CENTRES FOR EXCELLENCE IN MATHS

‘Identifying and addressing skills gaps to aid learner attainment’

Juliane Collings, Will Clarke, Harriet Fox, David Evans

OUR PARTNERS

FUNDED BY

Department for Education

Working in partnership with the Education and Training Foundation to deliver this programme.

About CfEM

Centres for Excellence in Maths (CfEM) is a five-year national improvement programme aimed at delivering sustained improvements in maths outcomes for 16–19-year-olds, up to Level 2, in post-16 settings.

Funded by the Department for Education and delivered by the Education and Training Foundation, the programme is exploring what works for teachers and students, embedding related CPD and good practice, and building networks of maths professionals in colleges.

Summary

The 2021-2022 cohort of GCSE resit students have had a challenging time throughout their GCSEs at school due to covid 19 and its impact across England. This cohort has had a range of experiences depending on their previous settings in terms of delivery during the past 2 years, as well having to experience the teacher assessed grading process.

With this in mind, our Action Research Group aimed to investigate how to best support these learners within an FE setting and how to identify and address a range of skills gaps in order to support attainment.

In this first of the two research cycles, the group explored at a variety of methods in order to achieve this, ranging from coaching, developing a new initial assessment tool, looking at the impact of some manipulatives as well as trialling an app to identify what would support students best. The second cycle focused on the most promising intervention, the app.

Data collection was both qualitative and quantitative, and included student interviews, observations, surveys and attainment data.

Our findings have been surprising, not at least due to a lasting impact of covid 19 on learners and teachers alike.

Learners seem to be needing much more personal interaction, preferring a teacher led instructional approach to more innovative methods trialled during our research.

.

Contents

Literature Review

Introduction

The Action Research Group have been discussing the impact that school and college closures during the pandemic have had on students and how this is now manifesting itself. Students come to college with a variety of mathematics specific skills gaps as well as other long-term issues such as mental health and anxiety, a lack of social skills, a lack of resilience and the inability to cope with any kind of productive struggle. Students are not equipped to independently learn, nor do they many of them have any revision strategies in order to progress their current skills and knowledge.

Having used a multitude of IT based strategies during the pandemic in order to provide learning opportunities for students, we decided to look further into how these strategies could be carried forward into our everyday teaching and learning.

In this exploratory and iterative research, the main focus throughout is on addressing skills gaps to allow for student progression and attainment in GCSE resit students. We reviewed previously published literature on the use of IT to support the identification of skills gaps. We also looked at the use of manipulatives to support filling skills gaps and the use of a soft initial assessment approach, so these topics are included below, though we decided to pursue another avenue for the primary research.

Initially we decided to keep the terms 'use of IT' quite generalised as we wanted to look at a variety before drilling down to one in particular.

We also wanted to investigate the best use of effective question design and how this would impact on the use of an SRS (student response system). 'Well-designed questions are an integral component in feedback and formative teaching: they are the fundamental building blocks that shape the content and structure of the lesson and manage the way the material is assimilated (Mattuck, 2009)' (M. Ghanbari &T. Bradley 2011). How can we push this application to its maximum for the best possible teaching and learning outcome?

Focus 1: Learning Management Systems (LMS)

According to Reigeluth et al (2008), “We currently see four major roles and four secondary roles, all of which should be seamlessly integrated into a single system”.

The four major roles include:

- Recordkeeping for Student Learning
- Planning for Student Learning
- Instruction for Student Learning
- Assessment for (and of) Student Learning

The four secondary roles include:

- Communication
- General student data
- School personnel information
- LMS administration

Skill gaps can be identified through the use of learning management systems (LMS), which is commonly defined as a “comprehensive, integrated tool for the information-age paradigm of education” (Watson, Lee, & Reigeluth, 2007 cited by Reigeluth et al, 2008). Prior to 2020 the LMS in use for one of our colleges was a Moodle, which was primarily used for sharing worksheets and presentations with students but not really used for assessment or collaboration. The LMS quickly changed to Google Classroom which allowed for a much more interactive online learning experience during the pandemic compared to what may have been if we had continued to use Moodle. A concern of using LMS is that it may be a struggle for both teachers and students to use (Reigluth et al, 2008) and this was truly tested during the pandemic. The transition to digital learning at the beginning of the pandemic was difficult for everyone but it became apparent, that teachers at this college adapted very quickly and soon found their own ways to use Google Classroom for online delivery.

