Exploring the potential of a multi-touch classroom to develop adaptive expertise in primary mathematics

Prof Steve Higgins,
TEL Research Group
School of Education
Durham University,
s.e.higgins@durham.ac.uk

Durham University

T·L·R·P Technology Enhanced Learning

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

EPSRC

The UK's TLRP – TEL Programme

- Teaching and Learning Research Programme
- Technology Enhanced Learning £12M
- Phase 2: 2008-2012
- One of eight projects

SynergyNet: Supporting Collaborative Learning in an Immersive Environment

HapTEL: Haptic Technology Enhanced Learning

Ensemble: Semantic Technologies for the Enhancement of Case-Based Learning

MiGen: Intelligent Support for Mathematical Generalisation

Inter-Life: Interoperability and Transition

A **Learning Design Support Environment** (LDSE) for Teachers and Lecturers

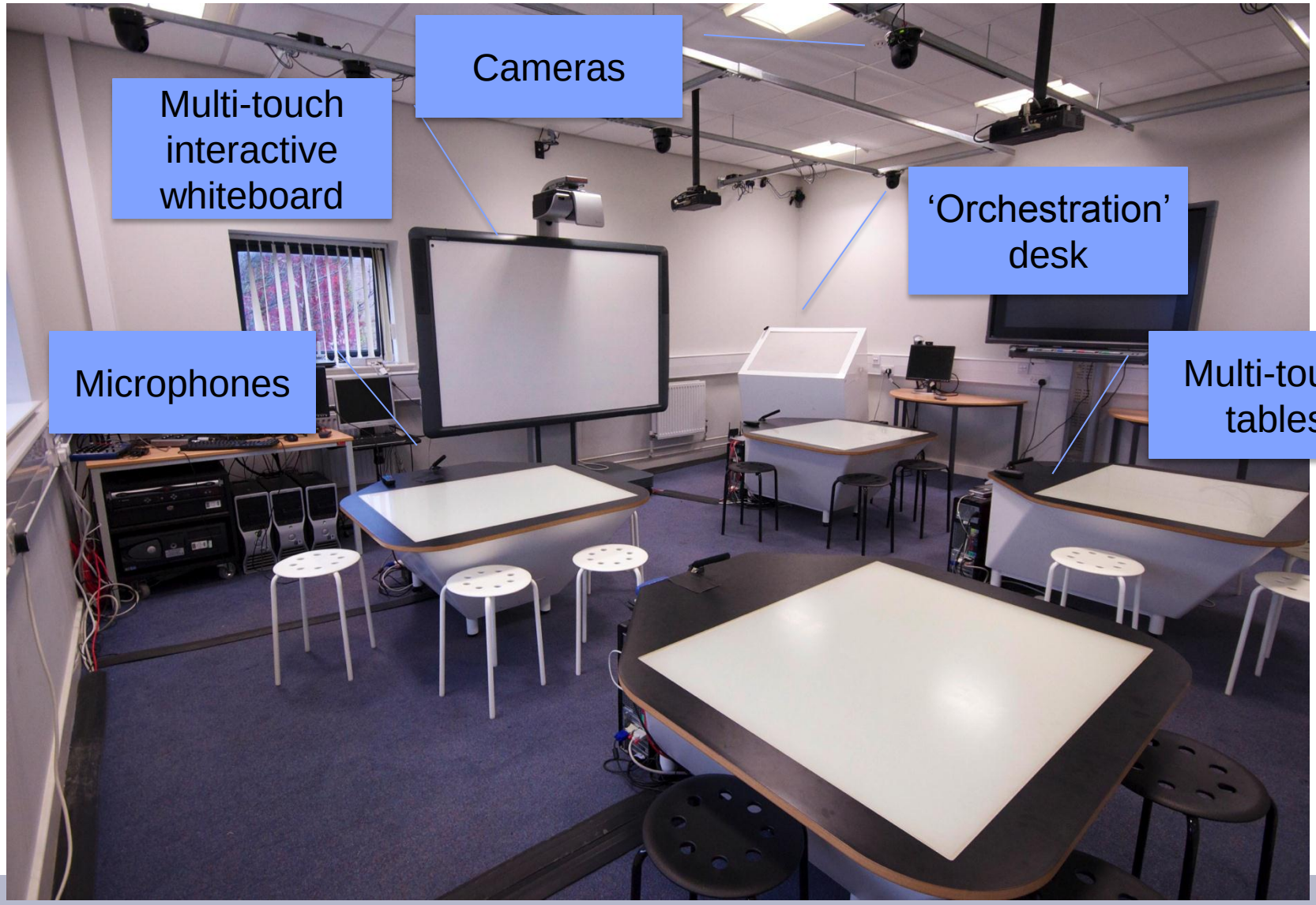
Echoes 2: Improving Children's Social Interaction through Exploratory Learning in a Multimodal Environment

Personal Inquiry (PI): Designing for Evidence-based Enquiry across Formal and Informal Settings of Learning

