

Learner Response Devices and Co-operative Learning: Preliminary Outcomes of TechTeam Maths in Years 7 and 8 (Draft Report)

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TechTeam Maths: Research Project Report

The mathematics performance of students in UK secondary schools is similar to that in other developed nations, but within the UK there is enormous variation in mathematics attainment. In order to improve outcomes for all schools, it will be necessary to improve daily teaching practices in schools (National Mathematics Panel, 2008; Askew, Brown, Rhodes, Johnson and William, 1997; Ma, 1997). A recent technological development in the UK may offer a means of making meaningful, replicable improvements in pupils' mathematics performance. This is the appearance and increasingly widespread adoption of electronic learner response devices (LRDs), such as ActivExpression, typically used in conjunction with interactive whiteboards, which are also growing rapidly in use.

Most classrooms in schools in the UK are now equipped with an interactive whiteboard, a large computer touch screen that makes it possible for teachers to manipulate and present to entire classroom groups anything that can be shown on a laptop or desktop. An electronic learner response device (LRD) is a small handheld unit that enables all students to indicate a given answer in response to any question posed by the teacher or written on the whiteboard. ActivExpression is one such LRD, which allows students to key in their own answers using a keypad like those on mobile phones, freeing the devices from the limitations of multiple choice assessments. Teachers can display students' responses immediately on a whiteboard in a variety of formats, from summary graphs to displays of individual students' responses.

In theory, LRDs such as ActivExpression provide teachers with a powerful tool to accelerate student achievement. A great deal of research has established that providing frequent formative feedback, to give both the teacher and the students themselves immediate indicators of students' current levels of understanding, can have a substantial impact on student learning. Studies in the UK (e.g., Black & William, 1998) and the US (e.g. Slavin, 1995; McMillan, 2004) have shown that frequent formative assessments in daily classroom instruction can accelerate students' learning by several processes:

- Giving teachers immediate information on students' learning, so that they can regulate the pace and content of lessons according to current levels of mastery and identify students in need of additional help;
- Giving students feedback on their own learning, enabling them to regulate and evaluate their own learning efforts;
- Giving students routine opportunities to participate actively in lessons, a key precursor to achievement success (eg Good, Growns & Ebmeier, 1983);
- Giving students routine opportunities to see how their peers are solving problems and incorporating effective learning approaches used by peers;
- Motivating students to learn academic content and skills by giving them a stake in the outcomes of instruction, as students are more interested in academic content when they have had to take a public position or give a public answer.

Research on the use of learner response devices is in its infancy, but early studies have shown positive effects on learning (eg. Haystead & Marzano, 2009; Mayer, 2009).



Combining Co-operative Learning with ActivExpression

The use of electronic learner response devices by students in isolation may not produce optimal outcomes, as students who are struggling with the content may not gain from just posting their answers. However, LRDs lend themselves to use in co-operative groups, where students can help each other study to prepare for assessments. The systematic introduction of co-operative teaching and learning strategies in mathematics lessons may have the potential to contribute significantly to improvement in students' mathematical attainment. In particular, co-operative learning combined with the use of LRDs may offer a means of making replicable improvements in students' mathematical performance.

Co-operative learning refers to methods in which students work in 4-5 member groups or teams to help one another master academic content. Teams receive recognition based on the degree to which all team members have learned the content of each lesson. To help their team to succeed on tasks and problems set in lessons, group members tutor and encourage one another to achieve. In this way, individuals are accountable for their own learning and for the learning of others in their team.

Research on co-operative learning methods, in which students in teams work toward group success based on the individual learning of all team members, has found consistent positive outcomes in primary and secondary mathematics (Slavin & Lake, 2008; Slavin, Groff & Lake, 2009; Slavin 1995). The combination of LRDs with co-operative learning may enhance the usefulness of LRDs in mathematics lessons.