The use of LMS as an assessment tool became a focus during the pandemic, with Hallal, Hajj Hussein & Tlais (2020) finding that students were able to adapt to the use of online platforms for learning and assessment, diminishing previous concerns.

While the use of LMS appears to have been kickstarted during lockdowns, the use of them has continued during in-person learning. It has become clear that teachers are more inclined to use Google Classroom to assess students, either on their general knowledge of the subject or on more specific focus areas. Students can then be directed to resources, which are also on Google Classroom, where they can address these skill gaps either in the classroom or in their own time. Atkinson & Lim (2013) support the idea that LMS can be used successfully as an assessment tool and even found that student "satisfaction with feedback has improved well above the university average". There is, however, evidence that teachers having sufficient training in the use of LMS could greatly improve its use (Chow, Tse, & Armatas, 2018) but that this can be a "time-intensive and therefore expensive process that requires considerable resources as well as expertise" (Reigluth et al, 2008). I believe that the use of LMS for assessment and feedback is an area which has the potential to improve my own practice, as well as potentially others.

Focus 2: Student Response Systems (SRS)

The Action Research group also looked at SRS to support the student progression and attainment.

The term ‘edtech’ is extremely broad, yoking together a number of vastly different uses of technology for education under a single heading. One particular iteration of edtech is the student response system (SRS). In such a system, students submit answers to questions by some technological method, and these are then collated to provide the instructor with aggregate data in the form of a bar chart (Beatty, 2007). The SRS has a long history that Abrahamson and Brady (2014) characterise as *“*a story…of pioneering efforts followed by failure, with subsequent re-invention by others.” They were initially developed for large classes in higher education and designed to overcome the physical difficulties of any kind of interactivity in a large, crowded space, but from here moved into smaller classes in school settings (Abrahamson and Brady, 2014).

Early iterations of SRS used purpose-built input devices for students, but these have now been mostly supplanted by the use of smartphone technology (Abrahamson & Brady, 2014). One of the most popular iterations of SRS in use today is Kahoot, which is used by more than half of school-age students in the UK (Wang and Tahir, 2020). This system, though highly gamified, with the inclusion of a scoring system, jaunty music and a high-energy interface, contains the primary features of a student-response system; students are presented with a question, along with four possible answers from which they can choose.

Plickers is an unusual iteration of SRS in that it requires only a single device, the instructor’s, which must be an internet-enabled smart phone with a camera. Instead of having access to a keypad or phone, the student instead has a printed QR code which can be held up in one of four orientations. This code is then scanned by the instructor’s phone and interpreted as one of four answers to a multiple-choice question, in a similar way to other student response systems. This arrangement makes it lower cost and less prone to technical difficulties than other popular systems such as Kahoot and Socrative (Wood, Brown and Grayson, 2017).

Aljaloud and co-workers (2015), in their literature review on the subject, note numerous benefits associated with the use of SRS, including improved interactivity, academic performance, metacognition, student enjoyment and attendance. They also identify several challenges that must be overcome if SRS are to be used effectively. These include cost, wasted time in lessons, either due to the shift in focus between input and response, or more practical problems including technical difficulties, distributing, and retrieving devices and

training students to use them (Aljaloud et al., 2015). They also identify ‘blind guessing’ as a limitation inherent to an anonymous response system.

It has been shown (Wang and Tahir, 2020) that a given system such as Kahoot can have a beneficial effect on learning, but that it can also be used in ineffective ways. This is perhaps not surprising. It should be noted that while SRS is a narrower category than ‘edtech’ it is still unhelpfully broad. Moreover, one teacher’s use of SRS may be completely different to another's,’ a problem identified by Beatty & Gerace (2009) who note that “Almost all of the literature conflates technology with pedagogy… forgetting that like any tool, a CRS may be used in many possible ways for many possible ends.”

