# Refining Methodologies to Address New Questions Raised

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*This paper reports progressive changes to my research questions, theoretical lenses, and research design as I work to gain further understanding of how to engage students in the learning of mathematics so deep understandings result.*

## *Introduction*

My intention is to illuminate connections between research questions, theoretical lenses, data collection instruments, and analysis tools, and to highlight some methodological decisions and their implications. I briefly describe key aspects of four consecutive research studies showing how each informed subsequent studies.

## *Research Design Changes From Study to Study*

These four studies examine how students respond to task complexity (Study 1), processes by which the creative development of new knowledge occurs, and what influences this process (Study 2), how psychological characteristics found to influence inclination to work with unfamiliar challenging problems affect group problem solving (Study 3), and whether we can build these psychological characteristics to increase problem solving capacity (Study 4).

### *Study 1*

This study focused on why my senior secondary higher-level calculus students sometimes became so engaged that they did not stop interacting in groups when the group work sessions were completed and it was time for each group to briefly report to the class as a whole. As a teacher-researcher without access to research funds, my daughter and her partner used two family video cameras to collect my data. I instructed them to focus each camera on a selected group during the group work time, then focus one camera on the reporter at the board during group reporting. I expected the data of interest to me would be captured before and at the start of an intense period of engagement. One group began to engage intently just as the group work session ended. Luckily, my 'videographer' continued to video this group as they continued to interact after the class were called to attention. In the minute and a half following the group work session, data was collected from this camera that was crucial to the development of my theoretical model (Figure 1, explained later). This illustrates that videos cameras may not capture what is critical for a research study unless appropriate decisions are made about the positioning of the cameras, and the time interval over which data is captured. But, as my study shows, there are times when these decisions may not be evident to the researcher apparent beforehand.

I employed four different theoretical lenses to study four variables in Study 1:

- Mathematical understandings (Skemp, 1976),
- Group interactions (Cobb, Wood, Yackel, & McNeal, 1992),
- Affect (Quilliam, 1995), and
- Student ability (Krutetskii, 1976).

The video record showed how students interacted in groups including how they responded to the mathematical ideas put forward by others (e.g., disregarded, built upon, queried, requested clarification). Indicators of affect were displayed through exclamations and body language (e.g., focus of eyes, direction of body, placement of hands in relation to task). Mathematical understandings were captured on video through the content of mathematical discussions (questions asked, indicators of agreement, and building upon the ideas of others). Student ability was displayed through the complexity of thinking evident in student discussion.

I connected the high level of student engagement in their creative mathematical activity with ‘flow’ (Csikszentmihalyi & Csikszentmihalyi, 1992). Flow is a state of high positive affect during creative activity that can occur when a person or group spontaneously set themselves a challenge that is almost out of reach and develop new skills as they work to overcome this. I found that flow in the context of mathematical problem solving (See Figure 1) occurred when a group discovered and spontaneously asked a question (intellectual challenge) about a mathematical complexity that was not apparent to group members at the commencement of the task (Williams, 2002) and used mathematics in unfamiliar ways to unravel this complexity (new skills and conceptual knowledge).