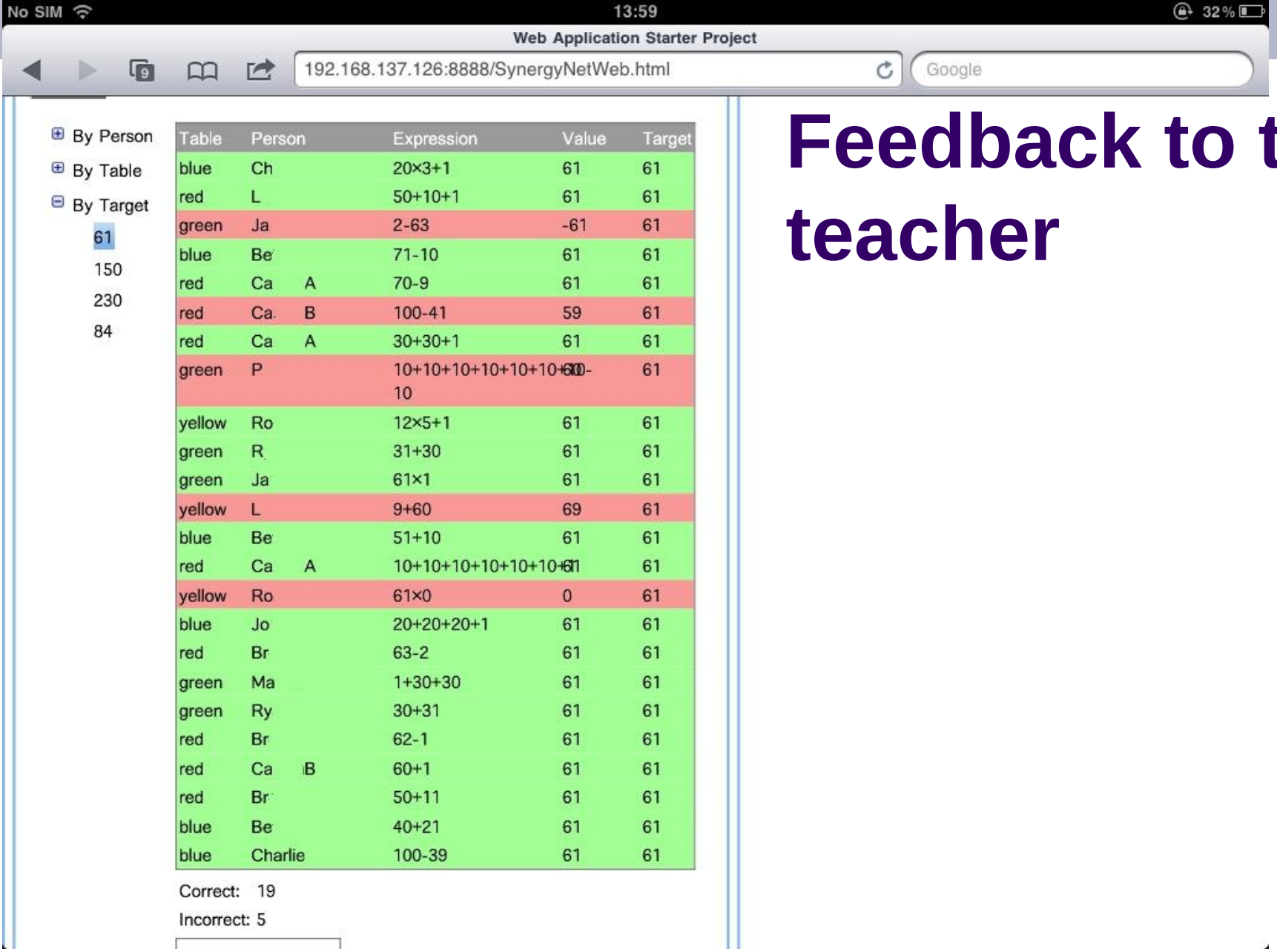
What are the pedagogical problems multi-touch can solve?

- Multi-touch tables
  - Direct touch, shared control, joint attention
  - Early years – guided interaction, bridging between experiences, plan, do, review; sharing experiences
  - Primary school– embedding effective collaboration and group ‘orchestration’ by teacher

SynergyNet Classroom



In use….



Feedback to the teacher

Teacher control

- From iPad (web interface)
- Timing/rotate tables
- Freeze the action
- Disable keys ‘on the fly’
- Get feedback on correct and incorrect expressions (by group, by individual, by target number)
- Show/hide correct/incorrect expressions
- Show/hide totals (competitive)
- Project tables on the IWB

Adaptive expertise

- Experts flexibly approach novel problems and can apply a range of solutions (Hatano & Inagaki,1986)
- Beyond routine expertise (Salomon & Perkins, 1989)
- Or a different form of expertise? (Schwartz, Bransford, & Sears, 2005)
- Flexibility and adaptivity (Verschaffel, Luwen, Torbeyens &Van Dooren, 2009: p 337)
-

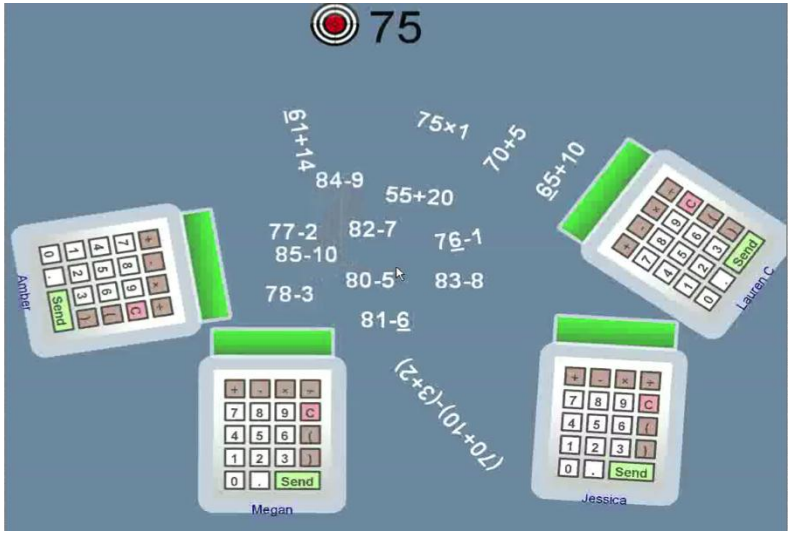
Situated expertise

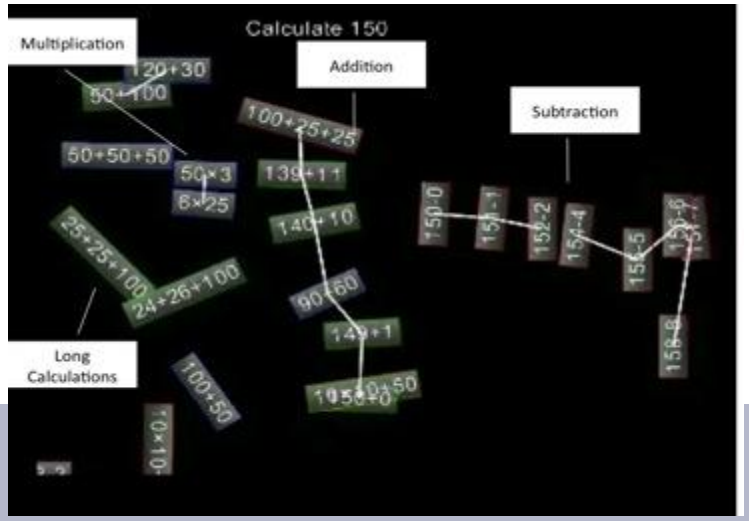
- The importance of **dialogue** between learners, which introduces more instances of **surprise, perplexity and disco-ordination**, and supports students in **making links** to their **own** areas of expertise, and those areas in which they are **just developing** expertise (Hatano, 1988)