Even a single student response system like Plickers or its alternatives may be used in quite diverse ways. Donohoe and co-workers (2019) discuss three distinct phases in which popular edtech tools, including Plickers, can be used; as an ‘activating strategy’, in teaching input, and as a tool for assessment. Even within one of these phases, different instructors may approach question design differently. Burton, Sudweeks, Merrill and Wood (1991) have developed a checklist of rules for writing multiple-choice questions to maximise the amount of useful information gleaned from a single question. Used effectively, a set of linked multiple-choice response questions can give more information than the sum of their parts. Plickers provides the ability to link groups of questions together into sets (of up to 5 in the free version, or of unlimited size in the subscription version). Approaches such as the easy-hard-hard pattern of one warm-up question, one challenge question and one consolidation question, allowing for class discussion, may be an effective model for doing this (Beatty & Gerace, 2009).

Focus 3: The use of Physical Manipulatives in the Teaching of Mathematics

Physical manipulatives in the context of the maths classroom are objects or models which may help the student develop understanding of a mathematical concept. Clements et al. (1996) [i] gave examples of concrete/physical manipulatives as “cubes, geoboards, or coloured rods.”

‘Heddens (2005)[ii] argue that using manipulative materials in teaching mathematics will help students learn: (“Virtual Manipulatives in Mathematics Education ... - Scribd”)

· to relate real world situations to mathematics symbolism.

· to work together cooperatively in solving problems.

· to discuss mathematical ideas and concepts.

· to verbalise their mathematics thinking.

· to make presentations in front of a large group.

· that there are many ways to solve problems.

· that mathematics problems can be symbolised in many ways.

· that they can solve mathematics problems without just following teachers' directions.’ (“MATH - floridaipdae.org”)

Through the use of physical manipulatives in the classroom setting the teacher is hoping that the student can gain understanding of a concept which can be remembered and repeated. Raphael and Wahlstrom (1989)[iii] looked at the influence of physical manipulatives on mathematics achievement and they found that although there was a positive influence, teacher experience was also a major factor; “Student achievement in geometry was related to teaching experience and occasional use of a variety of instructional aids. Student achievement in ratio, proportion, and percent was related to teaching experience but was associated with extensive rather than occasional use of aids.” Positive correlation between the use of physical manipulatives and improved mathematical achievement was also demonstrated by M.N. Suydam (1986)[iv], “Those who used manipulative materials scored at approximately the eighty-fifth percentile; those not using manipulative materials scored at the fiftieth percentile.”

There have been some cautionary voices in respect to the effectiveness of using physical manipulatives. Ball (1992)[v] argued that his/her research “show the fallacy of assuming that students will automatically draw the conclusions that their teachers want simply by interacting with particular manipulatives.” Additionally, Baroody (1989)[vi] stated that “to discourage their uncritical use, perhaps manipulatives should carry the following warning label: The Secretary of Education [or other appropriate authority] has not determined that using manipulatives is either a sufficient or a necessary condition for meaningful learning.”

Focus 4: The use of a soft approach IA to identify skills gaps and address anxiety

As mentioned, anxiety and skills gaps have been in the forefront of today's issues due to the pandemic. A lack of interaction as well as the limited mathematics provision has caused an influx of students in FE to display severe anxiety, related to not just mathematics but also socially and educationally in general.

As much as some teachers may argue whether or not testing students in their first few weeks of attending college is beneficial, communication between school and colleges is still not efficient enough to establish a starting point for new students. In addition to this, there are a number of awarding bodies as well as a variety of feeder schools and other educational settings.

It cannot be argued that there is a need for some kind of initial assessments (IA) to plan effectively for individual groups and to track progress.

At our college, we decided to try and address the fact that a high number of students are displaying various degrees of anxiety right from the start. Instead of testing our students as we would normally for an initial assessment, we decided to create an assessment that is less threatening, especially within the first few weeks of students attending lessons.

We live in a test-conscious, test-giving culture in which the lives of people are in part determined by their test performance. (Sarason et al., 1960, p.26).

This is embedded in a high percentage of our students, and it can create anxiety and stress.

According to Zeidner (1998) there are three distinct components of test anxiety.

