The Design of Teacher Assistance Tools in an Exploratory Learning Environment for Mathematics Generalisation

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m:gen intelligent support for mathematical generalisation

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T·L·R·P Technology Enhanced Learning

E·S·R·C Economic & Social Research Council

EPSRC Engineering and Physical Sciences Research Council

Outline of the talk

- Project aims and challenges
- MiGen context and tools
- Teacher Assistance tools
- Conclusions and future work

Project Aims

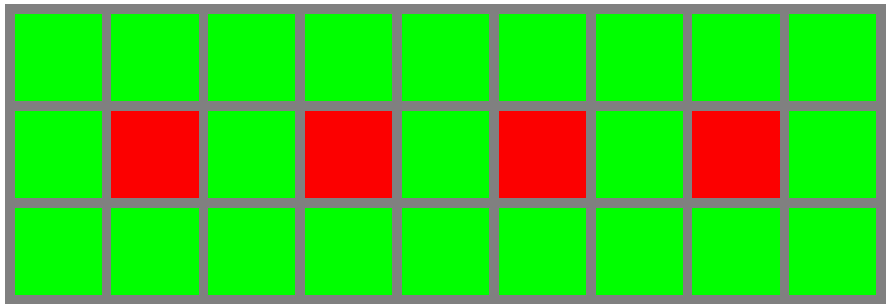
- to co-design, build and evaluate
  - with teachers and teacher educators
  - a pedagogical and technical environment for improving 11-14-year-old students' learning of *algebraic generalisation*

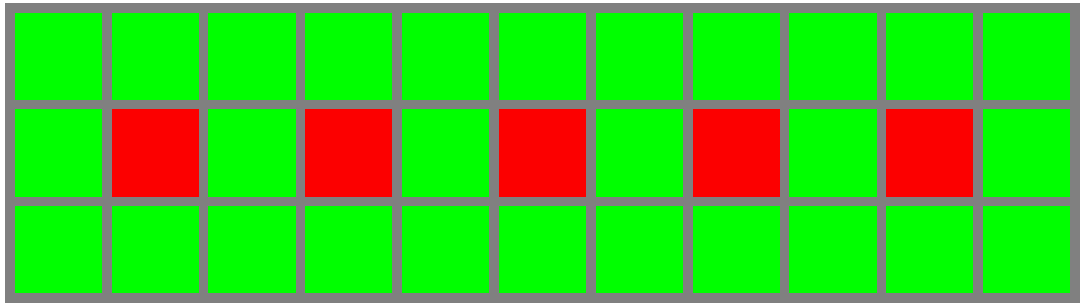
- seeing "the general through the particular" is a powerful way to introduce generalisation, and help develop algebraic ways of thinking

Project Aims

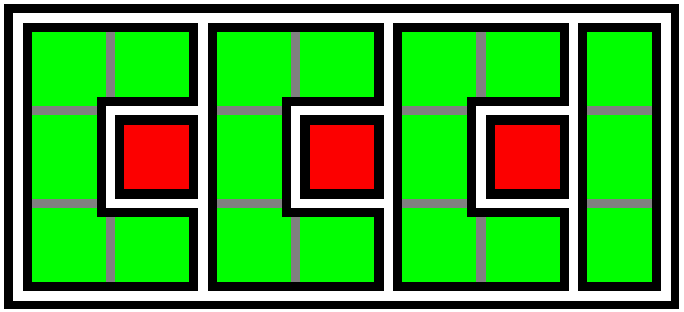
- MiGen allows students to create and manipulate *patterns* and *algebraic expressions*, and explore the relationships between them
- students are asked to construct “generalised patterns”, to derive expressions, to test out their patterns and expressions on new problem instances, and to compare their constructions with those of other students
- our aim is to support students’ exploratory construction while also fostering progressive knowledge building