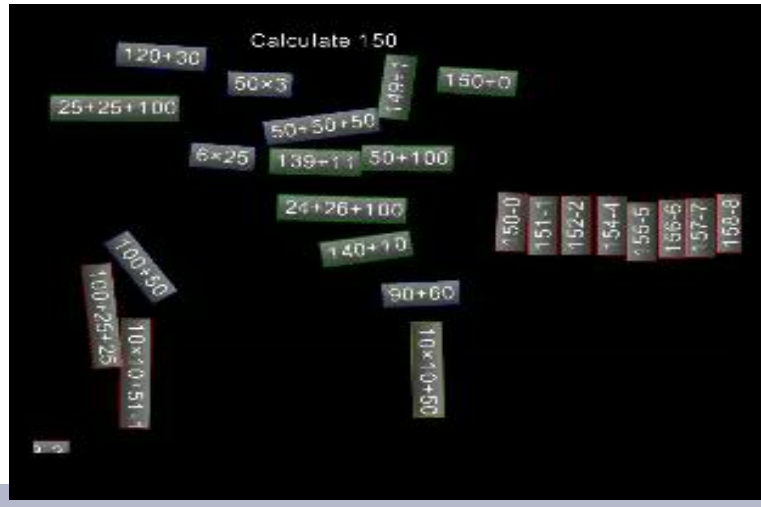
Developing adaptive expertise?

NumberNet

- ‘Make up some questions’ task
- Add to each of the other groups attempts (3x)
- Organise the correct expressions