- cognitive: the negative thoughts and depreciating self-statements that occur during assessments (e.g., 'If I fail this exam my whole life is a failure') and the performance-inhibiting difficulties that may arise from anxiety (e.g., recalling facts and difficulty in reading and understanding questions);
- affective: the person's appraisal of their physiological state (such as tension, tight muscles, and trembling);
- behavioural: poor study skills, avoidance, and procrastination of work.

Firstly, we addressed the title and instead of Initial Assessment, we decided to call it a Skills Check. This low-stakes assessment was a softer approach to enable all students to take part according to their individual abilities.

The questions were displayed on the whiteboard, one at a time and students were encouraged to write what they could, from ‘what do I see’ to fully solving the problem. This enabled all students to write something. The use of representations of any kind was encouraged throughout.

Students were told from the start that these assessments would not be marked. Students were given feedback in form of strengths and targets and students were asked to complete areas for improvement and their own reflection on the skills check.

‘It is the feedback information and interpretations from assessments, not the numbers or grades, that matter’ (Hattie & Timperley, 2007, p.104)

We used these skills checks to establish a baseline of skills and knowledge and the gaps that needed to be addressed.

The feedback from students was positive throughout. Some students commented that ‘I usually stress in tests but this one was ok. I could put anything down I knew. I actually wrote a lot.,’ ‘…. No, it was cool cause at least I wrote something instead of leaving it like I usually do.,’ ‘that didn’t feel like a test, it was really chill. I feel good about it.’

Conclusion

Having investigated available literature on a variety of areas as part of Cycle 1 of this research, it was clear that we had created a wealth of research points, but we agreed that we now had to focus on one in order to make this action research project as directed and effective as possible.

In summary the findings from the literature read by the action research group were:

1. The use of LMS for assessment and feedback has potential to improve teaching practice and allows for access in person as well as online.
2. Although research has shown that there is a positive correlation between the use of physical manipulatives and improved mathematical achievement, the use of manipulatives needs to be carefully planned and executed to benefit learning.
3. Anxiety in the classroom, Maths and otherwise can be addressed through well planned low-stakes assessments and appropriate feedback. This will assist in addressing skills gaps in individual students and classes.
4. Plickers is an app that offers a variety of applications such as a teaching aid as well as a form of assessment. It has potential to engage otherwise demotivated students.

The action research group found that we all had an interest in similar areas, but we all agreed that the use of an app was intriguing to all of us.

The action research group included some that embrace more advanced versions of modern technology as well as some that would normally shy away from a new IT based addition so are more suited to introductory (usually free) versions.

Due to some issues regarding licensing, we agreed to use this as an advantage and compare the free version to the fully licensed version.

Methods

Our research consisted of two cycles. The cycles were not strictly iterative, although it could be stated that one college did two iterative cycles, the other three did not.

The over-arching theme of both cycles was to identify and address skills gaps in post-16 learners of mathematics to aid learners' attainment. Cycle 1 was a broader approach across the four colleges, whereas cycle 2 was more collaborative and focussed.

Our focus shifted towards the use of technology at the end of cycle 1, however, the overarching aim remained.

Data collected for cycle 1 was mostly qualitative data such as first-hand observations, interviews, questionnaires, focus groups, participant observations etc.

Data collected for cycle 2 was quantitative (see Appendix).

When collecting data all student names and teacher names/colleges were anonymised to allow for confidentiality and non-biased reflections on findings throughout the action research project and beyond.

Covid 19 did still have an effect on our research as staff and students affected by covid 19 missed delivery and/or subsequently data on these students/staff could not be collated. Student numbers were greatly affected, hence the relatively small numbers of participants in our research.

In total, 4 colleges took part in this action research project. Each college provided one member of staff to take part.

Results and Discussion

In cycle 1 a variety of different methods were investigated at the four colleges, with student responses and best practice shared in fortnightly action research group meetings.

Maths lecturers at the four further education colleges discussed and decided to investigate how educational technology could be used to benefit grade 4 attainment in GCSE maths during phase 2.