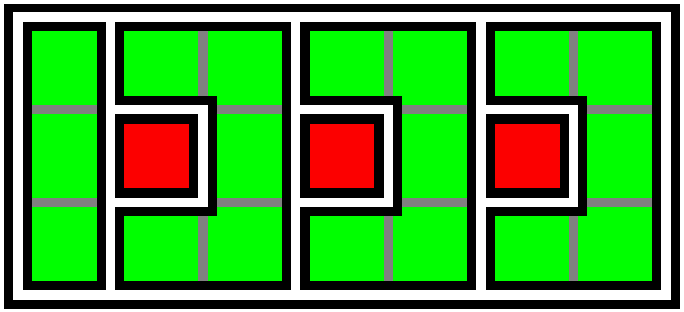
Generalised patterns

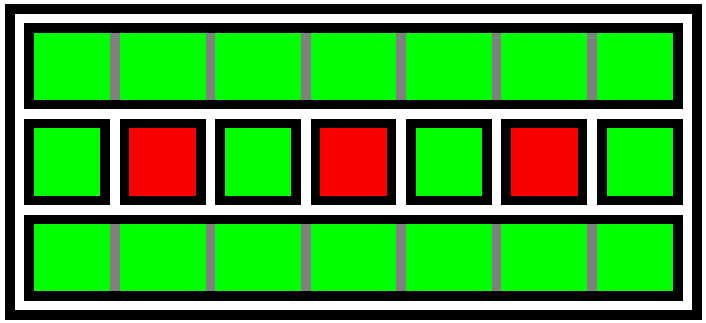


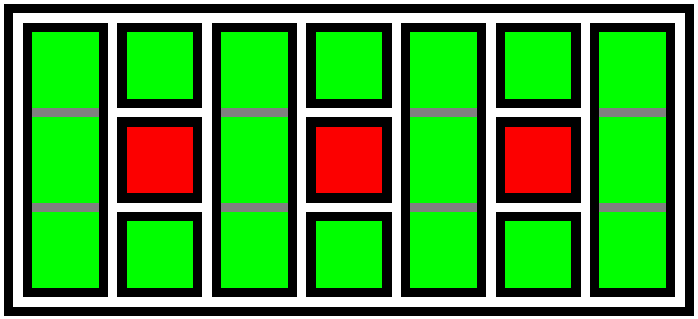


Possible construction approaches

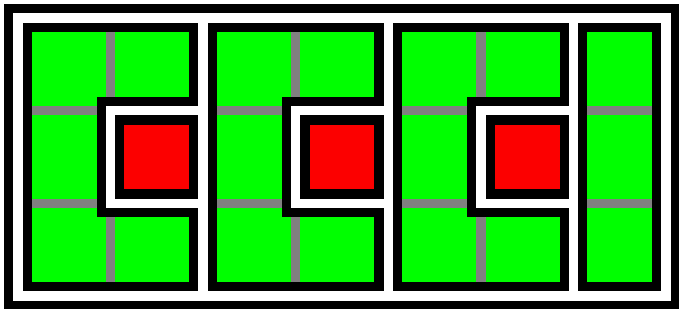




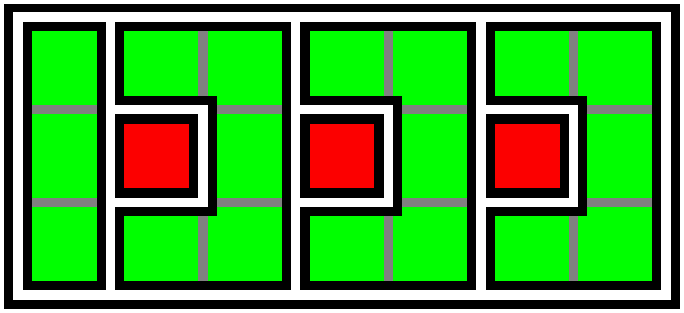




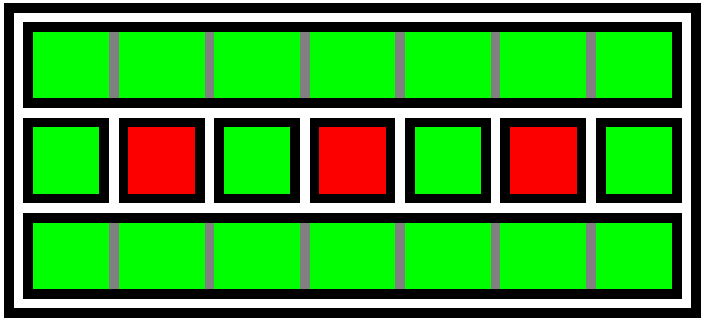
Possible expressions



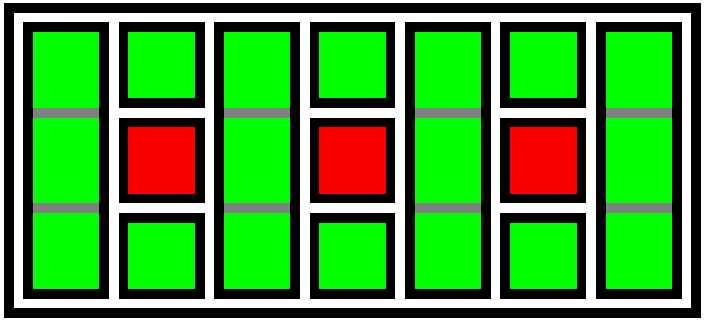
5 x reds + 3



