Teacher Assistance Tools for the Constructionist Classroom

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Abstract

The work presented in this demonstration is the product of the interdisciplinary MiGEn project, which aimed at designing and developing an intelligent, exploratory environment to support 11–14-year-old students in their learning of algebraic generalisation, but also providing tools to support teachers in its use in the classroom. We will present these tools, which are designed to assist teachers in monitoring students' activities and progress in lessons, and discuss their value for a constructionist environment.

Keywords

microworlds, algebraic generalisation, teacher assistance tools

Introduction

Research in students' learning with microworlds has long highlighted the indispensable role of the teacher as a 'competent guide' (Leron, 1985), a 'facilitator' (Hoyles, Sutherland, 1989), or 'orchestrator' (Trouche, 2004; Hoyles et al., 2004) of both well-defined investigations (Kynigos, 1992) and goal-oriented exploration, which aligns with a learning agenda (Noss & Hoyles, 1996). However, in practice, this role is difficult to achieve in a typical classroom and we believe this contributes to the lack of adoption of constructionist technologies. In the efforts, therefore, of the MiGen project (http://www.migen.org) to support teachers in employing a microworld for algebraic generalisation in the classroom, we designed and developed a suite of visualisation and notification tools, which we refer to as Teacher Assistance (TA) Tools. These inform teachers of individual students' progress, their history of actions, and their current working status. Such information is of real value to teachers who can then make informed decisions to support students and orchestrate the classroom activities.

In this paper, we first provide a brief description of the algebraic microworld that the TA Tools are designed to work with. We then give a detailed explanation of the tools, and we finally share some conclusions regarding our vision of supporting teachers in the constructionist classroom through tools that assist them in visualising students' progress and accomplishment of specific learning goals as students are working on their constructions.

eXpresser: A microworld for algebraic generalisation

We have designed and built a pedagogical and technical environment for improving 11-14 year-old students' learning of generalisation. The major components of the system are the microworld, the Intelligent Support component and the Teacher Assistance Tools. As well as building the technological system we have designed a set of activity sequences.

In the eXpresser microworld, students construct figural patterns by expressing the structure of the patterns by means of repeated building blocks of square tiles, and also articulating the rules that underpin the calculation of the number of tiles in the patterns. A typical activity will ask the student to reproduce a dynamic model presented in a window that appears on the side of the activity screen. Figure 2 shows such a model where a row of red tiles is surrounded by grey tiles.

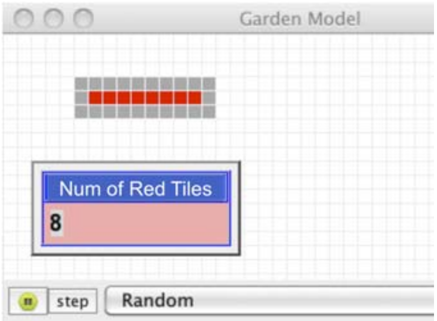


Figure 1. A model for a row of red tiles surrounded by grey tiles. Students are asked to construct a general model and find the general rule for the number of tiles surrounding the red tiles.

Students are asked to construct a model that works for *any number* of red tiles, and find a rule for the total number of tiles surrounding the red tiles. They can test the generality of their model and rule by *animating the model:* that is, by letting the computer change the number of red tiles at random and ensuring that their model remains coloured and therefore is impervious to changes in the values of the variables. To scaffold students' interaction in such an open and exploratory environment activities we provide a constant reminder of their tasks and goals by breaking down the task into goals. Examples include (1) Use pattern(s) to construct the model, (2) Make sure "My Model" is always coloured, (3) Check that the "Computer Model" animates without messing up, and (4) Make sure the "Computer Model" is always coloured. Underlying these surface goal, the main objective is to enhance students algebraic ways of thinkings (Mavrikis et. al, to appear).

Even though the system includes an Intelligent Support component that takes as input information from the microworld as students undertake tasks and enables the provision of real-time and adaptive feedback to students, we recognised the necessity of assisting the teacher in offering the best possible support to their students when using the microworld in the classroom.