For Phase 2, the group decided to focus on one particular challenge: supporting students with answering ‘big mark questions’, longer GCSE questions marked out of 3 or 4 on a variety of topics. Modelling the process of tackling these questions, as distinct from simply giving the answer, presents a particular challenge as the steps are often not straightforward or obvious to the students. It was decided to investigate five methods by which these types of questions can be modelled, including one novel method, the Plickers edtech app.

Cycle 1:

As already described, we decided that our main focus for the Action Research should be identifying and addressing skills gaps to aid learner attainment.

The group had plenty of ideas and we actioned different approaches across the four colleges.

College A: Coaching

One college decided to use a coaching model to support our action research aim. This was applied across GCSE and Functional Skills provision.

This cycle involved 1 teacher and 48 students, including functional skills level 1, functional skills level 2, and GCSE.

Due to exam boards requesting teacher assessed grades as a backup, the classes were sitting more formal assessments throughout the year than they have done previously. Every student has sat two assessments each half-term and this identified the topics that the students need to work on. Once this topic was identified, the students were organised into pairs or groups of

three based on their skills gap. These in-class tests were past papers, both non-calculator and calculator, to ensure that students have the opportunity to experience exam style questions prior to sitting the exams.

As well as using the in-class assessments, students that are part of the action research have been given two sets of multiple-choice quizzes on Google Classroom to help identify student skills gaps. (Appendix: Google forms)
The quizzes were compiled of a mixture of topics and once the students submitted their answers they were provided with instant feedback about their areas for improvement. This has allowed students to address their skills gaps with limited teacher input as can be seen below. A concern of using a learner management system (LMS) like Google Classroom is that it may be a struggle for both teachers and students to use (Reighluth et al, 2008). Thankfully, this was not the case for this cycle of the research project, and Atkins & Lim (2013) support the idea that LMS can be used successfully as an assessment tool and even found that student "satisfaction with feedback has improved well above university average".

Fortunately, this year the college has received funding for maths coaches, and it is these coaches that worked with the students to bridge the gaps. Each set of students has received one to three thirty-minute coaching sessions in between assessments to work on the identified topic. After each session, the students were asked if they feel "better, the same, or worse" about the topic, with the aim that the following assessment hopefully reflecting this extra support and identifying another skill to work on. The students were given a form detailing their name, the date, the topic that they worked on, and whether they felt better, the same, or worse about said topic. (Appendix: Coaching Session Survey)

The college was fortunate to have coaches for maths last year, so the teacher had some experience with ensuring that the coaches are deployed to their full potential. Last year some students were reluctant to attend coaching sessions but were eventually encouraged to attend, however a few students even refused to attend any at all. This was a concern for this year as well, but the participating teacher assured the students that the coaching sessions were not a punishment and that they were there to help boost the students even further. Posing the sessions in a positive way meant that all students attended at least one session, with students only missing them if they were unwell.

During cycle 1 of the action research project, the teacher found that it can be tricky to choose only one area of improvement for the lower ability students but that many of them will have similar topics. All the students have been willing to have coaching sessions, and 77% of the

students reported that they felt better about the topic after the session, 23% reported that they felt the same about the topic, and none reported that they felt worse. Most students were able to attend at least 1 coaching session, with some attending all 3. (Appendix: Data)

The teacher felt that after attending a coaching session, students were generally more confident with maths as a whole, not just the topic that was identified, suggesting that coaching sessions are beneficial for students. The next assessment would be sat during cycle 2 so currently it is unclear if the coaching sessions have actually improved the students' knowledge. The teacher noted that if she were to do this research again, she would consider asking some open-ended questions such as "how do you feel the coaching session went?" or "would you like to have more coaching sessions?". She felt that these questions would provide a deeper understanding of the students' engagement with the coaches.

College B: Representations and Manipulatives

This college chose to look at one particular topic area (compound measures) and how different delivery models would support learners' ability to remember and understand formulas.

