevant to the global context in which all academics and students found themselves during 2020/2021. By being contextually relevant, DMP also hoped to make the content more interesting and engaging for the students and begin to inculcate a sense of belonging which he hoped would ultimately foster improved academic success (Krause-Levy, et al., 2021). His efforts appeared to have the desired effect i.e., the regulative discourse appears to be enabling epistemic access to the instructional discourse, with several students noting:

> It is about real-life things what we mostly see and experienced. (Student respondent 102, 2020)

> The fact that it covers chapters that are relevant to the survival lar living organism and the understanding if how they all merge into an ecosystem. Also, the fact that every process points something we can relate and see happening in the real life. (Student respondent 86, 2020)

> Everything that I have learned is aligned with my future career path. (Student respondent 82, 2020)

Additional and optional weekly resources were also uploaded for the students to engage with as both a way to build foundational knowledge and provide enrichment for the students. Both of DMP's peer evaluators believed that these additional resources were useful:

> I am impressed by Prof. Parkers multi-pronged approach to online teaching and use of a range of material and methods in his teaching. He's given me allot of ideas that I will incorporate into my teaching. (Peer evaluator, 2020)

> Prof Parker uses voice notes and a combination of texts and graphics in PowerPoint presentations to provide clear and coherent descriptions and explanations of each session's topic and related subtopics. For each session, students are provided with a variety of learning resources which are categorized as 'core' and 'optional'. (Peer evaluator, 2021)

However, the overall engagement of the students with respect to the additional resources was somewhat disappointing in both years. For example, in 2020, approximately half of the enrolled students had not even attempted to open any of the additional resources mid-way through the course. Instead, students appeared to prioritise summative assessment tasks that contributed to their course record or class mark. When a quiz or assignment "counted for marks", engagement/completion by the students rose to close to 100% on all occasions in both years. This situation is analogous to the assessment "backwash" described by Ramsden (1992) where assessment tasks effectively signal to students where they should focus their learning efforts. Although DMP incorporated numerous formative learning activities during the 14 weeks of the course, he may need to consider other innovative tools like the inclusion of group participation grades to try and focus the learning attention of the students in the future.

As replacements for the usual, face-to-face practical or laboratory classes, DMP was able to motivate UMP to procure laboratory simulation software which was used to provide weekly practical simulation replacements from week four onwards. There were 10 of these practical simulations during the course that were related to the course content and theme for that week. Students were not graded on each simulation but were instead given a participation grade based on the number of simulations they had completed during the semester. For example, if a student completed 5 of the 10 simulations, she/he received a simulation participation grade of 50%. This grade contributed approximately 2.5% to the final class record grade. Although not all students engaged with the practical simulations in 2020 and 2021, 17% of respondents in 2021 stated that they enjoyed the practical simulations and that they believed that the simulations enhanced their learning during the course.

However, one of the major learning activities that was not possible during the COVID-19 pandemic was the running of practical or laboratory classes where students had the opportunity to explicitly practice and rehearse particular *ways to be* as a scientist (Boughey, 2002). Specifically, in the laboratory setting, students are actively taught how to dress, how to behave, and exactly what to do when in the laboratory. Importantly, the lecturer and any graduate assistants can use these laboratory sessions to role-model how to be 'good' scientists by, for example, always wearing their lab coats and closed shoes, keeping their workstations clean, etc. Such role modelling affirms the regulative discourse of laboratory practice and allows students to embody their identities as science learners and scientists. Such practical opportunities were not possible during 2020 and 2021 and this lack of opportunity was highlighted by several students as being a negative consequence of Emergency Remote Teaching:

> Students should be given a chance to complete practicals maybe once a week in a real lab. (Student respondent 85, 2021)
>
> I wish we were doing a more practical approach when learning about lots of things because that will increase the interest of students towards this module and learning will be fun. (Student respondent 111, 2021)

> The fact that we didn't do the practicals physically ourselves being guided through every step. (Student respondent 85, 2020)

It was also not possible to have contact classes during the pandemic, and, in both years, students felt that this was something that they would prefer instead of a purely online offering (6% of respondents in 2020 and 10% of respondents in 2021). Although the contact lecture/discussion model could be viewed as a rather passive form of learning, there is evidence to suggest that first year student learning can be enhanced with contact teaching (Terenzini & Pascarella, 1994). However, learning can be enhanced even further when students are taught in smaller groups (Terenzini & Pascarella, 1994). Thus, a hybrid approach that combines online and contact forms of teaching and learning, with additional group activities, is likely to be the most effective. Indeed, empirical research at a South African university has demonstrated increased cognitive engagement by students and higher test scores in a "partially flipped" or hybrid ecology course (Le Roux, 2016).