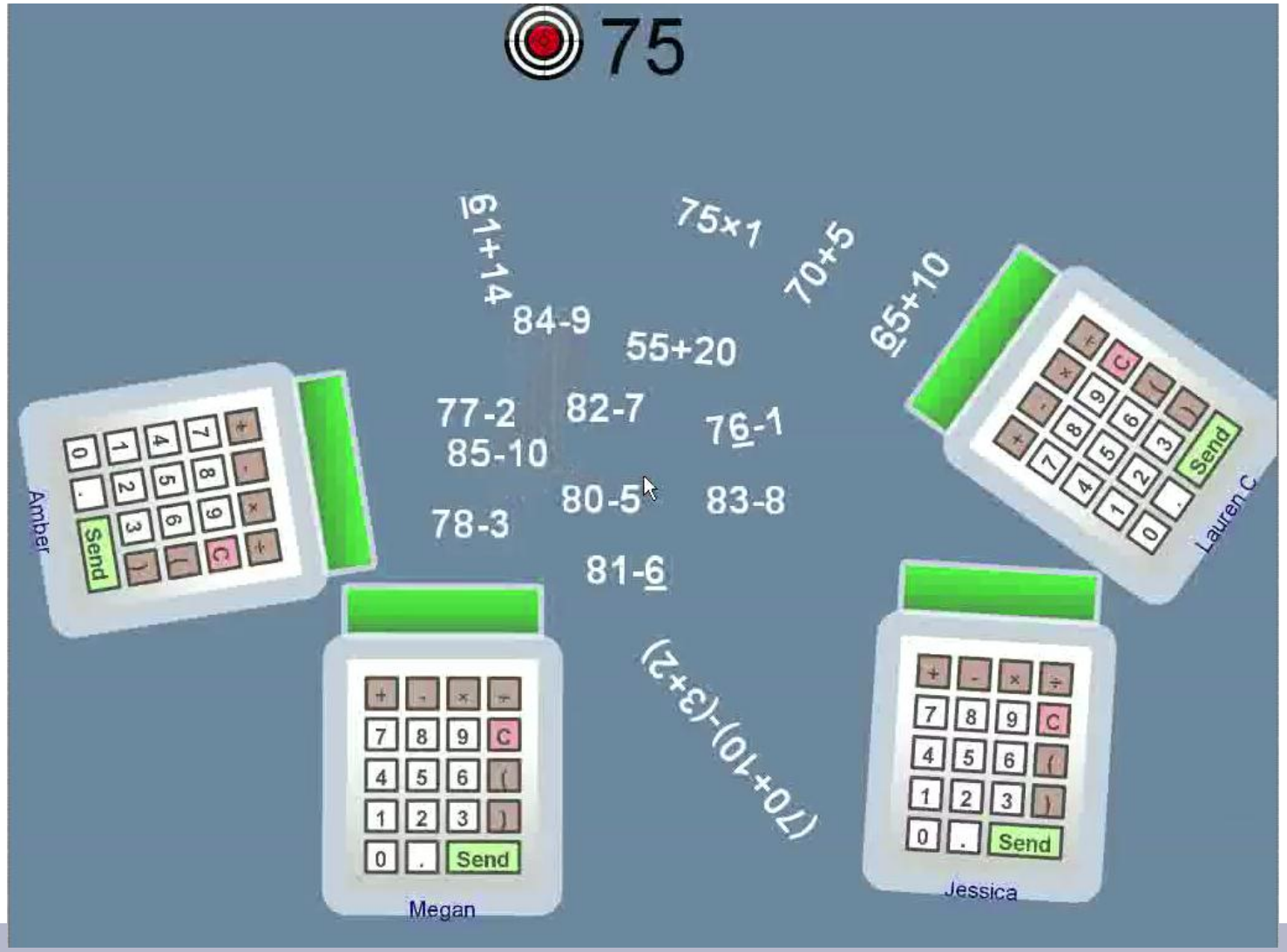




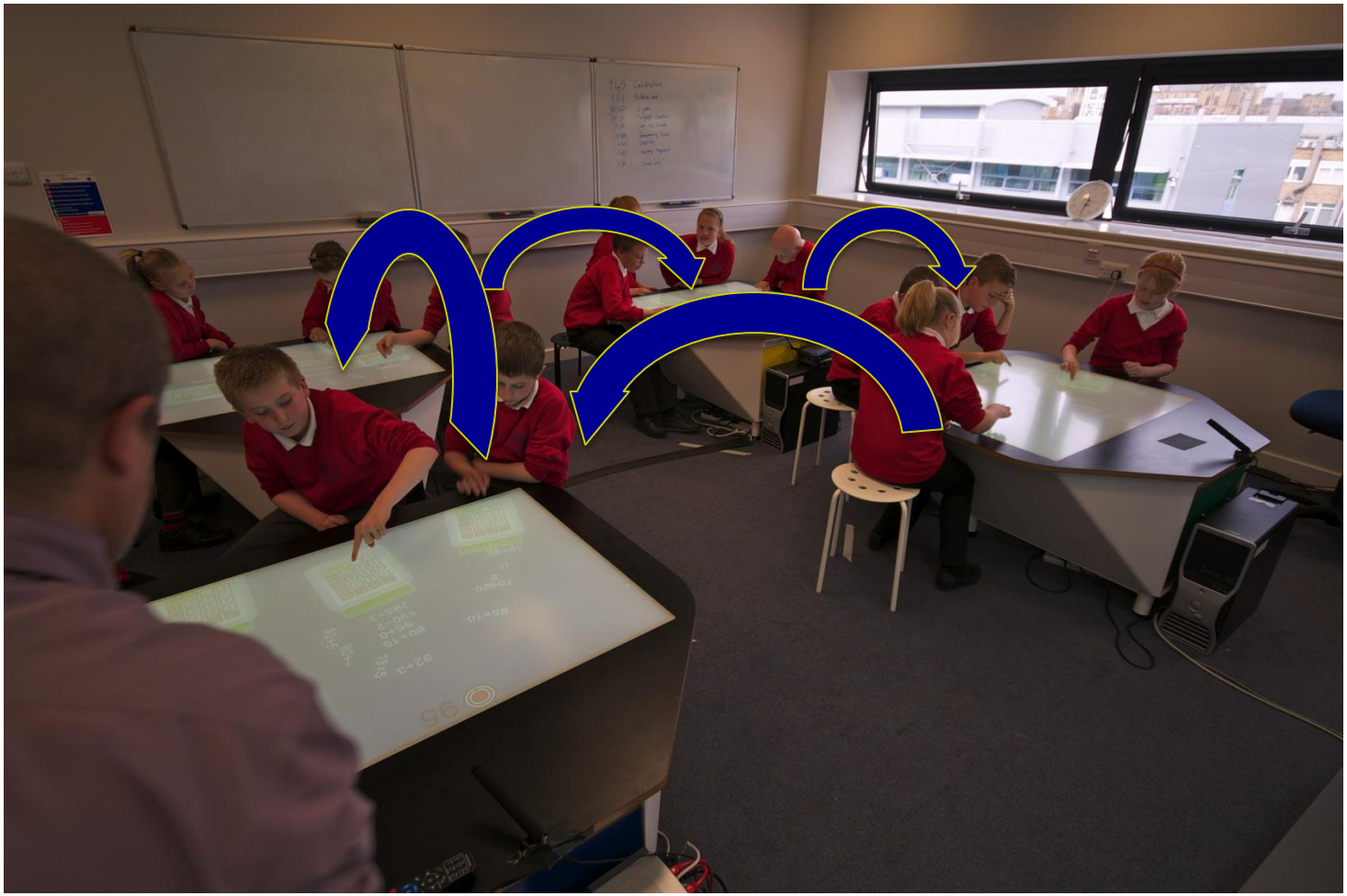


Durham University

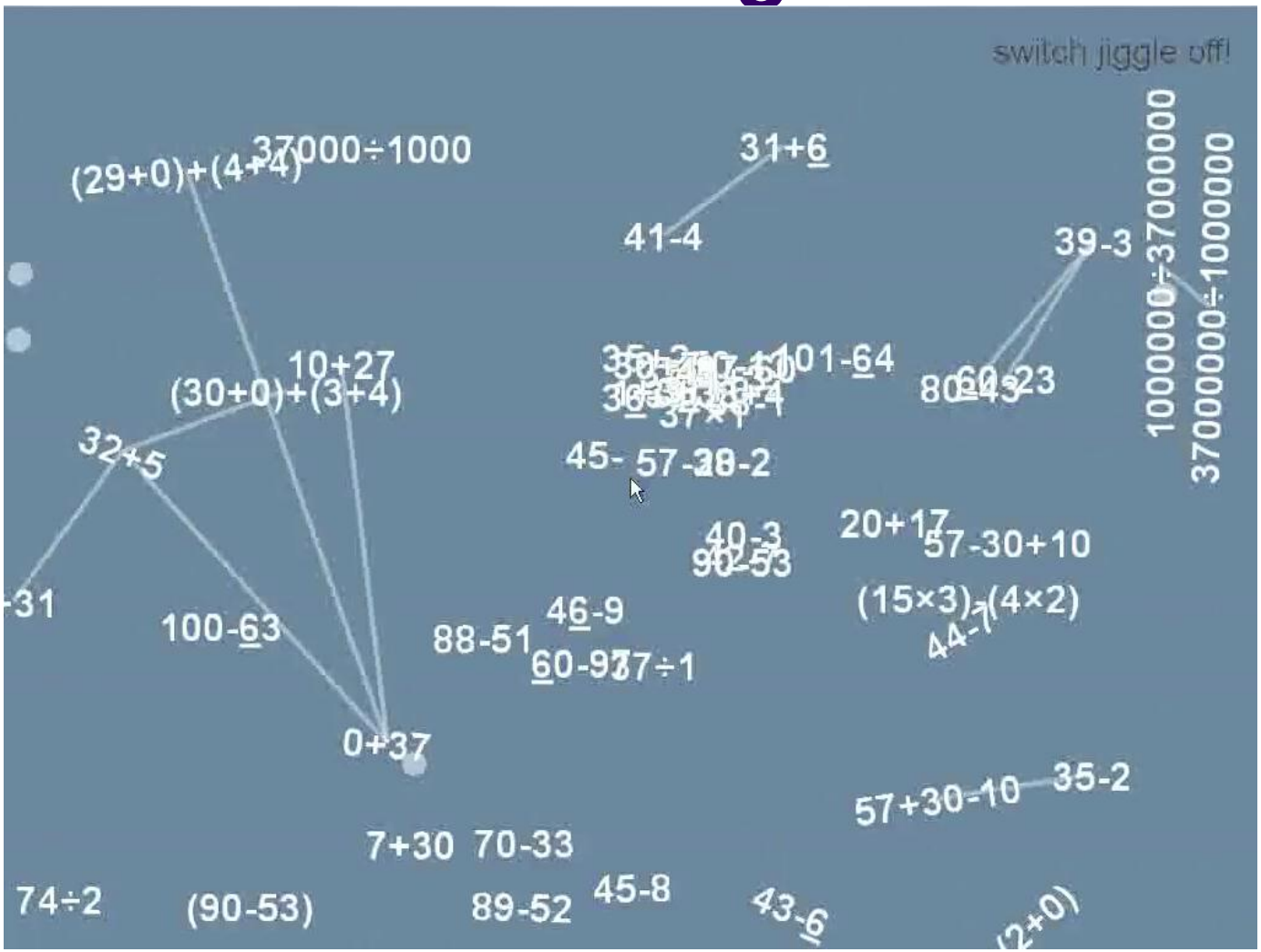
NumberNet


75
61+14
75×1
70+5
65+10
84-9
55+20
77-2
82-7
76-1
85-10
80-5
83-8
78-3
81-6
(70+10)-(3+2)
Amber
Megan
Jessica
Lauren C
Send