The widespread adoption of LRDs creates new opportunities to help teachers incorporate various formative assessment strategies into their daily lessons. However, the use of LRDs in co-operative learning contexts has not been rigorously evaluated. In order to inform policy and practice in schools, it was therefore important to ask the following research questions:

- What is the effect of the use of ActivExpression response devices combined with co-operative learning strategies on the mathematics achievement of students in comparison to students taught without ActivExpression?
- How does the extent of use of ActivExpression, combined with co-operative learning strategies impact student learning?

Research has identified dips in academic progress and attainment in Years 7 and 8, (Galton et al, 1999; 2003; 2009) and recent educational initiatives such as the Key Stage 3 National Strategy, Target Setting and Assessing Pupil Progress have attempted to re-dress this trend (DCSF). Raising mathematical attainment is a priority for many schools and academies. It would therefore seem appropriate to investigate the research questions outlined above with Year 7 and 8 students in mathematics lessons.

United Church Schools Trust (UCST) is a leading education charity in the UK. Founded in 1883, UCST has a long and distinguished tradition in the provision of independent education, and operates 10 fee-paying independent schools across the UK.

UCST is committed to driving educational improvement by providing high quality learning environments, support and leadership and operates at the forefront of education.



UCST interest in participating in the TechTeam Maths research project reflected the group's commitment to raising academic standards, being at the forefront of curriculum innovation, and maintaining a high quality teaching force through the provision of high levels of professional development and support.

Prior to the research project, the UCST group had identified the use of ActivExpression as a potential tool for raising academic achievement through curriculum development and increased student engagement. Some preliminary training on the use of ActivExpression had been delivered to teachers in the schools through the group's e-learning support network.

Method

Partners, Participants and Design

UCST/ULT recruited 4 independent willing to participate in the research project. Intervention and control conditions were randomly assigned to the participating classes at each year level, taking account of students' prior achievement. Classes were paired based on achievement levels; one was randomly assigned to use ActivExpression response devices for 12 weeks starting in the Spring term 2009, while the second served as a delayed treatment control group. In the Autumn term 2009, at the end of the intervention period, control classes were able to use ActivExpression in their lessons.

Participant consent was obtained from teachers, students and their parents/guardians.

Initial training on ActivExpression and co-operative learning

Using a matched randomised design across the school, described above, teachers were expected to use ActivExpression devices with all of their students in the intervention classes, and to continue using their usual teaching methods during the research period with their control classes.

One training day was provided in November/ December 2008, at the beginning of the research project, for all participating teachers on the principles and strategies of TechTeam Maths and on the effective use of ActivExpression. The training focused on the research process; how to use and manage the ActivExpression technology; co-operative learning strategies including Think-Pair-Share, Random Reporter, and Zero Noise Signals, and the benefits of team work. While the research required that teachers would not be previous or current users of the device, it was necessary that the teachers had a minimum level of confidence in using the devices prior to the start of the implementation period.

Pretest (November/December 2008)

The pretest measures were the Optional Mathematics Test for Year 7, Paper 2, Level 4-6 (QCA), and the Optional Mathematics Test for Year 8 Paper 2 Level 5-7 (QCA). The level of



difficulty for each cohort was to accommodate possible gains in the post-test across all ability groups, where the post-test would be Paper 2 repeated plus Paper 1, both at the same level of difficulty as the pretest. QCA guidance was given on the administration of the test papers. The pre-tests were administered between December 1, 2008 and December 19, 2008.

Resource Development

Exemplification flipcharts were produced to support teachers' lesson preparation and review for their intervention classes. In particular, the flip charts aimed to illustrate how TechTeam Maths might be presented in mathematics lessons using ActivStudio or other software that recognises ActivExpression. The flip charts drew on the content in the Secondary National Strategy Key Stage 3 Mathematics Framework (DCFS) and on schools' schemes of work. The aim in producing the flipcharts was to support teachers' adoption and implementation of TechTeam Maths by illustrating how the intervention programme could be integrated into teachers' existing lesson plans where possible. The flipcharts were designed to clearly demonstrate content coverage, co-operative learning strategies, appropriate pace, learning outcomes and opportunities for formative assessment.

