Computer-based Analysis of Student Constructions to Foster Creativity in Collaborative Activities

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1. Introduction

Research in collaborative learning has long recognised that working in groups has the potential to enhance learning, but that careful planning and structuring of collaborative tasks and strategic formation of collaboration groups is a necessary prerequisite [1,2]. Similarly, creative interchanges are not necessarily to be expected just because of the orchestration of a collaborative situation [3].

Although the right circumstances can act as catalysts of creativity, and good facilitators know how to achieve that, in a classroom teachers face the challenge of forming potentially productive groups i.e. groups that provide opportunities for students to engage in fruitful discussions, enabling them to reflect on their approaches to a problem, justify and critique their solutions, or generate a variety of novel ideas. Pragmatic and logistic constraints in the classroom can push teachers towards resorting to forming groups that do not necessarily take advantage of informed decisions [1].

Our anecdotal evidence from observing teachers use constructionist tools in the classroom suggests that teachers sometimes choose pairs based on the order that students finish tasks, or based on their experience in using the tools (e.g. to help each other). This 'haphazard' grouping together with the lack of time for in-depth analysis of students' constructions at the point of grouping may result in missed opportunities for fruitful and productive discussions. Undertaking tasks in any constructionist digital tool usually results in a large set of constructions and therefore creating strategically meaningful groups based on those becomes a complex and time-consuming task for the teacher. Students' constructions typically involve several objects with many different attributes and/or a long trace of manipulations of objects; neither is evident to the teacher at a glance and both require deep inspection of the student's construction.

Understanding how every student has approached the problem requires a significant amount of time even for experienced teachers. Therefore, we believe that a digital tool that supports this process would not only save precious class time but also lead to better outcomes from both a learning and a creativity point-of-view. By employing configurable criteria, the tool compares students' constructions allowing teachers to form strategic groups and researchers to analyse the student constructions in an objective way. Below, we present the tool and its current and potential usage.

2. Data-informed grouping: the case of eXpresser

In order to experiment with the potential of such a tool, we have developed an instance of it for the mathematical microworld eXpresser designed to help 11 to 14 year-old students develop algebraic ways of thinking [4]. In eXpresser, students construct figural patterns by expressing their structure through repeated building blocks of square tiles, and articulating the rules that underpin the calculation of the number of tiles in the patterns (see Figure 1). A typical use of the eXpresser in the classroom consists of few tasks undertaken individually by students, followed by a collaborative task in which students compare and comment on their different approaches [5].

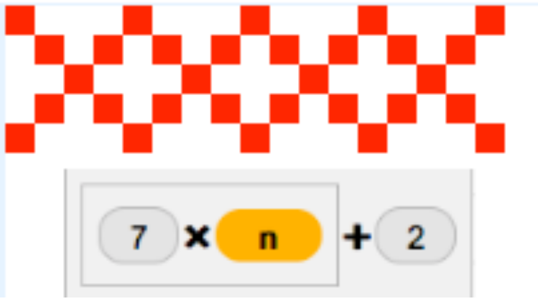

Figure 1. An eXpresser pattern and a rule for the number of tiles for any „n“ (where n is the number of crosses).

Our tool analyzes students' constructions and distils several types of characteristics that were agreed with teachers and teacher educators: number of iterations of the patterns in the construction, displacement of building blocks, number of tiles of each colour in the pattern, exact building block, number of variables, and relationships within a pattern. For every pattern created by a student, the tool builds a vector comprising all these attribute values. This information together is used to define a *mathematical distance between two patterns* in order to compare them leading to a *metric of originality* that determines how novel each student construction is.

3. Discussion

There are several potential uses of the tool. We have mainly used it so far to suggest groupings of students to teachers of groups of students who have followed different construction approaches (i.e. whose individual constructions have a low similarity). Working together, these students have the opportunity (as described in [5]) to explain to each other why they chose their approach, how the approaches are different, whether they are equivalent, and whether they are correct. The use of the tool optimised classroom time in that the teacher strategically formed groups both based on the information from the tool and her understanding of the classroom so as students can build on each other's ideas, and benefit from the reflection that resulted from their interaction.

In the future, and as more students are using the system online, the availability of the originality metric allows us, as researchers, to classify, categorise and identify novel patterns. In addition, we have introduced the tool in the Mathematical Creativity Squared (MC2) project's 'Community of Interest' that consist of several stakeholders who are working together to design resources and configurable learning analytics for Creative Mathematical Thinking in schools (see http://mc2-project.eu). Apart from the obvious use from teachers as mentioned above, the community sees some potential in using the metric for 'gamification' of the learning experience. Based on the originality metric, students can be asked to monitor the similarity of their constructions with that of others. Finally, being transparent about the criteria to students has the potential to interest them further about the way the metric is derived and use it to explicitly construct different patterns.

References

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