NumberNet



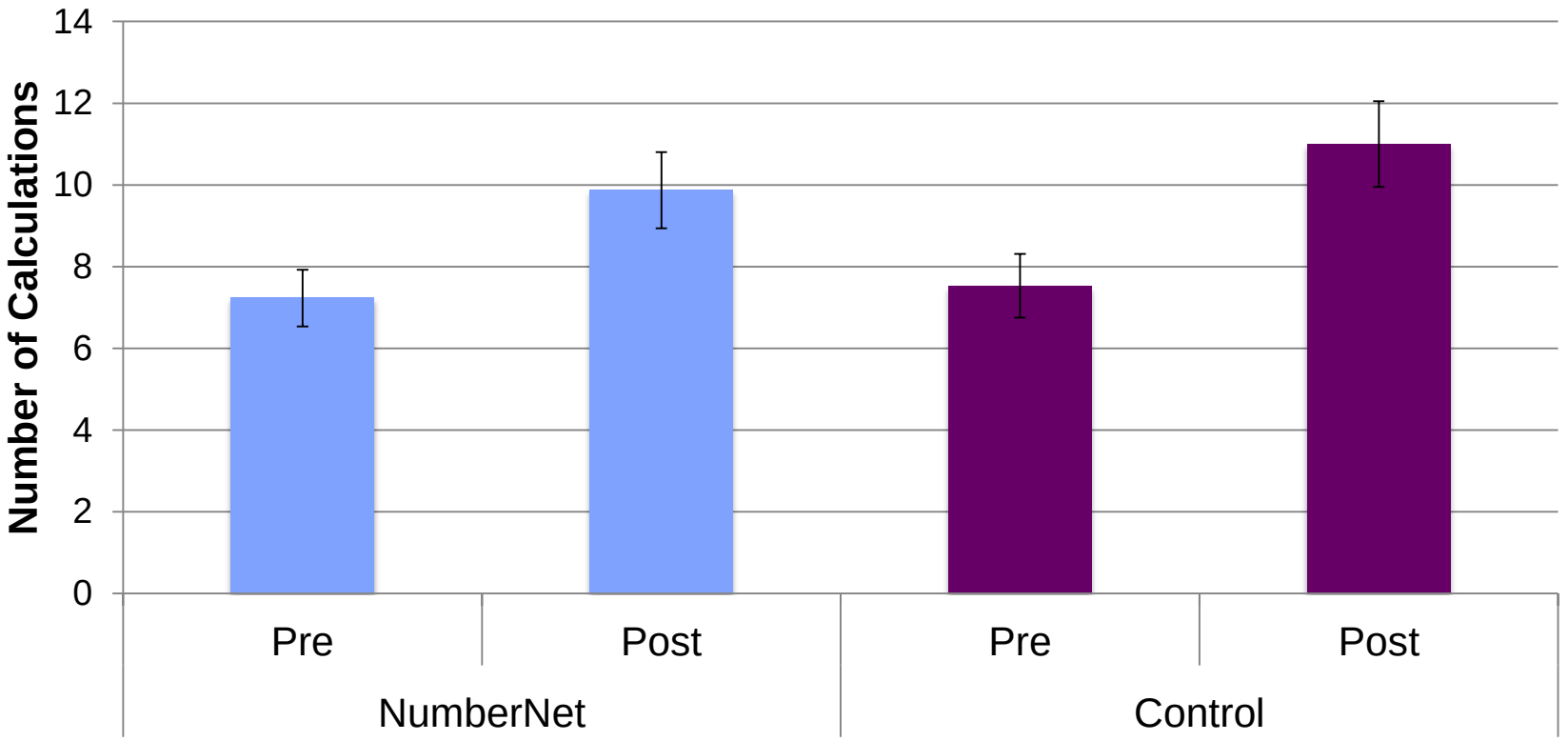
NumberNet: making connections



NumberNet Study 1

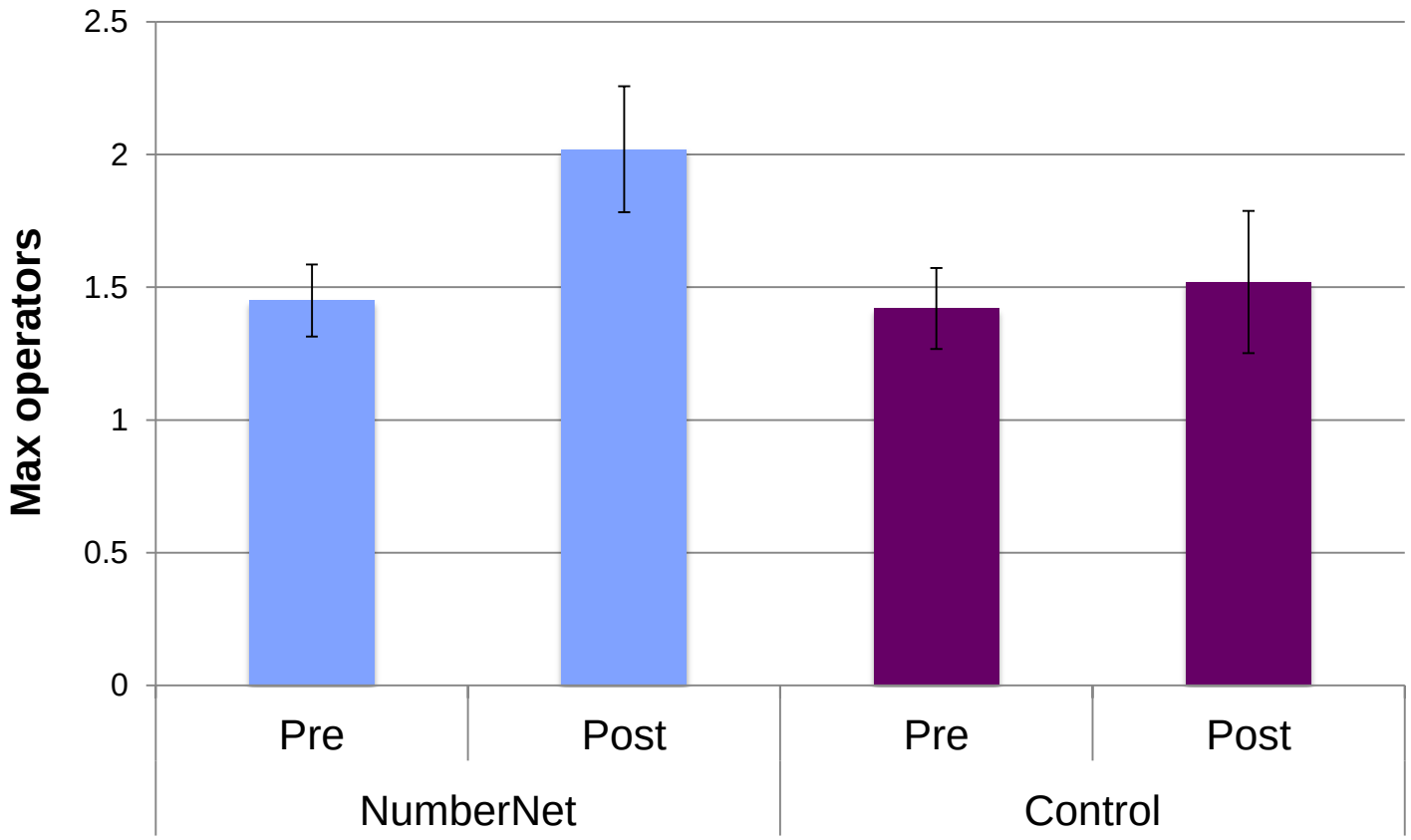
- Matched groups experimental design (N=86)
- Same time on number tasks in both conditions (NumberNet or Classroom)
- Used most simple version of NumberNet
- Paper-based pre/post test (dependent measures):
  - Number of correct calculations
  - Number of unique strings
  - Maximum operators in a single calculation