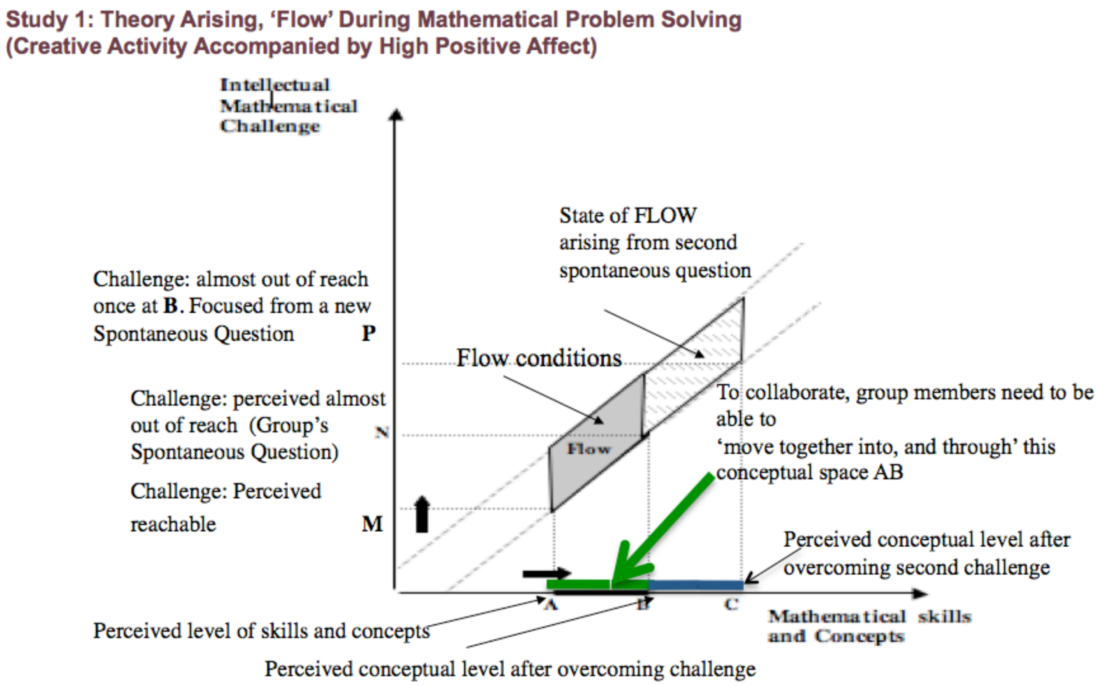


*Figure 1:* Engaged to Learn: Flow conditions during mathematical problem solving

The group that became intensely engaged asked a spontaneous question at the end of the group work session and this raised their intellectual mathematical challenge (to between M and N on vertical axis, Figure 1). Their exploration of this complexity occurred in the minute and a half after the group work session finished. They shifted beyond A (horizontal axis, Figure 1) as they creatively used their prior knowledge in unfamiliar ways to 'unraveled' the complexity they identified and ask a question about. They exclaimed as insight was gained (reached B, Figure 1). Conditions for flow existed through simultaneous activity within MN and AB. This raised questions for me about whether the same types of spontaneous student activity occurred in the classrooms of other teachers, and if so, what promoted such activity.

*Study 2*

An invitation to join the international Learners' Perspective Study (LPS) of the teaching and learning of mathematics in Year 8 classrooms in nine countries (Clarke, 2001) provided an opportunity for me to explore this question. I interrogated the LPS Research Design to make sure the data collected would fit my intended question. For the LPS study, three cameras focused respectively on the teacher, a different pair of focus students each lesson, and the whole class. During the lesson, a mixed image (focus students at centre screen, teacher as insert in corner) to stimulate two individual post-lesson student interviews.

Figure 2 shows my process of mapping the data I needed against the LPS data collection instruments to determine their adequacy for my study. The arrows in Figure 2 point from the constructs relevant to my study (left hand side) to each LPS data collection instrument to show where I expected to find relevant data. The solid arrows point to primary data sources and the dotted arrows to supplementary data sources. For example, Figure 2 shows 'Small-group Interactions' were described in the Student Interviews, observable through the Student Camera video, and sometimes elaborated through Student Written Work. And, in studying Individual Students, the Student Camera and Student Interviews were the predominant data sources, with Field Notes an additional data source. I could see that the probes used to elicit further information during student interviews would be crucial for collecting data on cognitive processing and social influences upon it. I was satisfied that the LPS study data collection process would fit the needs of my study once I was invited to participate in the interview process.

I expected that students engaged in the creative development of new knowledge would not always be focus students, so observed the body language of other students to identify those who could be engaged in this process as I undertook Field Notes. Where possible, these students were interviewed soon after. The data collected was sufficient to reconstruct the activity of these students using the lesson video, several questions focusing on that lesson at the end of the student interview about a subsequent lesson, student work sheets or computer screens, and the teacher interview. My conclusions were framed as 'those cases *identified'* and I pointed to a limitation in the data collection techniques associated with camera positioning, and how the complementary data sets and proactive selection of future focus students compensated for this limiting factor in some cases.

From Study 2, I found the creative development of new mathematical knowledge occurred in classrooms where this was not the explicit intention of the teacher (Williams, 2006), and that task complexity, and behavioral autonomy were contributing factors. These students spontaneously focused beyond, peripheral to, or deep within a challenging problem set by the teacher. Each such students was found to be resilient ('optimistic', Seligman, 1995). They perceived 'not knowing' as temporary and able to be overcome through personal effort, and were able to look into situations and recognize what they could and could not control and make decisions about what to vary to increase their likelihood of success. These findings about the role of optimism in individual problem solving raised questions about the role of optimism during collaborative problem solving.