The teacher assistance tools

When using computers in lessons, it is rather difficult for a teacher to observe what every student is working on and whether they are working on the task set or not. Especially with constructionist environments, where students construct models in a variety of ways, a teacher cannot be sure of students' prior actions by simply looking at their screens from time to time. Therefore making an informed decision and providing appropriate feedback can be difficult. Our main goal for developing the teacher assistance tools was to increase the teacher's awareness of their students' attainment and overall progress in lessons. There are currently 4 tools: Student Tracking Tool, Class Dynamics Tool, Goal Achievement Tool and Grouping Tool. The Student Tracking tool shows a timeline of significant events (termed indicators) from each student's interaction with the microworld. Although it can be used during a classroom interaction, the level of detail that it provides means that it mainly fits the purpose of post-hoc analysis of a classroom interaction, either by researchers or teachers. Since the focus of this paper is on the way teachers can be supported in the classroom, we will discuss in more detail the other 3 tools. For more details on the Student Tracking tool the reader is referred to Gutierrez-Santos et al. (in press).

Classroom Dynamics Tool

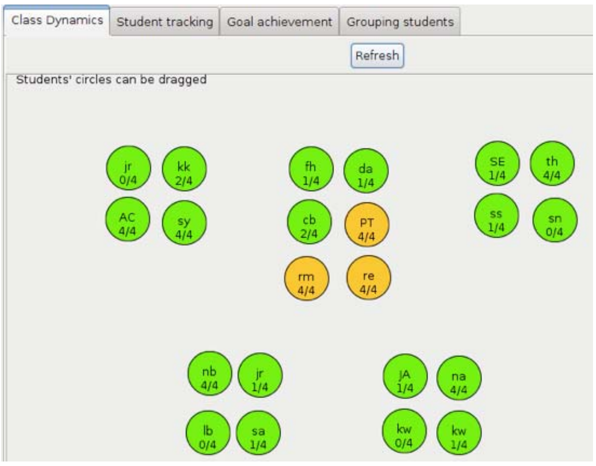
The Classroom Dynamics Tool (CDT) provides information about the state of the classroom to help the teacher decide at a quick glance where to focus their attention. It shows students as circles on a canvas containing their initials to identify them. A teacher can place the circles according to the students' spatial distribution in the class in order to make easy the identification of the students faster (see Figure 2). The circles are coloured to indicate the status of the students. In more detail, students shown in green are interacting with the microworld. Students shown in amber are inactive. This means that they have not interacted with the microworld for a certain time (by default, five minutes). Unless this is expected for some reason (e.g. sometimes the teacher interrupts the session to address the class and explain some common misunderstanding) it usually means that students are distracted: they may be talking to a peer or, as we have observed in some schools, playing games in their web-browser. Students shown in red are waiting for the teacher to help them. This means that students have requested help from the system in a situation where the intelligent support provided by the system cannot help the student any further. At this point, the student appears in red in the CDT to attract the attention of the teacher. Hovering over a student's circle in the CDT with the cursor shows additional information about the student: their full name and their status.

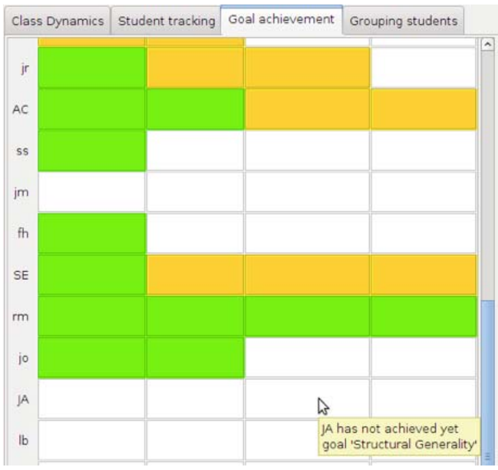
Goal Achievement Tool

The Goal Achievement Tool (GAT) provides information about completion of task goals, providing teachers with an overview of the progress of the class with respect to their plan for the lesson (see Figure 3). The microworld is equipped with the ability to design specific tasks the accomplishment of which is monitored by the intelligent components of the system (see details of the design of the intelligent aspects of the microworld in Mavrikis et al., in press).