Number of Correct Calculations



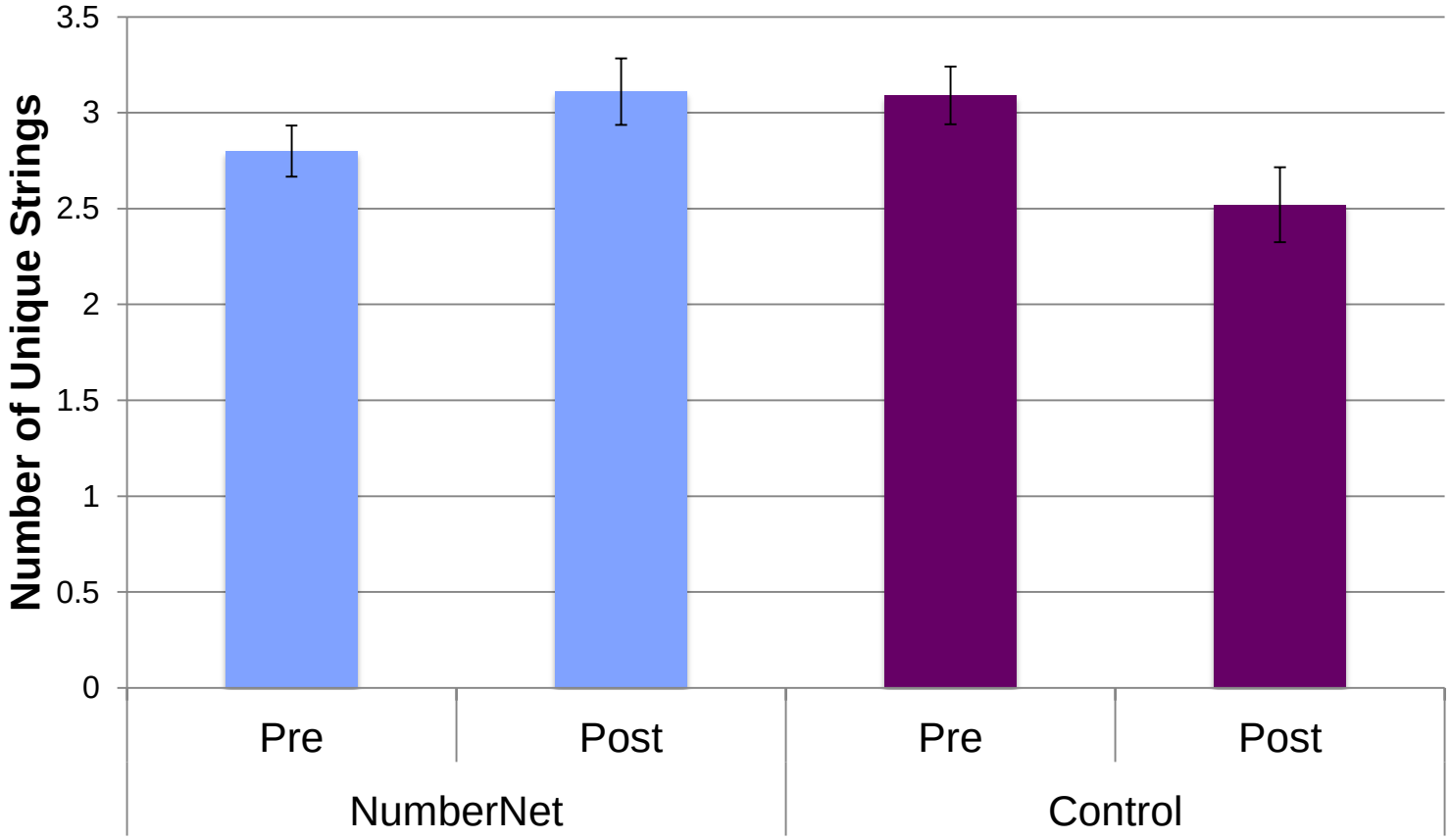
$F(1, 84) = 31.01$ $p < .001$, $\eta^2 = .27$

Maximum operators in a single calculation



$F(1, 84) = 2.036$, $p = .157$, $\eta^2 = .024$,

Unique strings



$F(1, 84) = .186$, $p = .667$, $\eta^2 = .002$

Experimental analysis

Both groups improved in terms of number correct

Effect of time **significant** for correct calculations, $F(1, 84) = 31.01$ $p < .001$, $\eta^2 = .27$ **and** maximum number of operators in a calculation, $F(1, 84) = 4.469$, $p = .037$, $\eta^2 = .051$. Not significant for unique strings, $F(1, 84) = .858$, $p = .357$, $\eta^2 = .01$.

