Project Based Learning (PBL) in the mathematics classroom: teacher embrace of facilitating student led learning

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My thesis explores perceptions of students leading their own learning during Project Based Learning (PBL) in the secondary mathematics classroom in the UK. In this paper I describe the contributions of two theoretical lenses, activity theory and complexity thinking, to my interpretation of *teacher* embrace of facilitating student led learning. I consider the role of a theoretical lens for interpretation, and outline how I view the two lenses as being complementary aids to help me gain understanding of an empirical phenomenon whose complexity may have been more difficult to grasp with only one lens. I describe each theory and detail their specific influence on my interpretation.

Keywords: Project Based Learning; PBL; student-led learning; activity theory; complexity thinking; theoretical lenses.

The study

The research is being conducted in a small inner-city secondary school where I am an Assistant Head Teacher. Over the last few years, we have adapted the mathematics curriculum for 13 to 15 year old students so that they experience a hybrid of project based learning (PBL) and more traditional teacher led pedagogies. That a project is student led is a defining component of PBL (Condliffe, 2016). The PBL projects that we use are designed to be taught as a complete unit, with students given the autonomy to navigate their own ways through the problem. Our designed approach is that students lead their own learning by: having choice in how they solve a problem and the methods they use; sequencing the tasks; allocating the tasks within the group; allocating the time within the overall time given and some choice in the way they present the outcome of their project. This doesn't mean there is no teacher input - quite the contrary: teachers should support and guide students throughout the process. This will include whole class discussions as well as intervening with individuals and groups.

In my earlier research, I found that participating teachers perceived one of their biggest challenges when teaching through PBL to be that of facilitating student led learning. There is limited discussion in the PBL literature around student led learning, with some of the large PBL organisations focusing on specific elements of student led learning: 'student voice' and 'student choice'. A major review of the literature on PBL highlighted that many studies are not explicit about what student choice means in PBL, and that the issue of student choice is underdeveloped in the literature (Condliffe, 2016). The same seems to be true of the wider literature: I have found few studies that focus on student led learning. To explore this area I developed the following research questions for my thesis:

> RQ1: What are students' attitudes to leading their own learning in this context?

RQ2: What are students' perceptions of what is challenging in leading their own learning?
RQ3: What strategies employed by teachers do students feel support them with leading their own learning?

This paper focuses on teacher embrace of facilitating student led learning; how teachers develop and use pedagogies and strategies to foster, encourage and support the development of student responsibility and choice in the classroom. The study used a grounded approach with parallel data collection and initial coding. The data that I interpret in this paper is drawn from three lesson observations of students undertaking PBL in the mathematics classroom, two focus groups of students, and an interview with one of the teachers I observed.

What is a theory?

A theory is a series of statements about the relationships between phenomena. It can help to explain or to predict. Using a theory can help to guide interpretation: it may sensitise to consideration of previously unnoticed variables, or may make visible something that had previously only been sensed (Charmaz, 2014). It may provide a new way of looking at reality (Prediger et al., 2010) and it can alter your viewpoint (Charmaz, 2014). It is impossible to separate theory and practice, as they are symbiotic. Theory helps us to understand our practices more deeply and reflexively and as such will change our practice. Similarly our practice will influence how we use theory: theoretical frameworks develop and transform as our studies progress (Prediger et al., 2010).

What are the benefits and challenges of using multiple theoretical lenses?

I found many benefits of using multiple theoretical lenses. The phenomena that I am studying are complex, and it might have been difficult to grasp the complexities of what is happening with only one theory. Using different theoretical lenses offered me different ways of approaching the phenomena and encouraged me to take into account different things such as the students' social context or the beliefs and values of the teachers. In this way, using multiple lenses gave me complementary insights (Kidron, 2008). Using multiple theoretical lenses also helped me to develop and better understand my own emergent theories. As I entered into a dialogue and compared and contrasted my theories with other theories, I had a better understanding of my own theory.