Conclusions

The enforced shift from face-to-face and contact teaching to Emergency Remote Teaching in 2020 and 2021 provided us with the unique opportunity to reflect on both the benefits and constraints of remote teaching in a foundational science course. Traditionally, foundational science courses are taught in a didactic fashion, are content-heavy and riddled with jargon (Ellery, 2017). Such an approach to teaching foundational science courses does not adequately equip students to become scientists and science learners (Ellery, 2018). In addition, the traditional didactic approach also has the potential to alienate students and strip them of their sense of belonging (Krause-Levy, et al., 2021). While many of the knower dispositions of scientists and science learners could be taught effectively using Emergency Remote Teaching, some were more challenging to teach, and for students to learn. For example, DMP was able to promote autonomy of learning but was not able to role-model the 'real world' behaviour of a scientist because face-to-face laboratory classes were not possible. Thus, the Emergency Remote Teaching mode, in isolation, is insufficient to cultivate knowers in science. However, when combined with the judicious use of face-to-face contact in the form of classroom and laboratory time, our approach is likely to be highly effective.

Overall, we believe that our analysis has demonstrated that an innovative approach to the teaching of a foundational science course has begun to facilitate the cultivation of different kinds of knowers in science – science learners and scientists. The careful consideration of the conjunction of the instructional discourse and the regulative discourse paid off. Although there is still much work to be done, we argue that foundational science lecturers should focus their attention on the use of a mixed pedagogy that foregrounds hybrid or flipped approaches to their teaching to promote greater engagement amongst students and affords their taking on of the identities of science learners and scientists.

Author bios

Daniel Parker is an associate professor in the School of Biology and Environmental Sciences at the University of Mpumalanga. Although a wildlife biologist by training, he is also a passionate undergraduate and postgraduate science teacher.

Jo-Anne Vorster is an associate professor at the Centre for Higher Education Research, Teaching and Learning at Rhodes University. She has been working in academic development since 1992 and her research interests include the nexus between academics' understanding of disciplinary knowledge and academic identity, academic staff development and the legitimation of academic developers.

Lynn Quinn is associate professor at the Centre for Higher Education Research, Teaching and Learning at Rhodes University. Her main interest is in academic staff development. She has taught and published on all aspects of academic staff development, including curriculum development, assessment, teaching and learning and quality promotion.

Margaret Blackie is an associate professor of higher education studies. Prior to going to the Centre for Higher Education Research, Teaching and Learning at Rhodes she worked at Stellenbosch University in the Department of Chemistry and Polymer Science. She has taught and published in chemistry, higher education, and theology.

Acknowledgements

Thank you to Jono Davy for the insightful discussions that provided the impetus for writing this paper.

References

Adendorff, H. & Blackie, M.A.L. 2022a. A decolonial science education: How do we move forward? In Hlatshwayo, M.N., Adendorff, H., Blackie, M.A.L., Fataar, A. & Maluleka, P. (eds.) *Decolonising knowledge and knowers: Struggles for University Transformation in South Africa.* London: Routledge, 103-120.

Adendorff, H. & Blackie, M.A.L. 2022b. Decolonization and science education: What is at stake? In Hlatshwayo, M.N., Adendorff, H., Blackie, M.A.L., Fataar, A. & Maluleka, P. (eds.) *Decolonising Knowledge and Knowers: Struggles for University Transformation in South Africa*. London: Routledge, 83-102.

Aziz, A. & Islam, S.N. 2022. Impact of Mixed Pedagogy on Engineering Education. *IEEE Transactions on Education*, 65(1): 56-63.

Barnett, R. 2009. Knowing and becoming in the higher education curriculum. *Studies in Higher Education*, 34(4): 429-440.

Barnett, R., Parry, G. & Coate, K. 2001. Conceptualising curriculum change. *Teaching in Higher Education*, 6(4): 435-449.

Bernstein, B. 2000. *Pedagogy, Symbolic Control, and Identity: Theory, Research, Critique* (Rev. ed). London: Rowman & Littlefield Publishers.

Blackie, M.A.L. 2022. An examination of the practice of chemistry through the lens of critical realism. *Journal of Critical Realism*, 21(4): 401-415.

Boughey, C. 2002. 'Naming' Students' Problems: An analysis of language-related discourses at a South African university. *Teaching in Higher Education*, 7(3): 295-307.