3 + 5 x reds

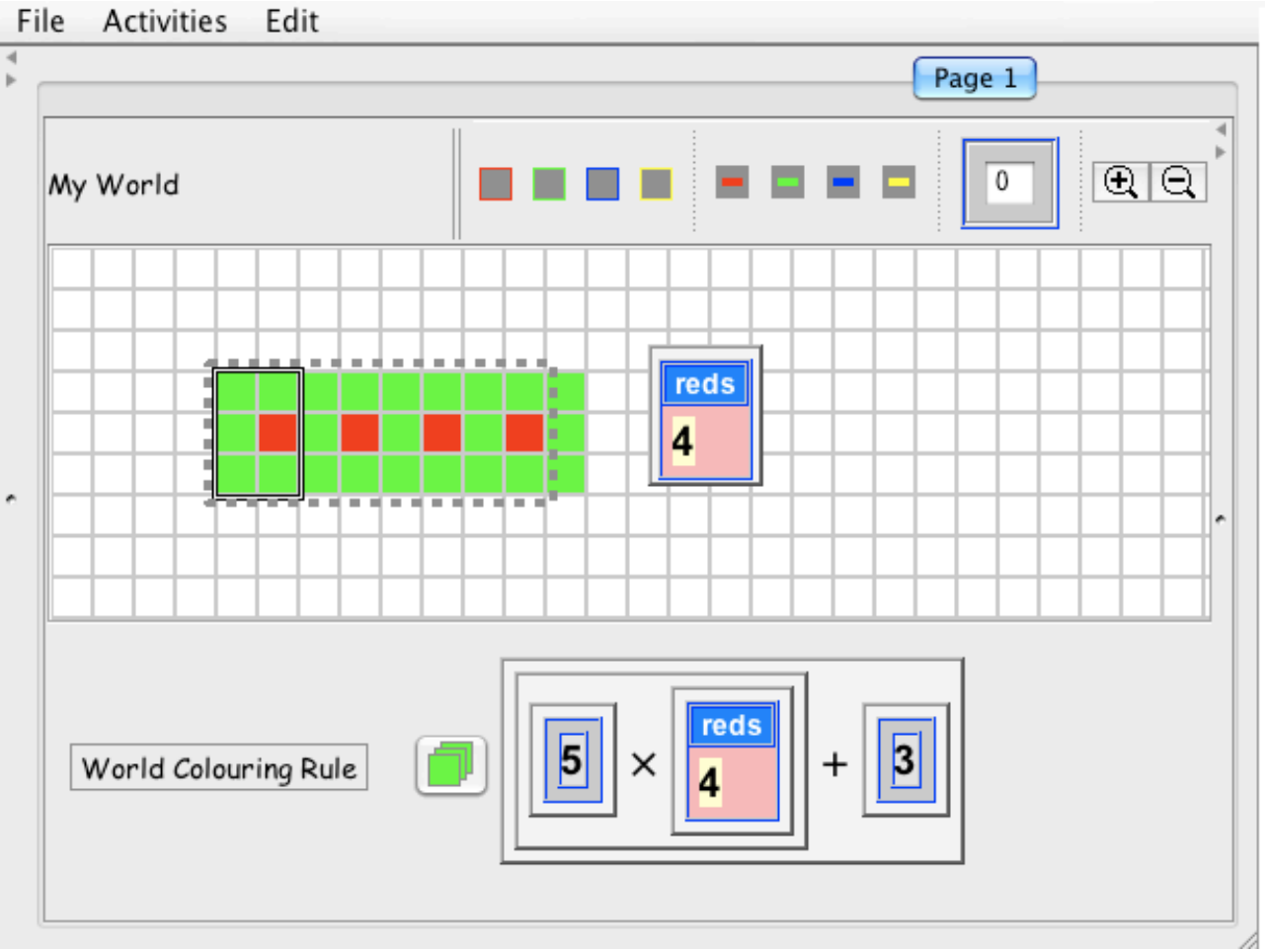


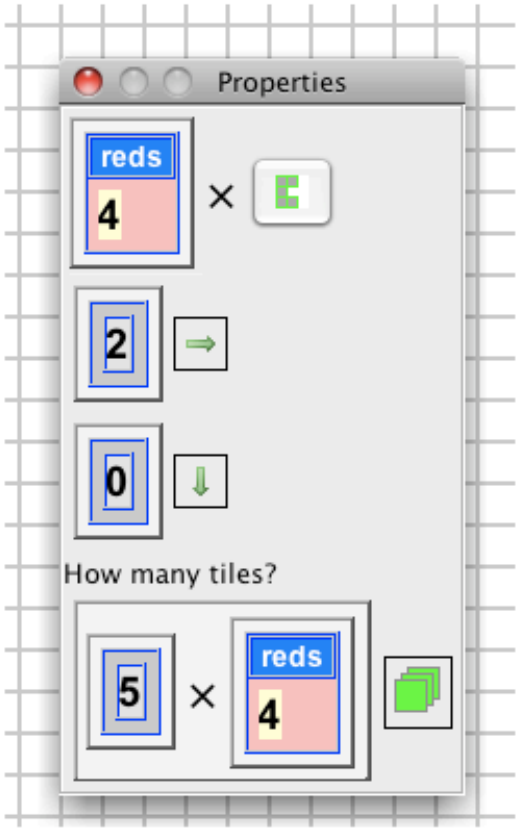
2 x (2 x reds + 1) + reds + 1



3 x (reds + 1) + 2 x reds

eXpresser tool





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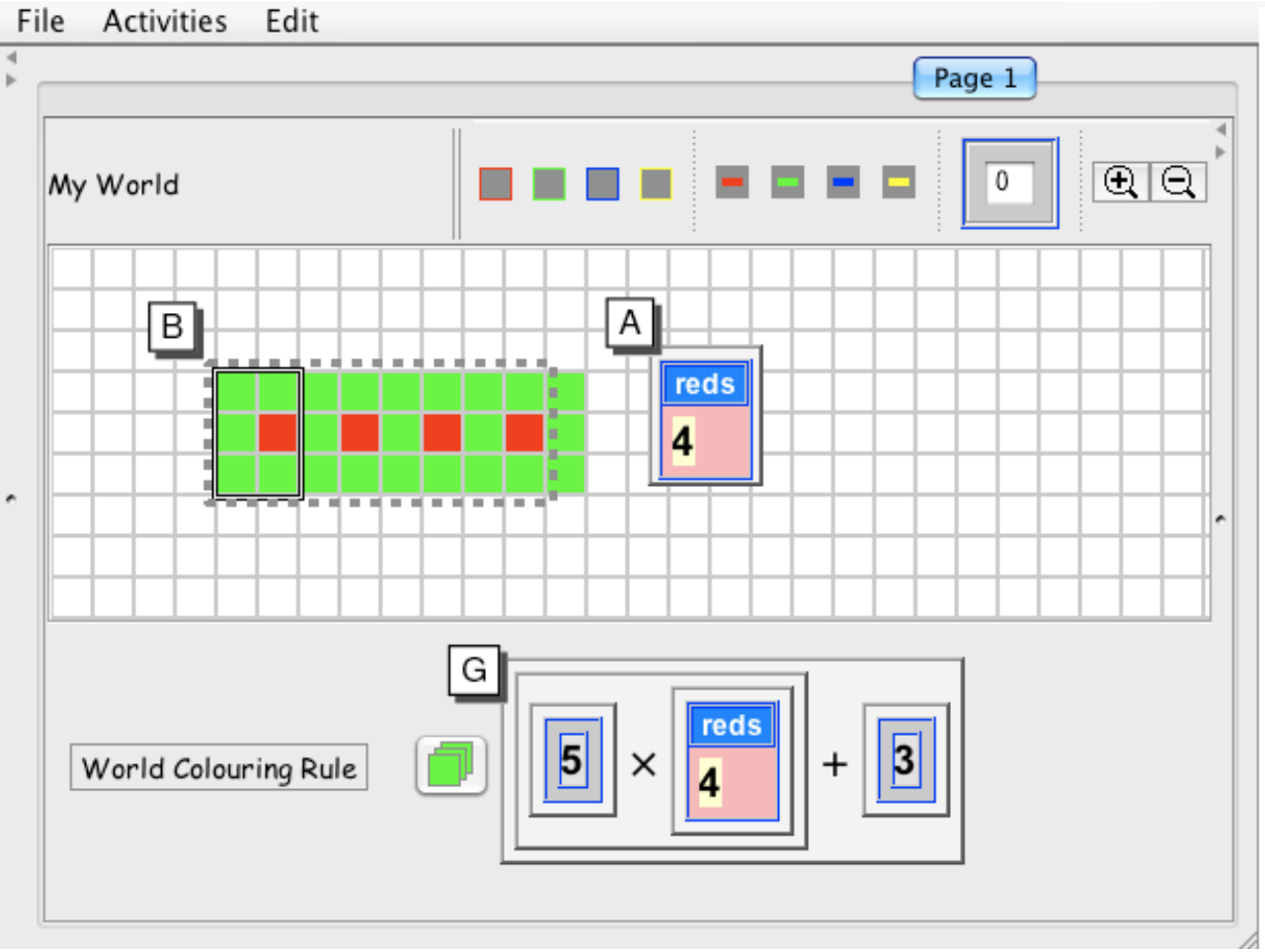
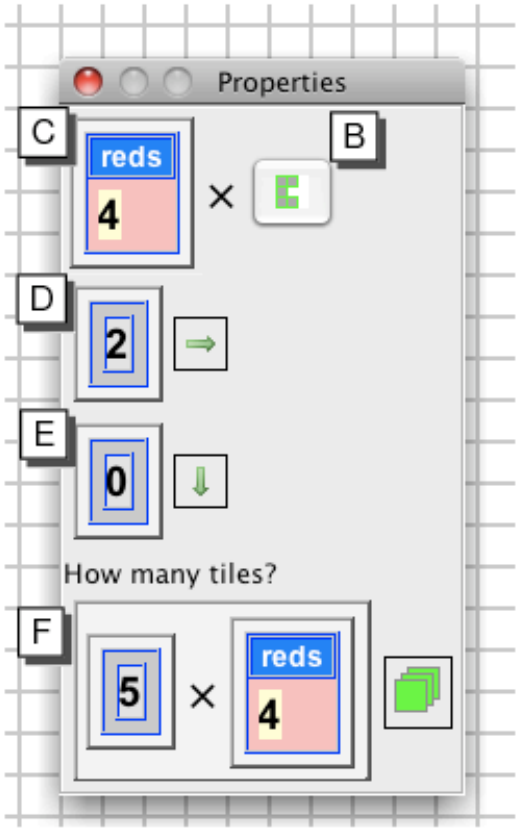
eXpresser tool





MiGen research challenges

- little work so far in supporting students in a constructionist context
- conversely, considerable guidance is required to ensure learning in such contexts
- feedback needs to be provided to students during their construction process
- since students are undertaking exploratory rather than structured tasks, teachers need to be assisted in monitoring students' activities and progress by appropriate visualisation and notification tools