The literature identifies challenges in using multiple theoretical lenses. The theories may have different kinds of dialogues, the same words might have different meanings, or what in one theory may be called 'epistemic,' might not seem to correspond to what is called 'epistemic' in another (Prediger et al., 2010). Similarly, the two theories might have different underlying assumptions which may lead to contradictory interpretations (Kidron, 2008). The theories may also use different units of analysis, which may prove challenging.

These challenges were not significant in my interpretation. There was overlap between the theories, however I did not attempt to integrate them locally into a new framework, but rather combined them to give complementary insights (Prediger et al., 2010). I found that the theories fed back on each other; my interpretation grew symbiotically with them both in an ongoing dialogue. Insights that I gained from one interpretation would aid and deepen the interpretation using the other lens.

Activity theory

Activity theory was developed by Vygotsky in the early 20th century to emphasise the social origins of the action of individuals (Engeström et al., 1999). Engeström developed a model of an activity system that built on the work of Vygotsky and others. It is often represented by a diagram made of three triangles. Figure 1 demonstrates this model being used to complete an activity theory analysis with the unit of analysis, the PBL classroom.

Activity theory is a top down deterministic theory: it views events as being determined by previously existing causes. It helps to reveal the social and material forces that are at play in a situation and supports attentiveness to the dialectic links between the individual and social structure. It is predominantly descriptive but can be explanatory and also developmental. An activity system is viewed as consisting of the following elements:

- the *subject(s)*from whose position and perspective the analysis is conducted, and the *object* motivating action and leading to an *outcome*;
- *mediating artefacts*, things that mediate action can include signs and tools, discursive practices and prior knowledge;
- *rules*, which can be visible or invisible such as beliefs and values;
- the *community*, the social group or environment in which the activity takes place;
- the *division of labour* which explores how the work is shared either horizontally, between people or people and tools in the community, or vertically, between people of power and status and others in the community (Engeström et al., 1999).

Interpretation through an activity theory lens

Activity theory helped me to notice the social context that teachers brought to the classroom that supported them to foster student led learning. The *rules* of the department were supportive of teaching through PBL: the department believed in the value of PBL and students exercising autonomy and independence; the projects were mapped into the scheme of work, so there was an expectation that they would be used; and due to high exam results, teachers had the 'earned autonomy' to teach with innovative and progressive pedagogies. There was a *division of labour* between the members of the department, who sourced, wrote and adapted projects that they all used. The teachers also received support through the department as a *community*; they encouraged and supported each other to take risks and shared their experiences.

Considering the wider *community* of the school and the borough reveals some reasons why it may have been challenging for teachers to allow students to lead their own learning. The school's most recent inspection report said that learners were often passive in lessons and lacked independence and whilst the borough has shown a huge improvement in academic results and has very high progress 8 scores, youth unemployment is one of the highest in the country. Seemingly, students appear to have academic skills, but lack the wider skills required for leading their own learning. One of the teachers reported that students became anxious when expected to lead their own learning, which made the teacher anxious about giving students autonomy. In this sense, the students' context influences teacher embrace of PBL.

When student led learning appeared to work well in the classroom, the *division of labour* often shifted, at least partially, from teacher to resource. The

teacher used tools such as writing frames or checklists to help give students structure to what they were doing. Whilst this labour did not shift onto the student, but rather the resource, transitioning the labour in this way may be a necessary step towards students leading their own learning. This idea is explored further in the complexity thinking interpretation.

When I completed my initial activity theory analysis, I was interested in what supported student led learning and so I disregarded the two lessons I had observed where student led learning had not taken place. However, when I considered the lessons through an activity theory lens, I realised that what I was viewing was a contradiction (McNicholl, 2013): the *mediating artefact*, in this case the project, was being used in a markedly different way to the one in which it was intended. The projects were used to give students an opportunity to apply their mathematics rather than as a PBL project, where students lead their own learning. Activity theory can provide transformational understanding when the researcher tries to resolve contradictions. As I wanted to explore this contradiction, I interviewed the teacher and discussed in more detail his embrace of student led learning.