Boughey, C. & McKenna, S. 2016. Academic literacy and the decontextualised learner. *Critical Studies in Teaching and Learning*, 4(2): 1-9.

CHE. 2016. *South African Higher Education Reviewed: Two decades of Democracy*. Council on Higher Education.

CHE. 2020. *Quality Assurance Guidelines for Emergency Remote Teaching and Learning and Assessment During the COVID-19 Pandemic in 2020* (p. 29). Council on Higher Education.

Cross, M. & Govender, L. 2022. Researching students' epistemic access under Covid-19: Epistemological and methodological challenges. *Critical Studies in Teaching and Learning*, 10(1): 1-22.

Ellery, K. 2017. Framing of transitional pedagogic practices in the sciences: Enabling access. *Teaching in Higher Education*, 22(8): 908-924.

Ellery, K. 2018. Legitimation of knowers for access in science. *Journal of Education*, *71*.

Fox, M.F. & Faver, C.A. 1984. Independence and cooperation in research: The motivations and costs of collaboration. *The Journal of Higher Education*, 55(3): 347-359.

Gee, J.P. 2012. *Social Linguistics and Literacies: Ideology in Discourses* (4th ed). London: Routledge.

Disaster Management Act 2002, Pub. L. No. 313, 43096 4 1. 2020.

Hlatshwayo, M., Adendorff, H., Blackie, M.A.L. & Maluleka, P. 2022. Introducing 'decolonising knowledge and knowers'. In Hlatshwayo, M.N., Adendorff, H., Blackie, M.A.L., Fataar, A. & Maluleka, P. (eds.) *Decolonising Knowledge and Knowers: Struggles for University Transformation in South Africa*. London: Routledge, 1-10.

Kraft, M., Simon, N.S. & Lyon, M.A. 2020. *Sustaining a Sense of Success: The Importance of Teacher Working Conditions During the COVID-19 Pandemic*. https://doi.org/10.26300/35NJ-V890

Krause-Levy, S., Griswold, W.G., Porter, L. & Alvarado, C. 2021. The relationship between sense of belonging and student outcomes in CS1 and beyond. *Proceedings of the 17th ACM Conference on International Computing Education Research*, 29-41.

Lave, J. & Wenger, E. 1991. *Situated Learning: Legitimate Peripheral Participation*. Cambridge: Cambridge University Press.

Le Roux, A. 2016. Exploring a partially flipped ecology classroom on a rural campus in South Africa. *Journal for New Generation Sciences*, 14(1): 51-62.

Lingard, B. & Mills, M. 2007. Pedagogies making a difference: Issues of social justice and inclusion. *International Journal of Inclusive Education*, 11(3): 233-244.

Madondo, N. 2021. Curricular change for social justice: Teaching science by drawing on students' lived rural home experiences in higher education. *Critical Studies in Teaching and Learning*, 9(2): 19-38.

Maton, K. 2014. *Knowledge and Knowers: Towards a Realist Sociology of Education*. London: Routledge.

Morrow, W.E. 2009. *Bounds of Democracy: Epistemological Access in Higher Education*. Cape Town: HSRC Press.

Ramsden, P. 1992. *Learning to Teach in Higher Education*. London: Routledge.

Simmons, M., Colville, D., Bullock, S., Willems, J., Macado, M., McArdle, A., Tare, M., Kelly, J., Taher, M.A., Middleton, S., Shuttleworth, M. & Reser, D. 2020. Introducing the flip: A mixed method approach to gauge student and staff perceptions on the introduction of flipped pedagogy in pre-clinical medical education. *Australasian Journal of Educational Technology*, 36(3): 163-175.

Stewart, M. 2012. Understanding learning: Theories and critique. In Hunt, L. & Chalmers, D. (eds.) *University Teaching in Focus: A Learning-Centred Approach*. London: Routledge, 3-20.

Terenzini, P.T. & Pascarella, E.T. 1994. Living *with* myths: Undergraduate education in America. *Change: The Magazine of Higher Learning*, 26(1): 28-32.

Volbrecht, R. & Boughey, C. 2004. Curriculum responsiveness from the margins? A reappraisal of academic development in South Africa. In Griesel, H. (ed.) *Curriculum Responsiveness: Case Studies in Higher Education*. South African Universities Vice-Chancellors Association, 57-80.

Wood, D., Bruner, J.S. & Ross, G. 1976. The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry*, 17(2): 89-100.

Zupanc, G.K.H. 2008. Teaching zoology in the twenty-first century: Old challenges and new opportunities. *Journal of Zoology*, 274(2): 105-106.