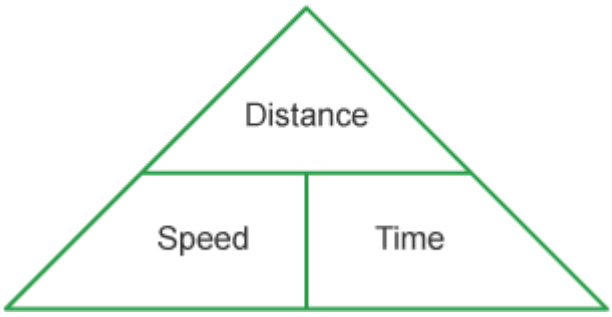
The teachers reported that from his research there does not seem to be any specific academic research on this area of mathematics.
From looking at various sources he established that there are two main styles of formula that are used in teaching.

1. Simple multiplication and division method

- **speed** = distance ÷ time
- **distance** = speed × time
- **time** = distance ÷ speed

These are formulae that a student has to remember by heart. Having to remember all three formulae could be difficult for most students, as such the teacher intends to emphasise that they will also be supplied with two out of the three variables and that distance uses multiplication otherwise always divide.

2. Magic triangle method



Speed, distance and time can be calculated using a magic triangle. D (the distance) goes in the top of the triangle, S (speed) goes in the bottom left of the triangle and T (time) goes in the bottom right of the triangle.
If you want to calculate the speed cover up S in the triangle and you get S = D/T
If you want to calculate the time cover up T in the triangle and you get T = D/S
If you want to calculate the distance cover up D in the triangle and you get D = S×T

To aid comparison, the questions and examples used for teaching both methods were the same. The teacher taught each method to two classes of predominately GCSE grade 3 students. After a period of 3 weeks, he presented all four classes with the same selection of past examination questions. By conducting the research in this manner, he hoped to see whether there is any correlation between formulae method teaching and results.

When teaching using the magic triangle method the teacher used a physical manipulative in the form of a A4 laminated sheet which contains a large magic triangle which the students can insert their calculations on. Part of the literature review outlines some of the possible advantages of uses physical manipulatives in leading to improved achievement.

To aid comparison the questions and examples used for teaching both methods will be the same. Each method was delivered to two classes of predominately GCSE grade 3 students. After a period of 3 weeks all four classes were presented with the same selection of past examination questions. By conducting the research in this manner, the teacher hoped to see whether there is any correlation between formulae method teaching and results.

Class A used the A4 Laminated Magic Triangle method to answer their questions. The students found working in this method very much to their liking, especially being able to insert the relevant data onto the sheet and then doing the calculation. Being able clean the A4 laminated sheet and reuse it also proved popular. Most students could find the information they required to answer the question and approximately 75% of students answered the question correctly. After 3 weeks the activity was repeated, and the students were asked the same examination questions. This time the teacher did not supply the Magic Triangle laminated sheets. This time fewer students could answer the questions correctly (approx. 50%). Looking at their calculations it was evident that the majority of students could not remember the correct order of the Triangle.

Class B used the Simple Multiplication and Division method to answer their questions. The students found this method easy to use and around 70% answered the question correctly. After 3 weeks the activity was repeated, and the students were asked the same examination questions. Again, this time students were not supplied with the formulae for their calculations. This time fewer students could answer the questions correctly (around 40%). Looking at their calculations it was evident that most students could not remember the Multiplication and Division formulae.

In conclusion the results of the initial lesson of using both methods were remarkably similar to each other for both classes. The results, for both classes, were also similar to each other when the teaching aids were taken away for the second lesson. The decrease in correct answers

for the second lessons were expected due to the formulae not being available to the students. With this limited research I have found no noticeable difference in the results of using a physical manipulative in the form of a A4 laminated sheet.

Data:

