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The utilisation of multiple theories in a single research study requires careful consideration with respect to the complementarity of the theories and the commensurability of the associated research accounts in relation to the specific setting or research site. This paper proposes that commensurability is constructed to facilitate the comparison that researchers are trying to make. The Social Unit of Learning project is conducted in a laboratory classroom facility equipped with 10 built-in cameras and up to 32 audio channels allowing structured, rigorous, fine-grained investigation of the social aspects of classroom practice. The rich and detailed data generated allows parallel analyses predicated on different theories. Complementarity of theories is distinguished from commensurability of research accounts, which requires the identification of operationalised constructs (e.g., categories or measures) common to the accounts generated.

Keywords: Classroom research, video technology, research methodology, research design.

Comparability as a challenge in learning research

With the abundance of theories and perspectives that have been generated through research over the years, a continuing challenge that researchers face relates to the difficulty of navigating the multitude of theories available (Bikner-Ahsbahs & Prediger, 2014; Cobb, 2007). In this paper, we consider the conditions under which multiple theories might be deployed for the simultaneous, parallel analysis of a single social setting, with a specific focus on the roles of complementarity and commensurability in undertaking comparison of either the theories or the analytical accounts arising from any such multi-theoretic research design.

Clarke and his colleagues (e.g., Clarke, Emanuelsson, Jablonka, & Mok, 2006) have advocated "complementarity" as central to the contemporary conceptual management of theory and methodology, particularly in their use of "complementary accounts" (Clarke, 1997). In the same way that two research accounts of a social situation may be different but equally legitimate and informative, so two theories may be complementary in their foregrounding of different constructs. Like the accounts, both may be simultaneously "true" within their own coherent conceptual framework so that they are disjoint but separately coherent. Tensions between theories emerge when we juxtapose the analytical accounts derived from two different theories in relation to the same research setting and the coherent body of practice that occurs there. A specific difficulty with juxtaposing and connecting existing theories and their associated constructs is the possible incommensurability of the accounts generated by their application, particularly because theories arise historically from observations based on different research designs, settings and participants.

Direct comparison of analyses employing different theories, without considering the contexts or settings in which the theories are being applied and the intended purpose of their application, empirically undermines the integrity of the comparison and the legitimacy of the conclusions drawn

from the comparison. Consideration of "the right to compare" (cf Stengers, 2011; Clarke, 2013) must take into account differences between findings or interpretive accounts that relate to different physical spaces, different times, and/or involve different actors, activities, or cultural contexts. Clarke (2013) expressed an analogous concern regarding international comparative research, where a single theory is applied across multiple culturally distinct settings for the purposes of comparison with respect to a specific construct (e.g., student achievement). In such studies, researchers can risk compromising the validity of the comparison made in their study by misrepresenting the valued performances, school knowledge, classroom practice, etc. that are differently conceived by the communities being compared. A construct such as "student participation" can be conceived so differently (both theoretically and in practice) in different cultural settings that it cannot be employed as a "boundary object" (Akkerman & Bakker, 2011), that is, as a point of connection by which classroom practice in the different settings might be compared. In the application of a single theory across different cultural settings, it is the questionable validity of application of the same construct in the compared settings that renders the accounts incommensurable.

We are employing commensurability in the sense of the construction of common points of distinction[1], which can be seen as related to the notion of boundary objects. *Boundary objects* have been described as "artifacts that live in different practices, but can be used in different ways" (Bakker, 2016, p. 272). Consistent with Akkerman and Bakker (2011), we caution against the identification of a boundary object simply on the basis of similarity of name without an empirical grounding suggesting functional equivalence. In the case of "participation," such assumed functional equivalence can conceal profound differences in nature. To illustrate the extent of such differences, the significance attached to student talk as facilitative of learning in Western theories (and practice) is contested by theorists writing from a different cultural and theoretical position (e.g., Kim & Markus, 2004), leading to entirely different theorisations of the constitution of student participation. Attempts to connect theories in which definitions of student participation were predicated on such different epistemologies would lead to accounts that not only lacked comparability, but were in fact incommensurable, since the connecting construct "student participation" would admit no common points of distinction in the application of the two theories to any setting. In this sense, one might describe the two *theories* as being incommensurable *in their application*, but we suggest that the theories are better thought of as complementary (disjoint, but separately coherent), and it is the *accounts* arising from their application that are incommensurable. Accounts, like theories, can be complementary (disjoint but separately coherent), but commensurability is an attribute of accounts alone, implying consideration of context and purpose.