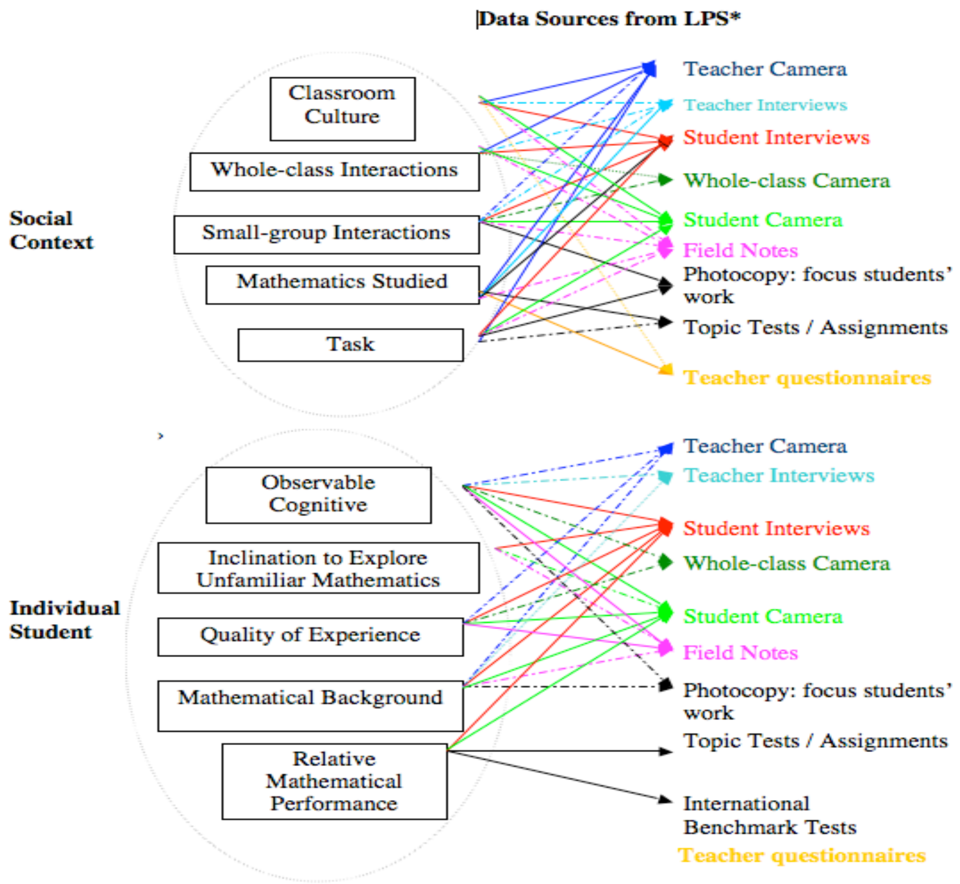


*Figure 2:* Mapping my data requirements onto the LPS Research Design

*Study 3*

To study the role of optimism in collaborative problem solving, I designed tasks for upper elementary school classes and worked with two classes on three tasks (six eighty minute sessions) across the school year. The data collection instruments available through the International Centre for Classroom Research were progressively becoming more innovative and at the time of this study, a good coverage of the observable group activity (3 cameras), and audio records of the talk of half the groups could be captured (with the option to shift the microphone to another group if considered appropriate). A fourth camera captured student reports to the class and the interactions of another group if more than six groups were involved. Four individual video stimulated post-lesson student interviews were undertaken after each lesson to gather data on what was happening in at least three of the groups. Although the data collection instruments did not capture sufficient data to study all groups in detail, discriminating selection of which groups to audio record, and which students to interview provided sufficient data to study how the activity of optimistic, and non-optimistic students influenced group interactions, and to identify situations that theory suggested should be optimism building (successes during flow situations, Seligman, 1995). This raised questions about whether optimism can be built as student work within the Engaged to Learn Model and whether this builds problem solving capacity.

*Study 4*

A longitudinal study is presently underway to study students as they progress from Grade 4 to Grade 6 with the classes undertaking unfamiliar challenging problems within the structure described in Study 3. Where the nature of optimistic indicators displayed by a student changed over time, there was opportunity to retrospectively study the activity of that student in previous tasks because the data collection instruments now contained two audio leads for each camera. Thus, the activity of each student was available for each research lesson and students in the study from Grade 4-6 were interviewed twice a year. Limitations to the data collection process were now associated with which students to select as the four students to interview each lesson, and the ethics restriction of only interviewing any student twice each year (so they were not missing too much of their time in class).

## *Summary*

The increased sophistication of the data collection instruments over time enabled ever-increasing coverage of classroom activity, and data to stimulate interviews with students from more groups. The 'just in time' innovative actions of the ICCR research team have kept pace with my research requirements. Detailed interrogation of classroom activity as it related to different aspects of the Engaged to Learn Model (Figure 1) have required ever increasing coverage of classroom activity, to stimulate reconstruction of what occurred in class in for larger numbers of students. Across the four studies, my focus has shifted from the conditions for engagement accompanying insight (Study 1, simultaneous activity in MN and AB), 'moving into and through' MN and AB and teacher actions that enable such activity (Study 2), group interactions that enable creative activity (group progressing together into and though AB) (Study 3), and the nature of optimism and how it builds (Study 4) which I have not yet theorized sufficiently to locate in detail with respect to the Engaged to Learn Model.

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