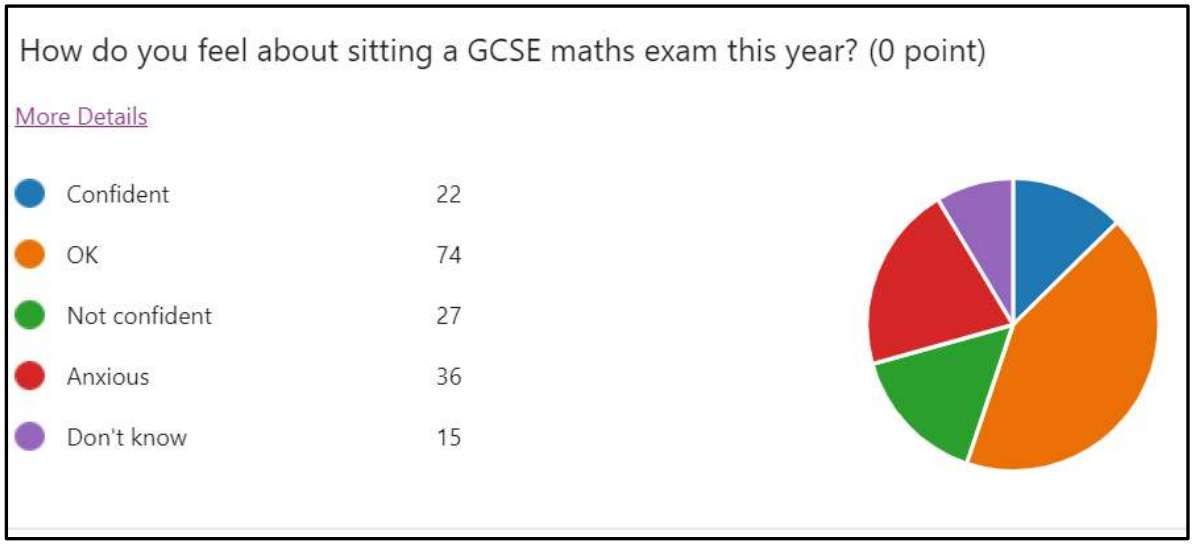
The same questions were asked of both classes. Class A had 11 students and Class B had 10 students. The table below shows that a large majority (70-75%) of the learners got the problem correct when using the manipulatives, compared to 40-50% when not using them.

Question	Class A Lesson 1 correct	Class A Lesson 1 incorrect	Class A Lesson 2 correct	Class A Lesson 2 incorrect	Class B Lesson 1 correct	Class B Lesson 1 incorrect	Class B Lesson 2 correct	Class A Lesson 2 incorrect
1	8	3	6	5	6	4	3	7
2	8	3	4	7	8	2	5	5
3	7	4	6	5	7	3	2	8
4	9	2	7	4	6	4	5	5
Total	32	12	23	21	27	13	15	25
% rounded to nearest 5%	75	25	50	50	70	30	40	60

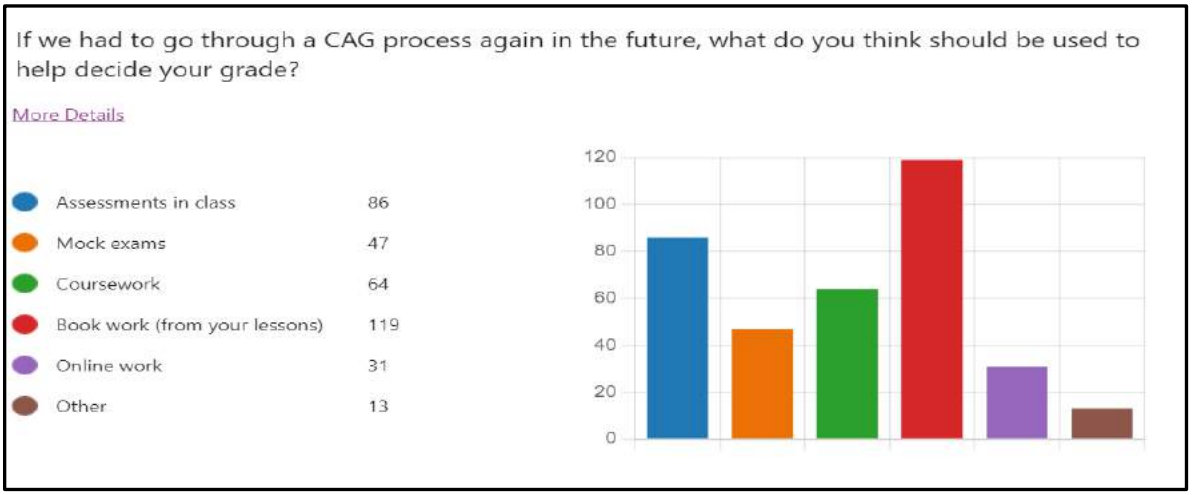
College C: Skills Check to replace Initial Assessments

When looking at how to support students during this first year of potential examinations, this college decided to be more responsive to learners. The college issued student surveys and based their decisions upon these results.