Activity theory thus aided my interpretation and also prompted me to collect further data. However, it didn't always enable me to access the subtle, contingent and wider changes that were occurring in the classrooms, which is why I looked to complexity thinking.

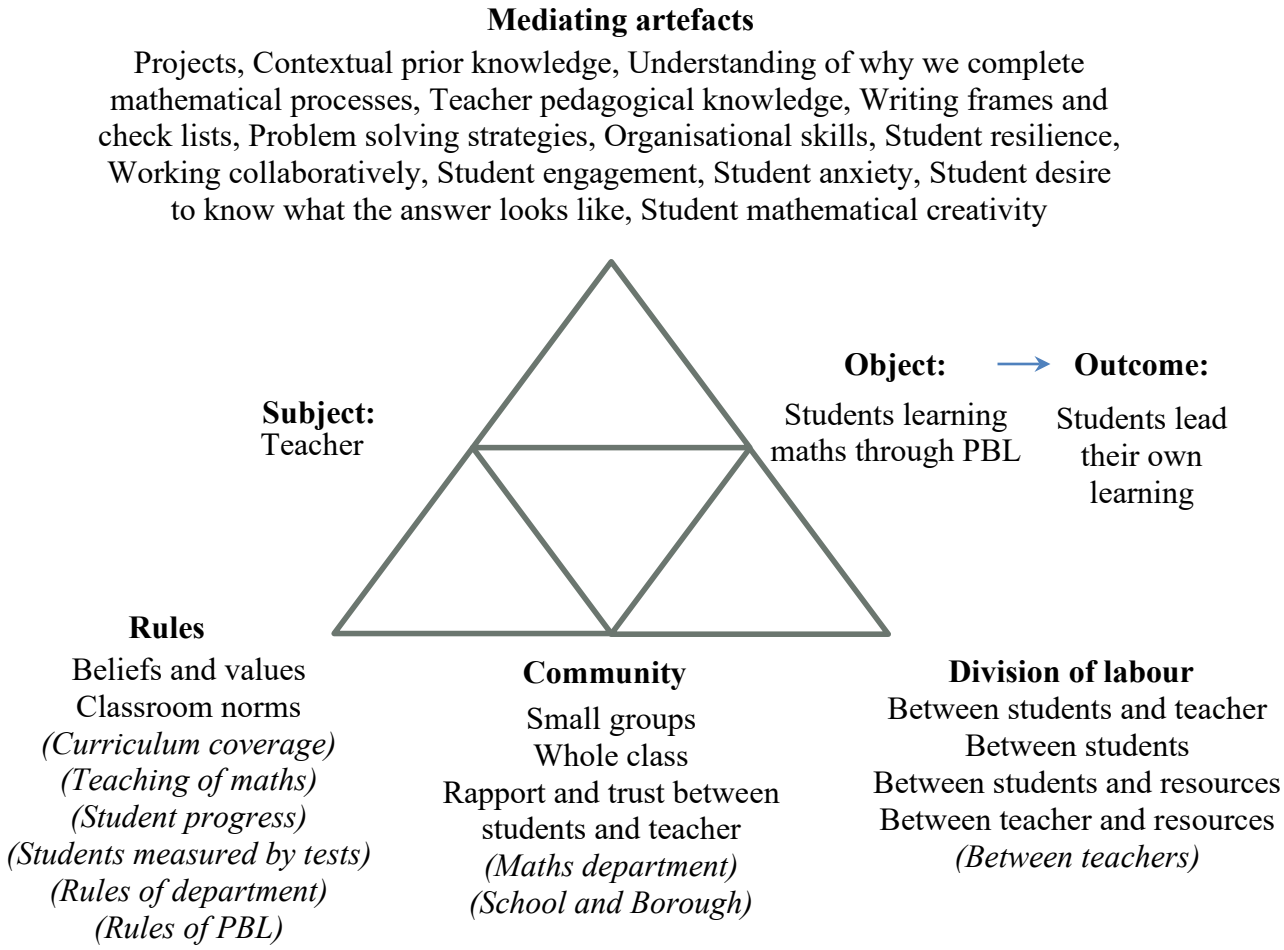

Figure 1 – An activity theory analysis of the PBL classroom. Elements that agents bring to the classroom with them are in brackets.