Time by condition interaction was **not significant** for correct calculations, $F(1, 84) = .186$, $p = .667$, $\eta^2 = .002$ **nor** for maximum number of operators in a single calculation, $F(1, 84) = 2.036$, $p = .157$, $\eta^2 = .024$

NumberNet activity developed more creative solutions – adaptive expertise?

Time by condition effect was significant for number of unique strings, $F(1, 84) = 11.63$, $p = .001$, $\eta^2 = .122$, ES 0.74: Lipsey and Wilson,2001: p 207.

Exploratory video analysis

- Case studies of one group's interaction to gain an understanding of whether using NumberNet has any effect on the students' mathematical flexibility when compared with practice on the more traditional activity

Interaction analysis

- Groups learn from other group members (e.g. agreeing not to duplicate and suggesting corrections)
- Groups learn from other groups (using ideas)
- Groups learn from identifying patterns in solutions (their own and others)

Initial group strategy & competition

(1.42-2.00)

Chelsea: is any of you doing 30 add 31?

Adam: I'm doing all the take aways!

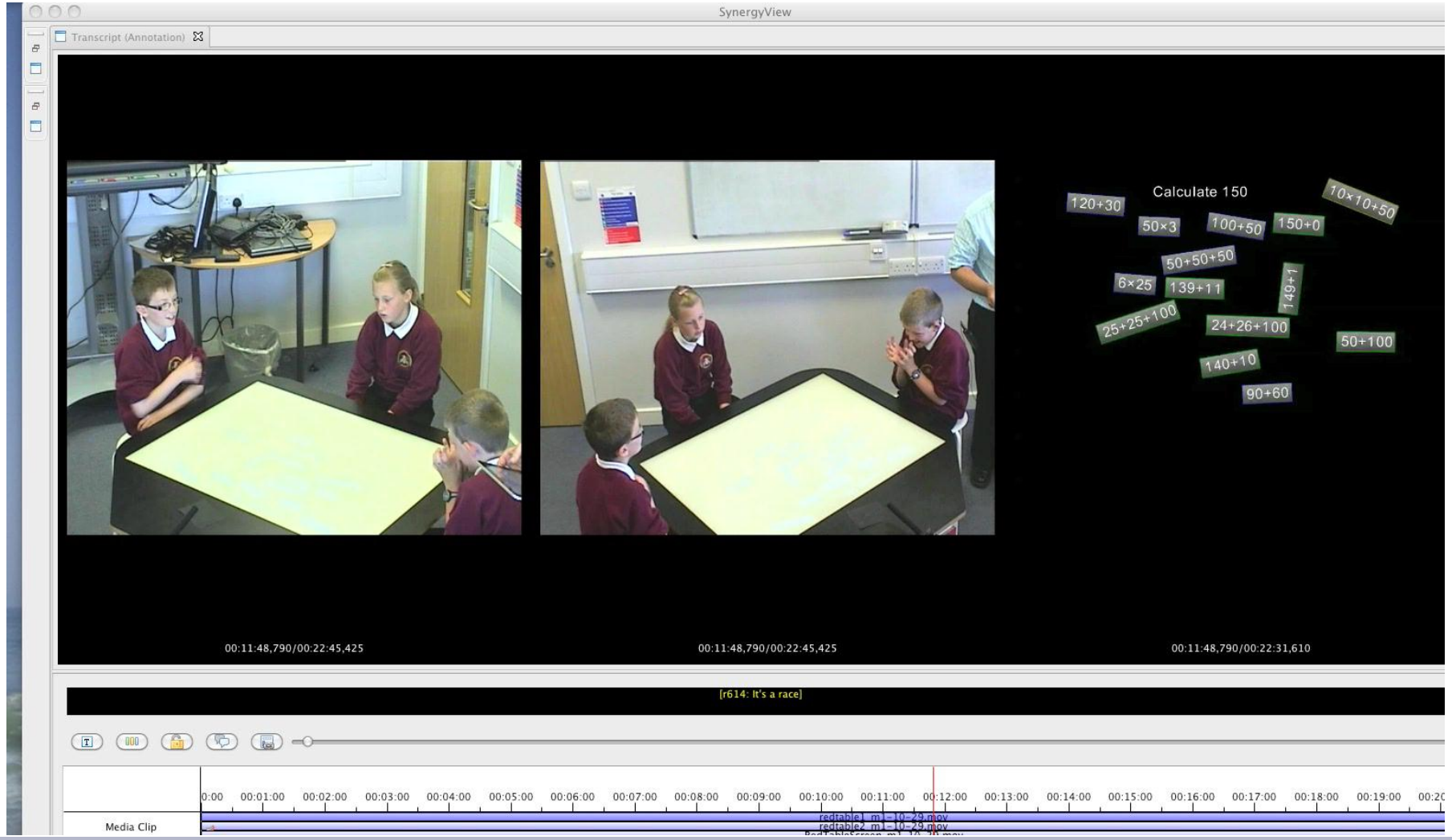
Jack: I'm doing take aways as well

Chelsea: I'll do add

Adam: I'm doing take aways

Jack: Ahh Adam, I've done 100 take away 39, beat that!

Between group learning



Jack: Who done... Who's green? Jiminy… That's quite smart! *[the calculations have a colour border indicating the table where they were created, so Jack is asking which is the green table, and so who was responsible for the calculation*]

Adam: Oh look at that! 10 times 10 that equals 100, add 50! Now that's clever, whoever did that! I'm doing that…

Once the teacher turns on the number pads, Jack goes on to adapt the calculations he has seen, creating the calculations 10*10+51-1, and drawing Adam's attention to it:

Jack: Haha! Adam, look at the size of that!

Adam: Oh yes, did it... 1... 5...

Jack: 'Cause 10 times 10 is 100, add 51 is 151 and take away 1 is 150... bingo!

Adam: Bingo!

Group competition and correction

Chelsea: Yes!! *[arms raised in triumph]*

Jack: You've done a big one as well?

Jack: *[after looking at Chelsea's calculation]* That's wrong! It's 150, not 151! You've done add 1, delete it. We're going to get one wrong! Delete it! Cancel it!

Teacher: Right, I'm going to stop you again.