The implementation period (Jan – May 2009)

The implementation period was to start immediately after the administration of the pre-test and to end on May 22, 2009. The research project required that TechTeam Maths would be taught in most if not all Mathematics lessons during the implementation period in the intervention classes. A high level of implementation fidelity was also required, meaning that the combined use of ActivExpression and the co-operative learning strategies introduced in the initial training would feature in the lessons.

Update training (13th February 2009)

While there had been full attendance at the initial training, attendance at the update training was partial.

Feedback from support visits to intervention lessons during the first weeks of implementation identified a need to focus on co-operative learning strategies in the update training scheduled for February 2009.

The update training focussed mainly on co-operative learning strategies in the context of TechTeam Maths, thus reinforcing fidelity of implementation and pedagogy driving the use of the technology. The training also provided the opportunity for teachers to share their areas of concern regarding implementation and for trainers to offer support in those areas. Teachers reported that the technology had presented some difficulties. Concerns about the software included the following:

- Incompatibility of ActivStudio and ActivExpression
- Difficulty with response formats in some areas of instruction: algebra, fractions



- Lack of a function allowing pupils to confirm whether they want to send their answer
- Excessive time needed to set up devices
- Difficulty scrolling down on imported flipcharts
- Time consuming preparation of 'new' flipcharts/questions

Trainers' responses to concerns raised by the teachers in the training session are presented in Appendix 1.

Support visits

Several follow-up visits to TechTeam Maths lessons were carried out between January 2008 and May 2009 by support staff in the research team to assess implementation and give advice. The support visits provided the opportunity for teachers to express their concerns about implementing TechTeam Maths and for support staff to offer strategies for addressing the concerns teachers raised. Examples are given below.

- **Concern:** Reliance on Flipcharts for reading questions and information is a significant barrier for some students for whom literacy and comprehension was a significant issue.
Strategy: Accommodate students' literacy levels in their own planning and resource preparation, using ideas from the downloadable flipcharts as guidance and incorporating visual elements where possible.
- **Concern:** The amount of time the children took to register the devices in their own names at the beginning of lessons.
Strategy: Assign a number to each device and assign each student one specific, numbered device to eliminate the need to register the devices at the start of each lesson.

Support visits provided opportunities to note strengths in implementation and to provide positive feedback to teachers. Examples are presented below.

- Children are grouped into well-balanced teams of different gender, ethnicity and ability
- Excellent use of Random Reporter to involve all children in the lesson, emphasizing team responsibility rather than individual knowledge.
- The lesson structures and questioning techniques are clearly in place and used as a matter of routine.
- Teachers are exploring the new software and devices with confidence. The children are enthusiastic about their use, and teachers are doing well to harness that excitement and focus it towards the learning goals.
- Children are becoming more confident and comfortable using the devices.
- Lots of reminders to "check with teammates" and discuss ideas.



- Team learning is carried forward by asking individuals to explain their reasoning, or to show their working out.
- Pupils are gradually getting used to the idea of team work, despite the occasional personality clashes. They are gaining confidence in explaining their ideas to their peers, and sharing their understanding to help team members.
- Teachers use the immediate feedback from the ActivExpression voting system to address misconceptions and judge the general level of understanding during the lesson.

An important function of each support visit was TechTeam Maths lesson observations. To ensure fidelity of TechTeam Maths implementation, feedback to teachers reinforced aspects of the training, addressed misconceptions, and identified areas for development as reminders for improvement. Two examples of reminders to teachers are given below, and further examples are presented in Appendix 2.

Example 1.

Try to ensure that the ActivExpression devices are used at each stage of the lesson, particularly in longer lessons. For any topic, it is important to make regular assessments of the level of understanding in the class and this can be achieved immediately using the Express Poll. As a scaffold, try highlighting 5-10 questions in each lesson that will be asked using the devices, possibly also making a brief annotation as to the type of question (Team Huddle; Team Mastery; Team Check; Individual Check).