Grouping Tool

The Grouping Tool (GT) supports the teacher in managing collaborative activities, by automating the pairing of students based on students' prior constructions. To generate fruitful discussions, students with different constructions and dissimilar models should be grouped. During a lesson, identifying appropriate pairs is time-consuming and the teacher cannot dedicate more than a few minutes to this activity. Accomplishing it would require the teacher to investigate every student's construction, model and rule to identify the dissimilar ones and then pair the students, taking also into account factors such as students' attainment level. The GT is designed to aid the teacher in this task by automatically generating an initial set of pairings. These are shown visually to the teacher, who can then confirm or change each pairing. As shown in Figure 4, in the GT students are represented by their initials within a circle, and the degree of similarity between pairs of constructions is represented by a small green rectangle for low similarity; medium-sized yellow rectangle for moderate similarity; or large red rectangle for high similarity. The teacher can select students' circles and 'drag' them into different groups to change the pairings suggested by the system and take into account, for example, factors that are beyond the system's knowledge, such as students' interpersonal relationships.





Figures 2 and 3. Classroom Dynamics Tool and Goals Achievement Tool.

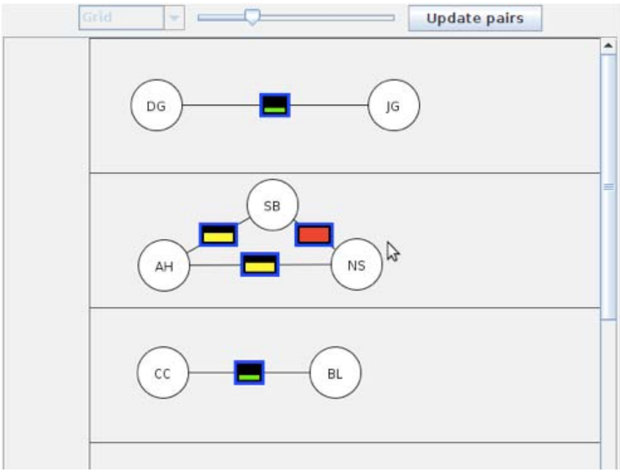


Figure 4. Grouping Tool.

Discussion and Future Work

In order to design the teacher assistance (TA) tools, we have collaborated with a number of educators and teachers in secondary schools in the UK. Initial prototypes of the TA Tools were designed based on their input. We then followed an iterative design process in order to provide the requirements that teachers identified as crucial.

Over the course of the project, we conducted several one-to-one, small-scale, and whole-classroom trials with our system in a number of secondary schools in the UK with 11-14-year-old learners. We observed the use of the TA tools by the teachers, especially their reactions and methods of incorporating the system into their lessons. It was evident that once our teacher collaborators used the tools in their classrooms, they were able to give us more informed feedback and influence subsequent development. We have also conducted evaluations of the TA tools with the help of trainee teachers, using secondary data we collected from the school trials.

Based on teachers' feedback, we identified that providing a tablet PC where the TA tools were installed would help the teacher to move around the class rather than returning to their desk to view the tools. In lessons, we found that teachers were consulting mainly the Classroom Dynamics Tool on their tablet PC. With this tool, they decided early in the lesson to move the circles representing each student to reflect the seating plan of their class. As most teachers stated afterwards, this helped them use the tool more effectively and locate quickly which students needed help at any given moment. As soon as a circle turned red, the teacher clicked on the circle to investigate the student's current construction and prepare their intervention. In one trial, the teacher decided to also display the Classroom Dynamics Tool on the Interactive Whiteboard. This encouraged students to stay on task, as they were aware of other students being able to view their progress. It also freed the teacher from having to hold the tablet PC.

Teachers also regularly viewed the Goals Achievement Tool during the lesson, to view students' overall progress in terms of task completion. They found this tool very useful when deciding which students to help based on the goals they have achieved, but also when designing subsequent lessosn. The next task was usually a collaborative activity (see Geraniou et al. 2011) and before asking students to pair up and start the task, teachers opened the Grouping Tool. This analysed the students' submitted models and rules and suggested possible pairings, based on the degree of dissimilarity of students' constructions. By quickly examining the suggested pairs and after ensuring that other parameters, such as students' interpersonal relationships and attainment levels would not hinder their collaboration students were grouped. Teachers recognised that the greatest value of the tool was in quickly generate pairs and being able to ask students to start the collaboration activity almost immediately after finishing individual work.

Our future plans involve improving the TA tools and investigating how they could be adapted to support teachers using other constructionist environments. We are in the process of sharing these tools with more teachers and disseminating our results to a wider community. Also, we are interested in continuing our research to investigate further how such support towards the teacher influences constructionist learning in the classroom.

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