We argue that the commensurability of two theories cannot be meaningfully examined except in so far as they are "put to work" in the analysis of data. The interpretive accounts generated by such analyses (whether qualitative or quantitative) can then be compared and assessment made of the points of correspondence or dislocation in the accounts (e.g., through the identification of common points of distinction). Such points of correspondence take the form of operationalised constructs

[1] Our usage of "points of distinction" draws on the comments of John Mason during a conversation on 10 February 2017.

having similar meaning within both theories and which therefore serve to align the interpretive accounts for the purposes of comparison and connection. Such operationalised constructs may be thought of as boundary objects (Akkerman & Bakker, 2011). A "boundary object" in this discussion is an operationalised construct that has conceptual legitimacy and similar meaning in both theories being applied, connected, and compared. Where no such constructs exist, the theories are disjoint and each may be applied independently of the other to investigate the same or different settings (Clarke et al., 2012). In such a case, the disjoint theories are complementary, although incommensurable with respect to any setting to which they might be applied analytically, sharing no constructs by which comparison of the resultant accounts might be undertaken.

How might different theoretical perspectives be juxtaposed and connected in a way that allows the commensurability of the analytical accounts to be examined? This paper proposes as one solution the construction of research designs that involve the generation of data, which are complex and rich in detail, while sufficiently structured to allow systematic investigation of both the research setting and the multiple theoretical perspectives employed. The affordances of such research designs are illustrated with examples from the Social Unit of Learning Project, which utilises the newly established laboratory classroom facility to generate data amenable to multi-theoretical analysis.

The Social Unit of Learning Project

The recent development of a laboratory classroom at the University of Melbourne (see https://pursuit.unimelb.edu.au/articles/high-tech-classroom-sheds-light-on-how-students-learn) has made possible research designs that combine better approximation to natural social settings, with the retention of some degree of control over the research setting, task characteristics, and possible forms of social interaction. Such designs allow conclusions about connections between interactive patterns of social negotiation and knowledge products (learning) to be made with greater confidence. The Social Unit of Learning Project used the Science of Learning Research Classroom (SLRC) at the University of Melbourne to examine individual, dyadic, small group (four to six students) and whole class problem solving in mathematics and the associated/consequent learning. The project aims to distinguish the social aspects of learning and, particularly, those for which "the social" represents the most fundamental and useful level of explanation, modelling and instructional intervention. The project conforms to an experimental rather than a naturalistic paradigm. The caveats for the experimental approach are discussed in greater depth elsewhere (Chan & Clarke, in press). The SLRC has the capability to capture classroom social interactions with a rich amount of detail using advanced video technology. The facility was purposefully designed to allow simultaneous and continuous documentation of classroom interactions using multiple cameras and microphones. The project collected multiple forms of data for analysis including student written products and high definition video and audio recordings of every student and the teacher in the classroom. This allows the examination of data from multiple perspectives by multiple researchers as well as the reciprocal interrogation of the different theoretical perspectives through answering research questions such as the following:

1. What commonalities and differences in process and product are evident during problem solving activities undertaken by learners as members of different social units (individual, pairs, small groups and whole class groupings)?

2. Which existing theories best accommodate the documented similarities and differences in process and product and in what ways do the accounts generated by parallel analyses predicated on different theories lead to differences in instructional advocacy?

The following presents work currently being carried out to lay the foundation for considerations of complementarity and comparability in a multi-theoretic research project.

Data generation

The SLRC is equipped with 10 built-in video cameras and up to 32 audio channels. Intact Year 7 classes were recruited with their usual teacher in order to exploit existing student-student and teacher-student interactive norms. Two classes of Year 7 students (12 to 13 years old; 50 students in total) provide the focus for this report. Each of the classes participated in a 60-minute session in the laboratory classroom involving three separate problem solving tasks that required them to produce written solutions. The students attempted the first task individually (10 minutes), the second task in pairs (15 minutes), and the third task in groups of four to six students (20 minutes).