Example 2.

Make sure the 'Random Reporter' strategy is truly random. Using an impartial system for Random Reporter – toss a coin, roll a die or pick numbered cards out of a jar – will avoid pupil's perception of being 'picked on' (or not being given a chance). Remember to choose the team member responding after there has been time to work out an answer to the question set; not knowing who will respond encourages children to make sure every member of the team has the answer. Before explaining any answers, give time (30-60 seconds only) for the person chosen to briefly confer with their teammates.

Project Evaluation Visits

Over the course of the study, each experimental and control class was observed by members of the research team other than the trainers/support providers, to learn how the classes differ in terms of teaching and learning behaviours in mathematics lessons. An observation protocol was used to structure lesson observations (See Appendix 3). Structured interviews were conducted with teachers to gain insights into their experience of training, support and implementation, and to identify enablers and constraints impacting on the intervention (See Appendix 4).

Posttest (May 2008)



The post-test measures were the Optional Mathematics Test for Year 7, Paper 1 and 2, Level 4-6,(QCA) and the Optional Mathematics Test for Year 8, Paper 1 and Paper 2, Level 5-7 (QCA). QCA guidance was given on the administration of the test papers. The post-tests were administered between June 8 and June 12, 2009.

Data analysis

Pre and posttest papers were coded and scored by a team of independent markers and re-scored for reliability. Similarly, to minimise error and ensure reliability, scores were double entered into the data management data base. Data were analysed using analyses of covariance, with pretests as covariates.

Patterns of Implementation

Drawing on the evidence from support visits, evaluation visits and teacher interviews, reviews of TechTeam Maths implementation were conducted regularly by the research team over the duration of the study. Implementation was found to be variable within and across schools.

While the implementation period was to start immediately after the administration of the pretests in early January 2009, implementation was significantly delayed in several cases, was inconsistent in some cases, and did not meet the requirement of the study in others.

Reasons for variability in implementation included the following:

- Teachers re-assigned to teaching groups not in Year 7 or Year 8
- Insufficient training in the use of ActivExpression
- Limited access to the ActivExpression devices
- Teacher lack of confidence in introducing co-operative learning
- Perceived incompatibility with curriculum content
- Other curriculum development priorities

The research project required that TechTeam Maths would be taught in most if not all mathematics lessons during the implementation period in the intervention classes.

The research study required a high level of TechTeam Maths implementation fidelity; there was an expectation that the combined use of ActivExpression and the co-operative learning strategies introduced in the training would feature in the mathematics lessons of classes assigned to the intervention.

Review of patterns of implementation was conducted prior to administration of the post-test measures. Levels of implementation were evaluated separately for the use of ActivExpression, the use of co-operative learning strategies, and for TechTeam Maths in which the two components were combined as required by the study and exemplified in the training, support visits and resources.



The composition of the intervention and control subsets is presented in Table 2.

Table 2. Composition of the matched intervention and control subsets

	TechTeam Maths		Control		Total	
	Subset	Students	Subset	Students	Classes	Students
Independent School	6	77	6	88	12	165

Classes were matched with control classes at the same level and with similar scores, as shown in Table 2. Intervention and control classes were matched within the Independent Schools.

Results

Table 3 summarises the findings.

Table 3. Outcomes on Optional Tests of Mathematics (in z-scores)

Independent Schools	N (classes)	Pre	Post	Adjusted Post	Effect Size
TechTeam Maths (SD)	77 (6)	+0.14 (0.94)	+0.22 (0.93)	+0.11	+0.20*
Control (SD)	88 (6)	-0.12 (1.04)	-0.19 (1.02)	-0.10	

* $p < .05$

Data analyses were carried out for Independent Schools. There were no statistically significant pre-test differences.

At post-test, controlling for pre-tests, there were significant differences among the Independent School Classes on the Mathematics tests ($ES = +0.20$, $p < .05$).