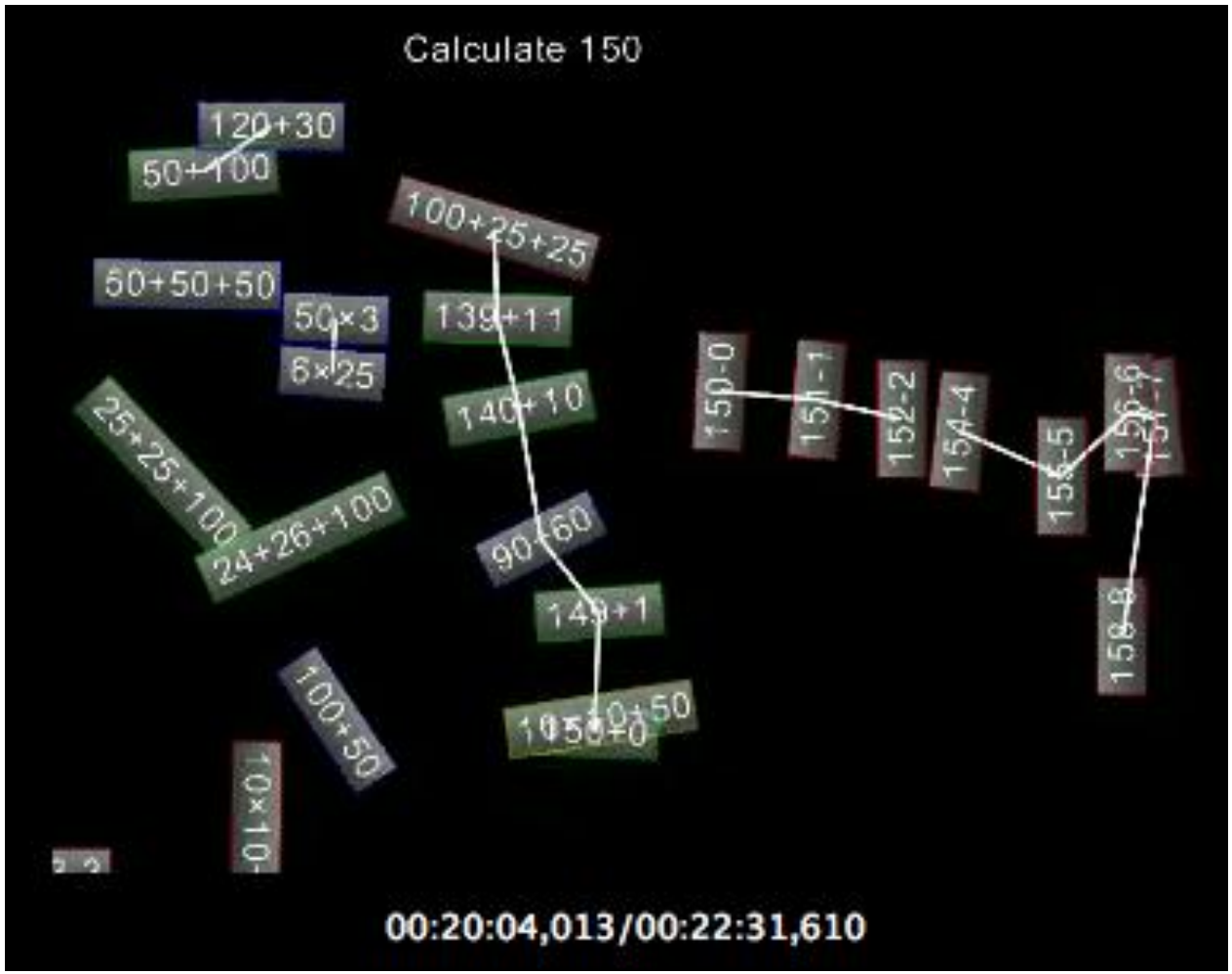
[Chelsea pulls the calculation back onto her number pad, deleting the +1 and trying to send it back to the table, as Jack and Adam cheer her on]

Jack: Hurry, hurry! Go on, quickly!

Adam: Yes! Get in! Last second!

Finding patterns

(15:20)



Conclusions

- Both conditions support routine expertise
- NumberNet allows within and between group learning
- NumberNet appears to support adaptive expertise
  - Flexibility supported by the task design
  - Adaptivity by pupils' understanding of the goals

SynergyNet: what we've learned:

- Multi-touch supports joint attention and collaborative interaction (joint control
- Teacher intervention at whole-class level
  - Leads groups to move to a higher level of reasoning (SOLO)
- Teacher orchestration
  - Teachers like to be able to manage the student tables, and project the student tables to the IWB
    - Dislike having to use table at front of room
    - Dislike having to carry iPad
    - Experimenting with Kinect.

The questions we're still asking:

- How does whole-class discussion influence the reasoning of the group?
  - Uptake of new ideas?
  - Students read signals that they need to progress?
  - How can we support the uptake of ideas between groups?
- What sort of tasks take advantage of the between-group interaction?

SynergyNet's publications

Journal articles

Higgins, S., Mercier, E., Burd, L. & Joyce-Gibbons A. (2011) Multi-touch tables and classroom collaboration *British Journal of Educational Technology* doi:10.1111/j.1467-8535.2011.01259.x

Higgins, S., Mercier, M. Burd, E. & Hatch, A. (2011) Multi-touch Tables for Collaborative Classroom Pedagogies *International Journal of Computer Supported Collaborative Learning* 6.4 pp. 515-538 [http://dx.doi.org/10.1007/s11412-011-9131-y]

Mercier, E., Higgins, S. and Da Costa. L (Being revised) "Different Leaders: Emergent Organizational and Intellectual Leadership in Children's Collaborative Learning Groups" *Cognition and Instruction*

Mercier, E., and Higgins, S. (Being revised) Developing Adaptive Expertise in Mathematics through Collaboration *Learning and Instruction*

Conference papers

Hatch, A., Higgins, S., Joyce-Gibbons, A. & Mercier, E. (2011) NumberNet: Using Multi-touch Technology to Support Within and Between Group Mathematics Learning. In H. Spada, G. Stahl, N. Miyake & N. Law (Eds.) (2011) *Connecting Computer-Supported Collaborative Learning to Policy and Practice: CSCL2011 Conference Proceedings. Volume I — Long Papers*. International Society of the Learning Sciences pp 176-183.

Alagha, I., Burd, E., Higgins, S. & Mercier, E. (2011) SynergyNet Exploring Design and Pedagogy in a Multi-Touch Classroom. In H. Spada, G. Stahl, N. Miyake & N. Law (Eds.) (2011*) Connecting Computer-Supported Collaborative Learning to Policy and Practice: CSCL2011 Conference Proceedings. Volume III — Community Events Proceedings*. International Society of the Learning Sciences pp 1081-2.