The problem solving tasks used in the project were drawn from previous research (e.g., Sullivan & Clarke, 1991). All three tasks had multiple possible solutions, included symbolic or graphical elements, and afforded connection to contexts outside the classroom. These features can make the thinking and/or social processes of the problem solving activity more visible, as the students can express their thinking through multiple modes (e.g., verbal, graphical, textual, etc.) and approach the task using different strategies or prioritise different forms of knowledge or experience. Nonetheless, despite sharing some similar features, the content foci of the three tasks were deliberately disconnected to avoid carry-over effects between tasks.

Task 1 provided students with a graph with no labels or descriptions with the following instructions: "What might this be a graph of? Label your graph appropriately. What information is contained in your graph? Write a paragraph to describe your graph." Task 2 was specified as follows: "The average age of five people living in a house is 25. One of the five people is a Year 7 student. What are the ages of the other four people and how are the five people in the house related? Write a paragraph explaining your answer." Task 3 stated that "Fred's apartment has five rooms. The total area is 60 square metres. Draw a plan of Fred's apartment. Label each room, and show the dimensions (length and width) of all rooms."

The resulting data collected in the project include: all written material produced by the students; instructional material used by the teacher; video footage of all of the students during the session; video footage of the teacher tracked throughout the session; transcripts of teacher and student speech; and pre- and post-lesson teacher interviews.

Parallel data analyses

As an entry point for analysing the project data, the written solutions, transcripts, and video record are used to understand the social process that took place to produce the written solution. The instructional material and teacher pre- and post-lesson interviews provide insights about the class capabilities and social relationships that the researchers would not otherwise be able to access.

Several parallel analyses are currently being undertaken drawing on the established research expertise of classroom research communities in three countries. For example, in Australia, Clarke

and Chan are conducting an analysis which identifies the negotiative foci of the students' social interactions during collaborative problem solving taking the social negotiation of meaning as a key constitutive element of learning (e.g., Clarke, 1997); in Spain, Díez-Palomar is conducting an analysis of the dialogic character (Mercer & Howe, 2012) of the spoken interactions of students working in collaborative groups; and in Finland, Tuohilampi is carrying out an investigation of the affective enablers and disablers of student participation in collaborative group work that uses Goldin's motivating desires (Goldin, Epstein, Schorr, & Warner, 2011) to explore the extent to which a group of students established a productive affective micro-culture. A theory is recruited to this study for its capacity to address constructs, artefacts or situations distinct from those addressed in other theories being employed – that is for its capacity to complement those already selected.

Connection of these three analyses is made possible by their application to a common set of social events occurring in the same research setting. The validity of any connections between the parallel analyses is heightened by their grounding in data from the same source and their application to a common interactive sequence. For example, consider the following excerpt when Anna and Pandit were writing up their response to Task 2 (pair task):

Anna:	Okay. So let's explain it here.
Pandit:	So - so 7 ... //One kid...
Anna:	//Because we have to write it in words. (Note. // indicates overlapping speech.)
Pandit:	So one kid has to be four... 17.
Anna:	No, no, no. So ...
Pandit:	(Laughs)
Anna:	I'm going to write it.
Pandit:	One kid has to be 17.
Anna:	So ...
Pandit:	So wait, no, no, no, no.
Anna:	... because ...
Pandit:	Oh a seven - a Year 7 is 13.
Anna:	I'm ignoring you.
Pandit:	You can't - So - So sad. I'll draw.

From the excerpt, we can examine the focus of the students' negotiation on the task requirements or sociomathematical focus (Anna: "Because we have to write it in words."), the coordination of the mathematical components of the task or mathematical focus (Pandit: "One kid has to be 17."), and the social obligations of the participants or social focus (Anna: "I am ignoring you"; Pandit: "You can't.").

At the same time, the transcript allows the investigation of the dialogic character (García-Carrión & Díez-Palomar, 2015) of the participants, where the excerpt began with Pandit offering information to Anna for her writing up of the results and ended with Anna rejecting Pandit's contribution. The conversation shifted from the dialogic interaction initiated by Anna ("So let's explain it here … because we have to write it in words.") to non-dialogic or authoritarian talk (Anna: "I'm ignoring you."; Pandit: "You can't.").