Discussion

The findings of the evaluation of TechTeam Maths were mixed, but a great deal was learned about the programme and how it can be improved in the future.



Among the Independent Schools, the implementation of TechTeam Maths was generally very good. Most teachers were sophisticated with technology, used interactive whiteboards well, and in some cases were familiar with co-operative learning.

Implementation ratings were made on a 5 point scale from 0 to 4. Four of the Independent School teachers had implementations rated as “3” and two recorded ratings of “4”.

Some teachers reported that team work and co-operative learning strategies made a positive difference in the engagement and learning of weaker students. They also reported that students were able to work better with harder conceptual material.

Conclusions and Recommendations

The results suggest that in the Independent Schools in the present study, the use of ActivExpression response devices combined with co-operative learning strategies impacted significantly on the mathematics achievement of students in comparison to students taught without ActivExpression.

In order to secure future improvement of the programme, the following recommendations are made:

- The programme should start at the beginning of the school year, to give teachers and students more time to learn the procedures.
- More prepared flip charts should be provided.
- Support high levels of implementation with increased coaching and leadership support.
- Develop a culture of team work and students’ working together to help each other to succeed in learning.
- Provide additional training and practice for teachers in the use the learner response devices and co-operative learning strategies prior to implementation in lessons.
- Provide more time for teachers to establish an appropriate level of implementation, and for teaching and learning strategies to become embedded prior to any future evaluation.
- Support implementation by integrating the programme into teachers’ existing schemes of work and lesson plans, and taking account of opportunities for assessing pupil progress (APP).

TechTeam Maths is currently being evaluated in ULT Academies, and although implementation problems may remain, the classes are off to a good start. Instead of comparing classes within schools, schools are now implementing the programme with all their Year 7 and Year 8 students, so teachers can help and support one another. Training placed more emphasis on co-operative learning, and most classes are doing a good job with this element. Problems with registering and using LRDs are being solved. A broader array of flip charts has been provided, and teachers are finding them useful. The 2009-2010 evaluation results will not be available until autumn, 2010, but based on our observations we



expect that Academies and Independent Schools using the programme will obtain improved outcomes.



APPENDICES

Appendix 1

Appendix 1A. Teacher Concerns and Support Strategies: Managing team-work and co-operative learning

Concern	Suggested Strategy
Encourages some students to talk too much about other things	Increasing the pace of the lessons, or the expectation of how quickly answers will be entered on the devices and then discussed, will cut down the amount of off-topic chat.
Students tell each other how to do it their way instead of teaching them	Better, more thorough explanations can be encouraged by the teacher rewarding that behaviour eg. Set targets for the class, and give points or merits to the students who co-operate with team members and explain their ideas to others.
Hard to control strong characters in groups	Teachers have to use their professional discretion in choosing teams, and changing teams around (if they prefer) at half terms.
Pace of lessons not as quick as I would like	There will be an initial adjustment period, but after a few weeks teachers should be able to move through the lesson content more quickly, and children will be more confident with the devices. Bear in mind that the devices do not need to be used to answer EVERY question.
Hard to 'police' this	Make the expectations and boundaries very clear at the start, and enforce them consistently. Have a set of rules specifically for the TechTeam lessons, or for the use of the devices, and make clear what penalties there are for breaking the rules. Above all, praise good behaviour to reinforce and encourage it.
Not as good a learning environment because of the noise	It will not feel the same as a 'traditional' classroom, but research shows that this actually improves learning, rather than detracting from it. This may be something more difficult for staff to adjust to than children.