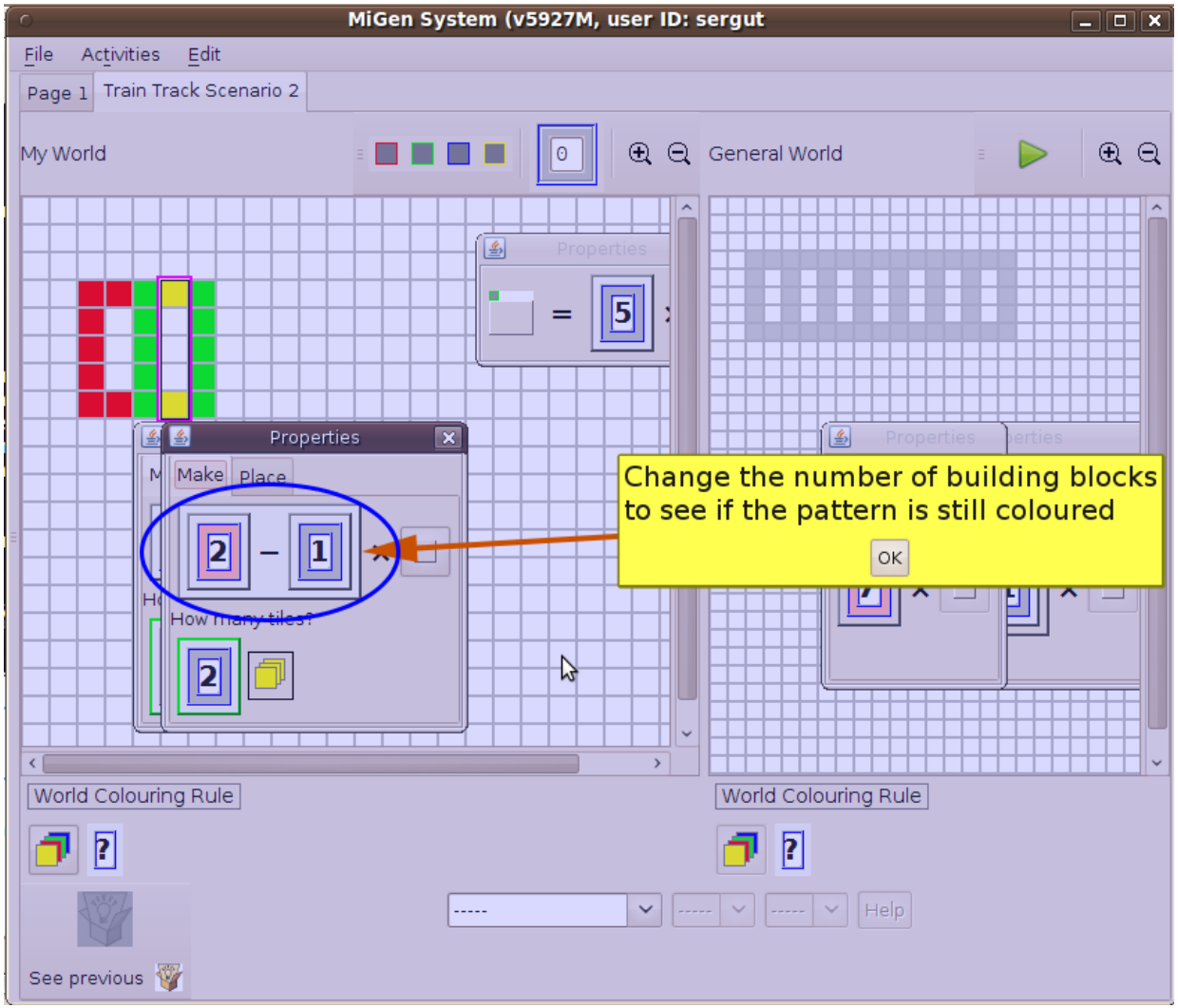
MiGen context

- Deployed in classrooms in schools
- Students working individually, in pairs, or groups on algebraic generalisation tasks as selected by their teacher and presented to them by the system
- Real-time provision of feedback to students during their construction
- Aiming to assist the teacher in focusing her attention across the class and informing her interventions (*not* to replace the teacher)

MiGen tools

- MiGen system comprises a number of tools:
  - eXpresser
  - Activity tool: presents activity sequences
  - eGeneraliser: generates feedback to students during their construction, and also infers occurrences of “landmarks”
  - Teacher assistance tools: present visually to the teacher the occurrence of landmarks – focus of this paper
  - Task design tool, planned

eGeneraliser - student feedback



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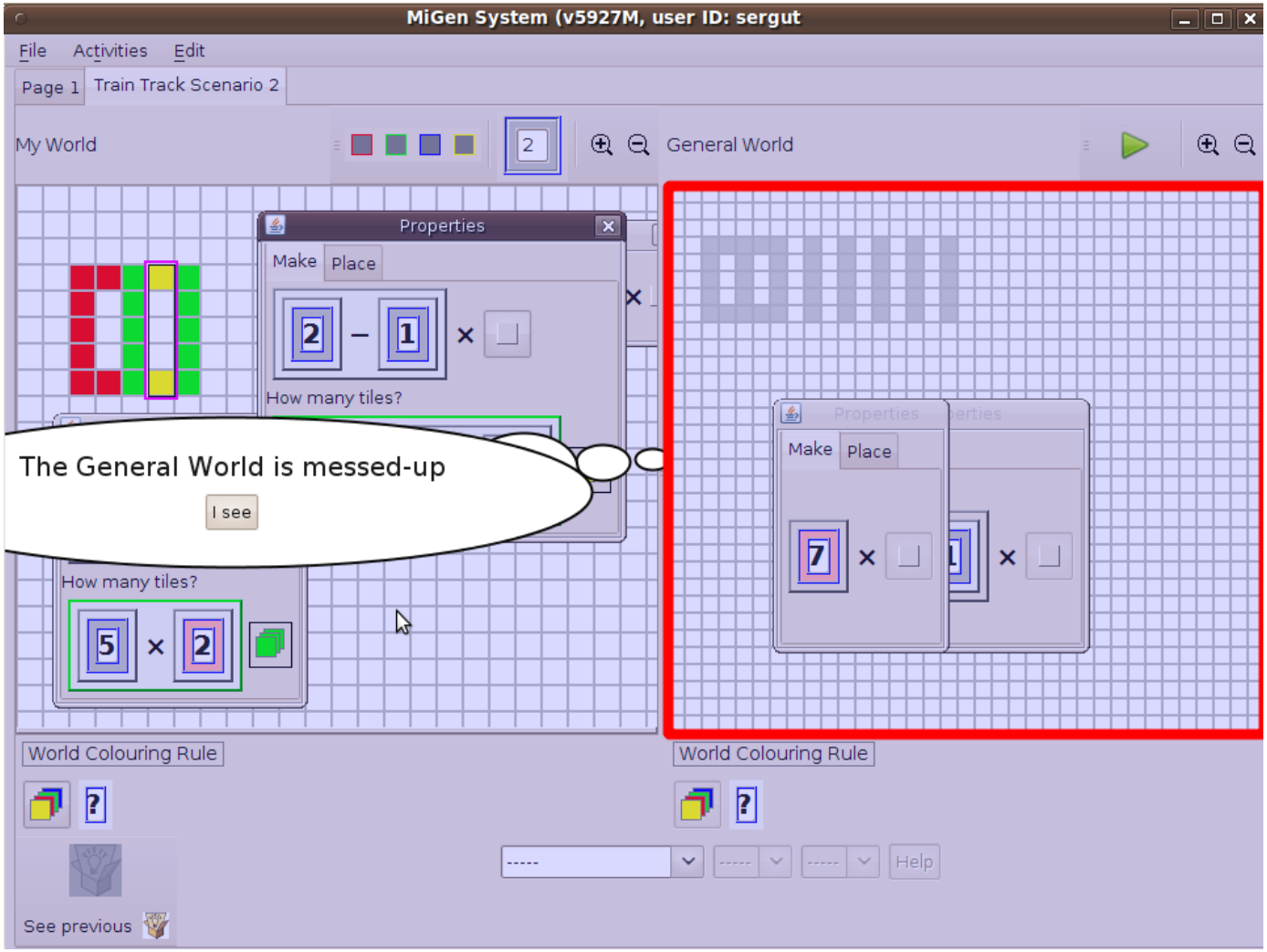
eGeneraliser - student feedback