Complexity thinking

Complexity thinking is less well-established and is a collection of ideas rather than a single theory. It is not explanatory but primarily descriptive. It is influenced by a broad range of literature, with its origins in the sciences, systems theory, cybernetics and information science. It is being used increasingly to look at social areas including business, economics and education. Complexity thinking is based on a pragmatist philosophy: 'truths' that are viable, reasonable, relevant and contingent (or changing). It views the researcher as part of what they are trying to understand. It is useful for analysing contexts where there are multiple interactions between different aspects of the context, and at least some of the 'players' are conceived as having agency that they may exercise in ways that are not always predictable (Davis et al., 2006).

In complexity thinking, expansive change is defined as change that creates a radically wider range of possibilities than was there before; instead of perpetuating the status quo, the space of the possible is expanded. According to complexity thinking, expansive change is possible only when, amongst other things, there is:

- *internal diversity*, enough difference and variation between agents that there will be a range of possible responses;
- *sufficient redundancy*, a common ground between agents for example a common language, shared responsibilities or constancy of setting;
- *close neighbour interactions*, where the neighbours that must interact with one another are notions such as ideas, hunches and queries;
- *enabling constraints*, structural conditions that have enough coherence to ensure common purpose and enough randomness to ensure constant adjustment and adaption (Davis et al., 2006).

Interpretation through a complexity thinking lens

As analysed earlier, the teachers seemed to find facilitating student led learning one of the most complex parts of PBL to enact. For a teacher to facilitate student led learning, the students and the teacher require expansive change. Consideration of the conditions for expansive change helps to provide some suggestions for why in some classrooms, teachers demonstrated a more limited embrace of students leading their own learning during PBL.

The expertise about PBL came from within the department. The only external input came from reading research and, as noted previously, there is little literature about the student led learning element of PBL. This led to limited *close neighbour interactions* between teachers and the concept of student led learning. Further, many members of the department had trained within the department, whilst others had been at the school for a significant period of time; this may have created a lack of *internal diversity*. This lack of *close neighbour interactions* and *internal diversity* may have meant that there were similar notions of what made good PBL and a more limited pool of ideas about how teachers can support student led learning.

Complex systems have *short range relationships* - complexity thinking suggests that, "the teacher must find ways to foster the local exchange of information" (Davis et al., 2006, p104). To support student led learning, teachers would want to facilitate local exchange of information between students around how to lead their own learning. However, when I considered the discourse on student led learning – it was very limited. Students and teachers had little vocabulary to discuss how students led their own learning. This lack of discourse around student led learning may have

constrained what could be said, thought and done. In the study school, the PBL projects were typically introduced to students in year 9 (their third year in the school). Whilst the students completed a series of activities at the beginning of the year to help build their skills, for the students who were observed, PBL was still a relatively new setting. In this way, it is possible there wasn't *sufficient redundancy*: the students and teachers didn't have a common language or consistency of setting. This lack of redundancy, or sameness, would have hindered interactions between agents would have meant that they were less able to compensate for another's failings.

The use of resources, such as a writing frame or checklist, was analysed as supporting students to lead their own learning. Through an activity theory lens they can be viewed as shifting the *division of labour*. From a complexity thinking perspective, they can be viewed as *enabling constraints*; they provided structure and gave a common purpose. They may also have created greater *redundancy*, as they provided a common frame of reference for students to work from.

Rather than viewing phenomena as having a cause and effect, complexity thinking suggests that the accumulation of small events will trigger a cascade of incidents. Complexity thinking helped me to consider the divergence from department-planned practice as being a series of incidents triggered by many previous events.

In summary

The adoption of two different theoretical approaches to interpretation of data allowed access to a wider range of likely factors contributing to limited enactment of student-led learning as originally conceptualised in department meetings. The value of identifying these possible explanations is they are now available for discussion in a teacher workshop where they can be further explored.

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