<p>Students at the moment are too hyper with the devices</p>	<p>This should settle down over time, but also refer to the answer on 'policing'.</p>
<p>Makes classroom management harder for some teachers</p>	<p>Refer to above answers on 'policing' and student talk.</p>
<p>Not all students have the social skills necessary for teamwork</p>	<p>That's the idea! It will be a learning curve, but the social skills are learned as part of the process and this should be nurtured and encouraged.</p>
<p>Intra-team relationships in some groups</p>	<p>See above answer on 'strong characters'.</p>
<p>Fostering 'Team Mastery' approach to learning</p>	<p>The interdependent approach is encouraged by teacher expectations and an effective system of rewards. Make sure that the students know you value their co-operative learning approach as much as the academic achievement, and put a reward structure (such as merits or team points) in place to demonstrate that.</p>
<p>Have I got the teams right? Should I change them if I am worried?</p>	<p>Teams can be changed, and it may benefit children to learn to work with a wide variety of other people. It is suggested that teams are changed at 8-week intervals, and always remember to keep a mix of abilities, gender and race within teams.</p>
<p>Some students are less articulate/assertive: is their voice heard?</p>	<p>That is the teacher's responsibility, as it would be in a more traditional classroom. Think carefully about the teams that these children are put into, and ensure that they are given opportunities to share their thoughts with the class as well as their team.</p>
<p>Pace of lessons</p>	<p>See above answer on pace.</p>
<p>Will students progress as well as before</p>	<p>That is what the research project is aiming to find out. Co-operative learning has been thoroughly researched and is proven to be a more effective means of learning and knowledge retention for the majority of children. The ActivExpression devices are a means of better engaging children in lessons, and can help teachers with assessment for learning.</p>
<p>As the novelty of texting answers wanes, how to</p>	<p>The TechTeam Maths approach aims to change</p>



sustain students' interest and engagement	the students' level of involvement and their interaction during a lesson. It does not aim to change the academic content or teachers' style of delivery. Engagement will be a product of all of these things. Children should continue to be as interactive with one another whilst working in teams. Interest in the devices may wane, and the teachers' delivery will have to capture pupils' interest!
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Appendix 1B. Teacher Concerns and Support Strategies: Managing the software

Concern	Suggested Strategy
The software is not very user friendly	Struggle through, for the time being – updated version to be installed for Sept 09
Not conducive to teaching some maths topics: Not good for doing algebra Not good for doing fractions	These topics can be used with the devices, but answers will have to be entered in 'text' mode. It is also helpful to give the children specific instructions how to enter an answer, or leave an example answer on the board.
Should have a function for pupils to confirm whether they want to send their answer	A design question for Promethean.
Takes a long time to programme	There will be more resources as time goes on, but teachers can make use of the developers in the US and the flipcharts on Learning Objects.
Software freezing/software unreliable	No real answer for this until the updates are available in September09
Can't scroll down on imported flipcharts	No answer for this either, hopefully will be addressed in updated version
Incompatibility of ActivStudio and ActivExpression	Being incorporated in update for September 2009
Time consuming to prepare 'new' flipcharts/questions	See answer above on resources.



Appendix 2

Examples of Feedback from Support Visits: Reminders for Improvement:

- Help to keep pace in a lesson while still keeping all children involved by using *Tell Your Partner*. *Tell Your Partner* is a very simple strategy and can be used in any situation where you want to ensure that the students stay engaged, e.g.

You have just asked the class a question and you are not sure they understood.

“Tell your partner what I have just asked you”

You have just given the class an instruction and you are not sure they have understood what they are meant to do.

“Tell your partner what you are going to do next”

- You are modelling a mathematical skill / strategy and you want to ensure that the less confident students stay engaged. Have the expectation that all children participate, all of the time. This strategy prevents some pupils “switching off” whilst others are giving answers or explanations.
- Try to ensure that the ActivExpression devices are used at each stage of the lesson, particularly in longer lessons. For any topic, it is important to make regular assessments of the level of understanding in the class and this can be achieved immediately using the Express Poll. As a scaffold, try highlighting 5-10 questions in each lesson that will be asked using the devices, possibly also making a brief annotation as to the type of question (Team Huddle; Team Mastery; Team Check; Individual Check).
- Now that pupils are gaining confidence in sharing their knowledge with each other, try to encourage them to explain the reasoning, not just the answer. Explaining their ideas and breaking down the methods used to arrive at an answer helps children to embed and retain knowledge much better.
- Start to encourage children to explain their reasoning to the rest of the class. Use Random Reporter to choose one child to explain their team’s answer by coming to the board at the front and demonstrating their working out. This builds confidence, and can help offer another perspective on solutions for children who are struggling with concepts.
- Discourage children from putting their hands up to ask for help by introducing the “Three Before Me” rule. Pupils must ask their question to three other children before asking the teacher. This can easily be enforced by the teacher responding to a raised hand by going over to the pupil, telling the pupil to ask all of their team mates first, and standing by to make sure that this happens (and that team mates respond).