Teacher Assistance tools

- A suite of tools, co-designed with teachers, aiming to assist the teacher in
  - monitoring students' activities and progress as they use the eXpresser
  - intervening with additional individual support as she decides appropriate e.g. providing additional guidance, encouraging reflection, setting new goals
  - grouping students for collaborative activities

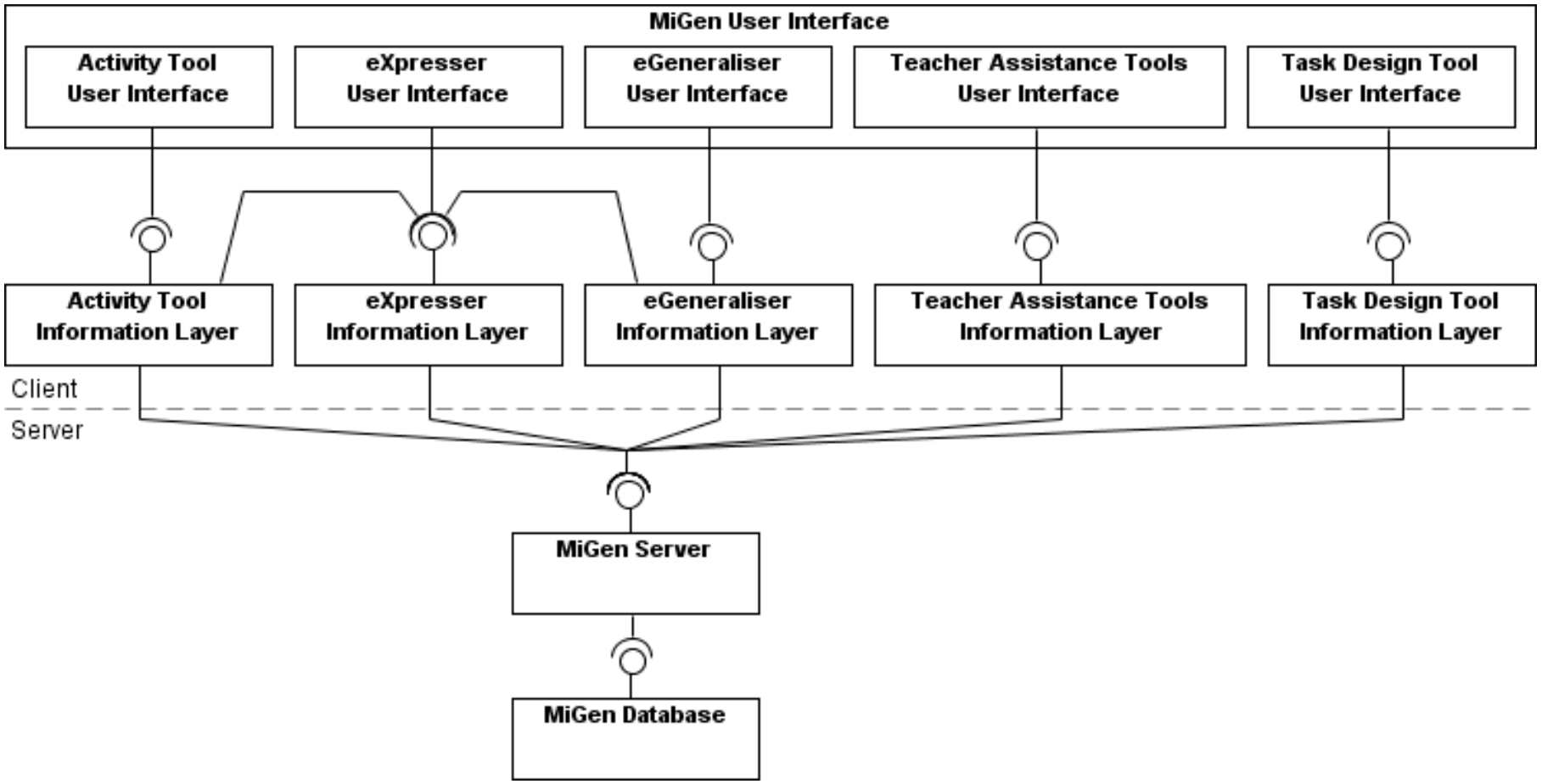
Landmarks

- As the student interacts with the eXpresser, so a series of *landmarks* are automatically inferred by the system, which are then notified to the teacher visually via the Teacher Assistance tools
- *Task-independent landmarks* occur when the system detects that specific actions or sequences of actions have been undertaken by a student
  - e.g. ‘student has placed a tile on the canvas’, ‘student has made a building block’, ‘student has made a pattern’, ‘student has unlocked a number’.