From an affective perspective, Anna and Pandit both appeared to share the same motivating desire to "Get the Job Done" (Goldin et al., 2011, p. 553). However, Pandit appeared to also appeal to the motivating desire of "Let Me Teach You" (p. 554) by dictating the information to be written down by Anna ("So one kid has to be four... 17 … One kid has to be 17. … Oh a seven - a Year 7 is 13."). Her attempt to take on the higher epistemic role did not appear to be well received by Anna. Upon being rejected by Anna, Pandit's desire quickly changed to "Don't Disrespect Me" (p. 553) by being disengaged from the task and switched to off-task drawing.

Although all three analyses focus on the same interactive episode during collaborative problem solving, each analysis highlights different aspects of the social interaction. The multitheoretic research design of the project provides the context for the consideration of how commensurability may be conceptualised in relation to the parallel analyses.

Discussion and conclusion

This paper presented three analyses that are currently being applied to the data that have been generated from the laboratory classroom concerning the same interactive episode of collaborative problem solving. The approach allows direct comparisons to be made between the applications of the three analyses (negotiative foci; dialogic theory; and motivating desires) in terms of what constitutes evidence within the realm of each analytical framework, the unit of analysis, and the conclusions that can be drawn from the analyses, all of which could form the basis for the evaluation of the commensurability of the separate analyses. In the case of the project, commensurability can be evaluated in relation to a common construct with respect to which each of the analyses might be employed to make comparative distinctions (either descriptive or evaluative).

For example, for the purpose of distinguishing between different interactive episodes with respect to the construct of "student engagement", the analytical accounts derived from dialogic theory and the theory of motivating desires can be seen as commensurable, whereas it is more difficult for an analysis with respect to negotiative focus to make useful distinctions with respect to engagement. The analyses based on dialogic talk (in terms of the ways in which students put forward their arguments) and on motiving desires (in terms of the fulfilment of goals or beliefs through social interactions) can each be seen as potentially capable of distinguishing between interactive episodes in terms of some conception of the quality of "student engagement" during collaborative problem solving, even though the premises on which the two analyses might make such evaluative distinctions would be different. On the other hand, the consideration of the negotiative foci of particular interactive episodes distinguishes between types of "student engagement" in a descriptive but non-evaluative way. In this sense, the account provided by the analysis of negotiative focus does not suggest any points of evaluative distinction in terms of student engagement, in the way that is possible with the accounts provided by the other two analyses. This renders it incommensurable with the other two analyses with respect to the construct "student engagement".

We want to emphasise that commensurability between theoretically-grounded analytical accounts should not be seen as "an ideal state" but as a reference point for examining the connections between theories. Stengers (2011) makes the essential point: "Commensurability is created and it is never neutral, always relative to an aim" (p. 55). In the case of multi-theoretic research designs, researchers are obliged to construct commensurability to facilitate the comparison that they are

trying to make between theoretically-grounded analytical accounts. The utilisation of multiple theories is enhanced through the identification of shared operationalised constructs (such as "student engagement"), intrinsic to or derivable from the interpretive accounts in question, the existence of which is prerequisite for their commensurability. Complementarity between the theories discussed can be accommodated independently of arguments concerning commensurability. The emphasis on complementarity removes the obligation that interpretive accounts should converge to a single truth. We posit that theories can be complementary in their conceptual totality (having different epistemological and ontological bases) but nonetheless invoke operationalised versions of specific constructs common to both theories which could be used to interrogate the setting, and form the basis for interpretive accounts which can then be juxtaposed with respect to their implications for practice. The viability of multi-theoretic designs does not demand that all accounts be commensurable. Some accounts may be simultaneously coherent and consistent with the data, but disjoint, in that they employ different operationalised constructs.

In conclusion, this paper argues for the importance of considering the roles of complementarity and commensurability in multi-theoretic research designs. We suggest that the consideration of complementarity resides between theories while commensurability can only be examined in relation to the interpretive accounts arising from the application of the theories. By juxtaposing theories applied analytically to data generated from the same setting, the research design of the Social Unit of Learning Project accommodates the complementarity of theories and affords an informed judgement of the commensurability of the parallel interpretive accounts. The consideration of commensurability obliges researchers to articulate the nature of the comparability between theoretically-grounded interpretive accounts when juxtaposing theories. We feel that the explication of complementarity and commensurability in this paper should contribute to the further theorisation of multi-theoretical research approaches.

Acknowledgment

This research was conducted with Science of Learning Research Centre funding provided by the Australian Research Council Special Initiatives Grant (ARC-SR120300015).

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