- Placing greater emphasis on the Team Huddle and Team Mastery questions will help reinforce the co-operative learning aspects of Tech Team Maths. Having only one team answer (as opposed to having each child input an answer) in the early stages of a lesson forces more pupil discussion. Used alongside Random Reporter to select the individual team members to respond, the Team questions will build a sense of interdependence for success and recognition. Remember, if the answer for the team is incorrect, it is the weakness of the team in not supporting that member, not the individual's lack of intelligence.
- Make sure the 'Random Reporter' strategy is truly random. Using an impartial system for Random Reporter – toss a coin, roll a die or pick numbered cards out of a jar – will avoid pupil's perception of being 'picked on' (or not being given a chance). Remember to choose the team member responding after there has been time to work out an answer to the question set; not knowing who will respond encourages children to make sure every member of the team has the answer. Before explaining any answers, give time (30-60 seconds only) for the person chosen to briefly confer with their team mates.
- To re-emphasize the importance of teams working well together, try seating the children in table groups, rather than rows. Rearranging the class tables quickly at the start of lessons would allow children to sit around a square, with two children facing the board and two children side-on. This would further embed the co-operative learning goals, and would also make it easier for children to discuss their work.
- Encourage an element of competition between the teams, focusing on the success of the entire team. Put in place a system of rewards to recognise those teams where everyone finishes the work, where every member of the team was seen to contribute to the discussions, or if all team members answered the questions correctly. This approach emphasizes inter-dependence and collective responsibility, where children will learn the value of supporting one another. If children are focused on working for their team's success it may also reduce the instances of pupils shouting to one another on opposite sides of the classroom.
- Try to follow the progression of questioning strategies used in the TechTeam Maths lesson template. Having only one team answer (as opposed to having each child input an answer) in the early stages of a lesson forces more pupil discussion; it also allows a 'safe' environment for children to try out their thinking, which boosts their confidence as well as their understanding of the subject matter. This method also means that there can be only one ActivExpression device per team during the first stages of the lesson, which can decrease set-up time and also minimise instances of pupils being distracted by the devices.



- Remind children to check with their team mates at regular intervals when they are working individually on problems. Reinforce this by awarding points/praise/rewards to teams that regularly check answers and understanding with one another.
- Start to incorporate a system of 'Random Reporter' for teams to feedback answers during a lesson. Remember to use an impartial system for Random Reporter – toss a coin, roll a die or pick numbered cards out of a jar – to avoid pupil's perception of being 'picked on' (or not being given a chance). There should be two steps to the choosing process: the first step chooses the team that will respond, the second step chooses the member of the team to speak. For example: use a spinner from a child's game to select a team, then roll a die to choose the member of the team. Remind teams during their co-operative learning time that all team members must understand the concepts and be ready to explain their work on behalf of the team.
- During team work, break work into timed sections in order to set expectations and keep children focused on the tasks set. For example, when giving pupils a set of equations to work through before asking a Random Reporter to answer one of them divide the questions into sections of 4-6 problems, giving a time limit for each section and then asking a Team Check question before moving to the next section. This may help keep pupils on-task during longer periods of independent work.
- Use a reward structure to reinforce co-operative learning and encourage children to be self-regulatory in staying on task. Make use of the existing merit structure by rewarding children whose whole team have contributed to a discussion, or are all involved in discussing and completing set tasks.
- Encourage an element of competition between the teams, focusing on the success of the entire team. Put in place a system of rewards to recognise those teams where everyone finishes the work, where every member of the team was seen to contribute to the discussions, or if all team members answered the questions correctly. Points are awarded for positive behaviour, never taken away. This approach emphasizes inter-dependence and collective responsibility, where children will learn the value of supporting one another. If children are focused on working for their team's success it may also reduce the instances of pupils shouting to one another on opposite sides of the classroom.
- Base a rewards system on something the children value (Eg. School merits, a certificate in assembly, a letter of achievement sent home, a small display in the classroom). Keep a tally chart of points earned each lesson, and at the end of each week make time to recognise and reward the team that has earned the most points.