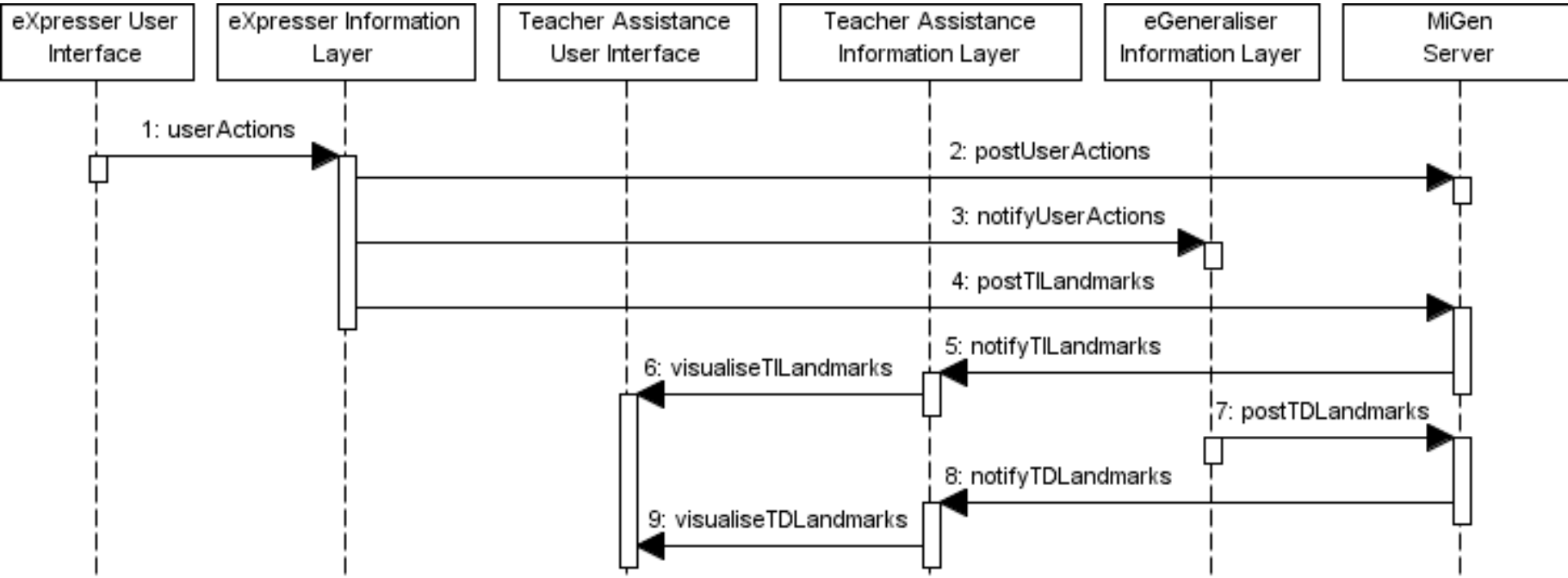
Landmarks

- *Task-dependent landmarks* require intelligent reasoning to be applied to combinations of actions - undertaken by the eGeneraliser
- TD landmarks require access to knowledge about the task and their detection may have a degree of uncertainty associated with it
- Examples of TD landmarks are: ‘student has made a plausible building block’, ‘student has unlocked too many numbers’, ‘student has coloured their pattern generally’

