A Student's Complex Structure of Schemes Development for Authentic Programming-Based Mathematical Investigation Projects

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INTRODUCTION AND RESEARCH QUESTION

In Gueudet et al. (submitted), we discuss how the instrumental approach can contribute to our understanding of the activity of university students using programming in the context of an authentic mathematical investigation. In particular, we distinguish between m-schemes, p-schemes and p+m-schemes, for a goal concerning respectively only mathematics, only programming, or both. Each of these three types of schemes is illustrated in the case of an undergraduate, Jim, as he engaged in the first of four programming-based mathematics investigation project, within a Mathematics Integrated with Computers and Applications (MICA) course at Brock University.

In this poster, we extend the work in Gueudet et al. (submitted) and present a visual summary of the complex structure of m-, p-, and p+m-schemes developed by Jim through his engagement in the 4 course projects. Our guiding research question is:

What do we learn about the activity of students using programming in an authentic mathematical investigation by using the theoretical frame of the instrumental approach, considering programming as an artefact?

THEORETICAL FRAMEWORK

Our work is informed by the instrumental genesis approach (Rabardel, 1995) which provides a lens to describe how a student, in an activity with a math goal, learns to use an artefact (e.g. programming) and learns mathematics at the same time, through the development of schemes. A scheme is a stable organization of the subject's activity for a given goal (Vergnaud, 1998). It comprises four components: i) the goal of the activity; ii) rules-of-action (RoA), generating the behaviour according to the features of the situation; iii) operational invariants: concepts-in-action and theorems-in-action (TiA), which are propositions considered as true; and iv) possibilities of inferences.

METHODOLOGY AND RESULTS

Jim was one voluntary student participant (among 6) enrolled in the MICA I course (46 students) in the first year of our 2017-2022 research study. Data collected for this poster work were generated from: Jim's 4 MICA I projects and 4 semi-structured individual task-based interviews following each project submission; a baseline questionnaire and interview; and 10 online weekly lab reflections. Jim's early data was first analysed for an initial identification and description of schemes, then reorganized in m-, p-, and p+m-scheme types, and ordered according to the development process (dp) model shown in Fig.1. The whole data was thereafter coded and regrouped in themes. Using codes pertaining to perceptions and strategies themes, the initial table of schemes was then refined and chronologically extended to the whole data.

In this poster, we present 9 of Jim's 21 identified schemes as brief bubble descriptions linked to the related 9 steps of the dp model, as partially examplified in Fig 1.

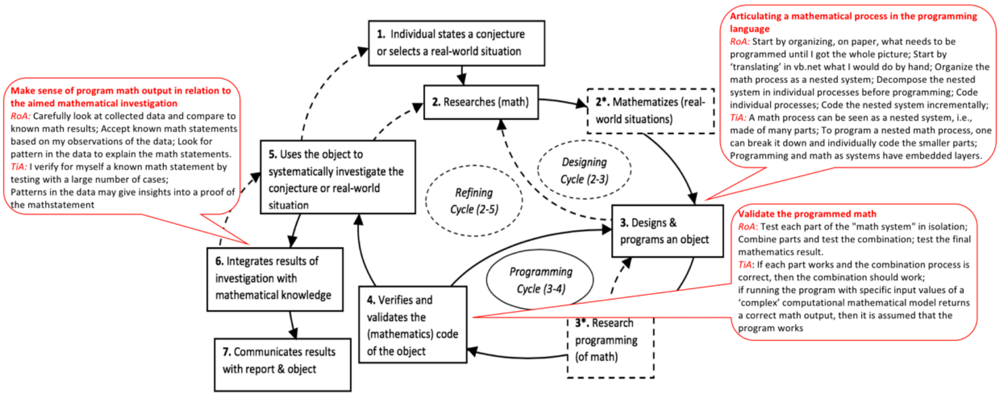

Figure 1: Development process (dp) model of a student engaging in programming for an authentic mathematical investigation or application (Buteau et al. 2019), enhanced with 3 examples of Jim's identified schemes (red bubbles).

IMPLICATIONS

Using the instrumental approach led i) to elaborate the dp model as a composition of goals, highlighting the complex structure of schemes; and ii) to expose how the activity of programming-based mathematical investigations is organized (RoA) and why (TiA).

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