Appendix 3

Appendix 3A. Confidential Implementation Fidelity Rating (CIFR): Intervention Group

School:			
Teacher:			
Class:	Year group:	Set:	
Date:	Time:		
Number of students in class:		Number of students in the class using the LRDs:	
Contextual information (computer, IWB and LRDs):			
Observer:			

Implementation

	0	1	2	3
Students register LRDs with confidence and ease (none; one or two; several; nearly all)				
Teacher facilitates student responses by circulating and providing support as needed (not at all; infrequently; often; very often)				
Teacher uses LRDs for team responses (eg Random Reporter) (not at all; misses several opportunities; misses some opportunities; maximises opportunities)				
Minimum time is spent waiting for students to respond using LRDs (Time is wasted on all occasions; time is wasted on most occasions; time is wasted on some occasions; time is not wasted)				
Teacher maintains an appropriate pace when students use LRDs in the lesson (pace is generally slow; pace is variable but often slow; pace is sometimes slow; pace is appropriate)				
Teacher uses displays of individual responses to reinforce correct responses/problem solving (not at all; very little; sometimes; maximises opportunities)				
Teacher facilitates student learning by addressing students' misconceptions/mistakes identified through LRDs (not at all; very little; sometimes; maximises opportunities)				
Teacher involves students in explaining the responses represented on the IWB (not at all; rarely; sometimes, but misses opportunities; maximises opportunities)				
Teacher uses students' responses to ensure an appropriate level of challenge (not at all; rarely; sometimes, but misses opportunities; maximises opportunities)				
Teacher saves formative assessment data from LRDs using EXCEL or similar (not at all; saves, but for a purpose is unclear; saves, for a purpose clear but information limited; Saves, for a purpose clear and information- rich)				



Student Engagement

	0	1	2	3
Students manage the LRDs devices (LRDs) effectively (none; some; most; all)				
Students complete the response activities enthusiastically (none; some; most; all)				
Students show interest in the class responses (none; some; most; all)				
Students respond positively to the teacher's explanations of the responses (none; some; most; all)				



Appendix 3B. Confidential Implementation Fidelity Rating (CIFR): Control Group

School:			
Teacher:			
Class:	Year group:	Set:	
Date:	Time:		
Number of students in class:			
Observer:			

Teacher Implementation

	0	1	2	3
Teacher uses IWB to enhance student learning (not at all; misses several opportunities; misses some opportunities; maximises opportunities)				
Teacher uses formative assessment strategies (please give detail in comment box below) (not at all; misses several opportunities; misses some opportunities; maximises opportunities)				
Teacher facilitates student learning by addressing misconceptions/mistakes with the whole class (not at all; misses several opportunities; misses some opportunities; maximises opportunities)				
Teachers extend and expand students' learning through their responses to the teachers' questions (not at all; misses several opportunities; misses some opportunities; maximises opportunities)				
Teacher records/saves formative assessment data (not at all; saves , but f a purpose is unclear; saves, f a purpose clear but information limited; Saves, fa purpose clear and information- rich)				

Student Engagement

	0	1	2	3
Students responding enthusiastically in the lesson (none; some; most; all)				
Students show interest in each others' responses (none; some; most; all)				