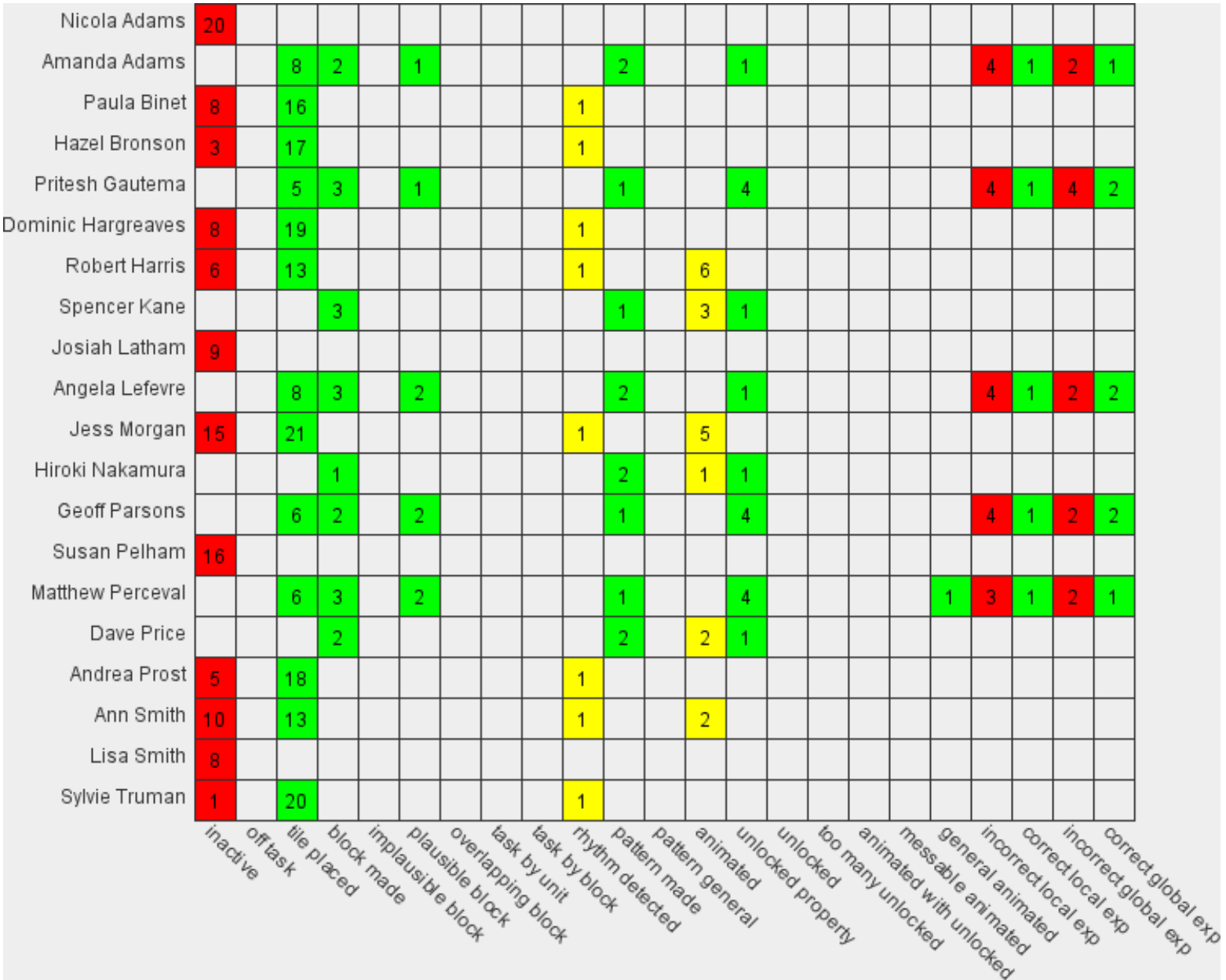
MiGen System Architecture



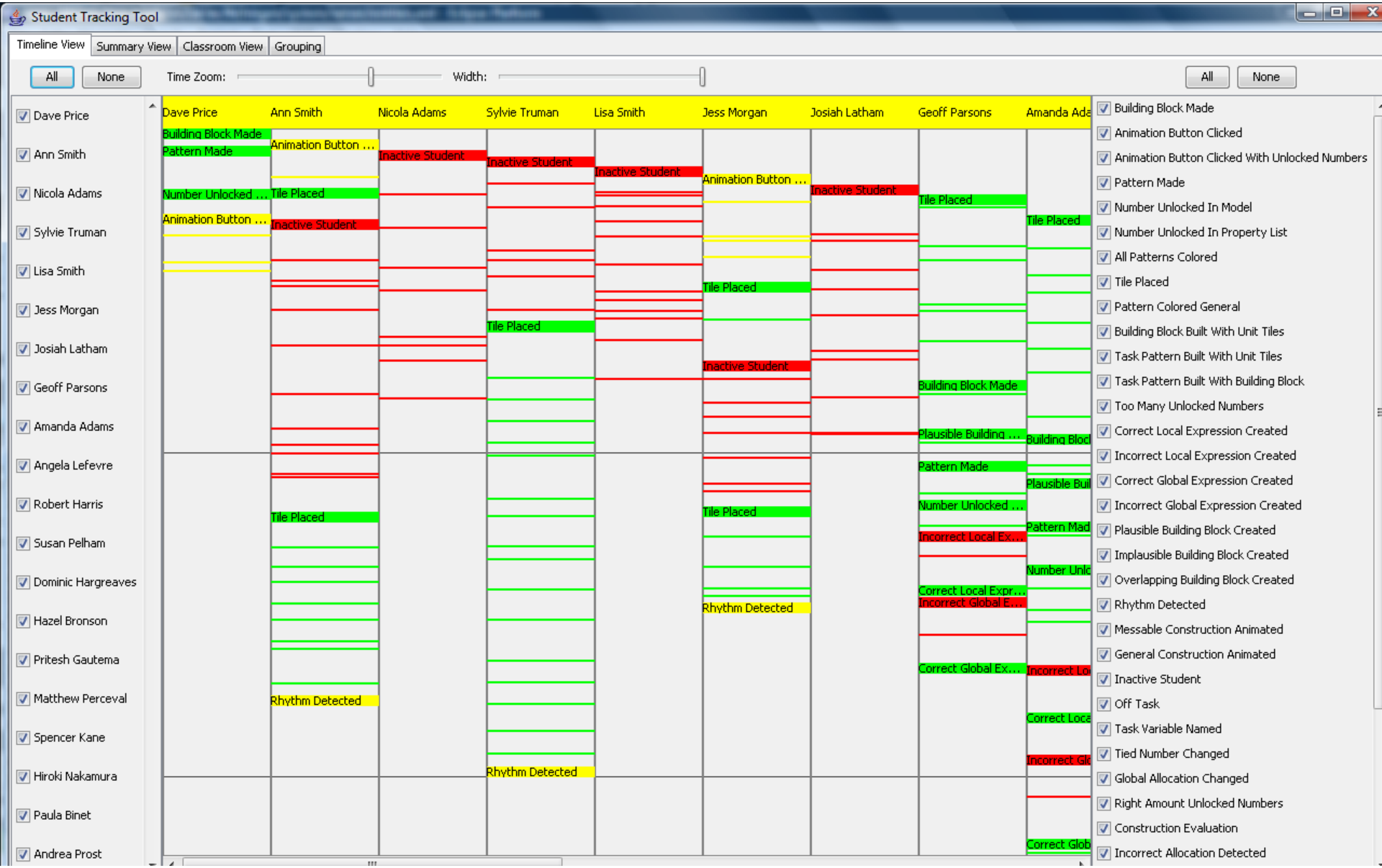
Sequence diagram



Student Tracking tool - summary



Student Tracking tool - timeline



Conclusions

- Aim of MiGen's TA tools is to provide information to teachers about their students' activities and progress as they use the eXpresser, so as to support teachers in facilitating students' productive interaction with the system
- The paper describes the architectural design of our TA tools in general
- And gives a detailed description of the Student Tracking tool that has been co-designed with our teacher collaborators

Conclusions

- Ours is the first work targeted at notifying teachers about students' attainment of landmarks during exploratory constructionist learning tasks
- The set of landmarks used in MiGen has been identified as a result of iterative research, development and trialling by the project team
- These landmarks are a mixture of task-independent and task-dependent ones, and detection of the latter may have a degree of uncertainty

Future work

- The system was tested with students and teachers in the classroom in July, obtaining further feedback for improving its functionality and user interfaces
  - For the Student Tracking tool, the timeline view was found to be more useful for the teacher than the summary view
  - Also, teachers saw potential of this tool to be used after a classroom session, for assessing students' progress and planning the next lesson
- Further trials are planned in schools in November, and in early 2011, so as to undertake further evaluation and improvement of the system

Classroom Dynamics tool - group