The maths team wanted to gauge how the students felt regarding the upcoming GCSE examination. With 13% (22/174) stating they felt confident, the team wanted their first initial assessment to be inclusive of all and ensure the process was adopting a more nurturing approach.



Additionally, the team wanted to seek which assessment method the students preferred when they completed the centre assessed grades process. The highest output of data was bookwork at 69% (119/174). With this in mind, the assessment format was designed to include bookwork.



In response to student feedback about confidence and choice of potential assessment methods for CAGs, this college maths team chose to create a softer attempt of assessing students at the beginning of the academic year. Staff were aware of recent gaps in learning and students missing time in a formal classroom setting. The skills check aimed to take the pressure off the students to perform under exam conditions at a certain level and allowed for a softer approach.

Students were sitting the skills checks in their classes. The questions were displayed one at a time on the whiteboard, diagrams were printed and given out to students. Students were asked to stick these in their books. (Appendix: Print outs provided to students)

Students were instructed to write anything they can about the questions, even if they felt they were unable to complete the whole question. Phrases like ‘what do you see?,’ ‘what do you know?’ were used throughout the skills check to encourage all learners to write something.

Students were also informed that these assessments would not be marked and graded to assure them that no judgements are made. Teachers did mark the skills check on a marksheet but not in the students’ books. (Appendix: Marking Sheet)

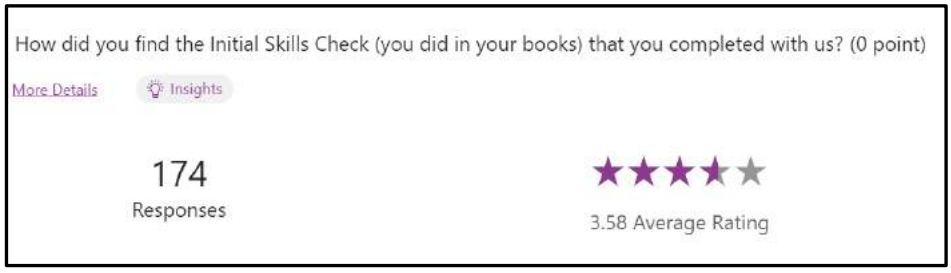
Students were asked to complete a STAR (strengths, targets, area for improvement and reflection) grid (Appendix: STAR – self assessment) once each individual class went through the questions. This formed the basis of individual class planning and target setting for individual students.

This skills check was a collaboratively planned assessment by the whole of the maths team at this college. The team agreed that recent events and lost learning and classroom time would have an enormous effect on students. Particular care was also taken when considering

cognitive overload. Images and text were not displayed at the same time, rather one at a time to ensure students could properly focus.

Analysing the data after the initial assessment check, the students rated the assessment 3.58 stars out of 5. Considering this data collection was sourced at the very start of the academic year when the students were not quite settled into the learning environment, the results were positive.

College D: Plickers App



This college chose to use the app Plickers to support with identifying and addressing skills gaps with their learners. The app was primarily used for summative assessments but would be further explored throughout the year.

Plickers is a classroom assessment tool. It uses QR codes which can be given to the students and held in one of four orientations to answer multiple-choice questions. These are quickly scanned by a single device. The freeware version of Plickers allows for ‘sets’ of up to five questions, and does not allow sharing amongst users, whilst the full version allows for unlimited questions and sets that can be shared between users.

The teacher has used Plickers in the past, in his previous role, working with Key Stage 2 and Key Stage 3 pupils. He was interested to explore its potential with post-16 learners. In particular, he hoped that it would provide a lower barrier to participation for less confident students; be a low-tech alternative to quiz apps like Kahoot and Socrative that require all the students to have internet-enabled devices; and allow progress to be identified and measured. His main concern before using Plickers was that the age group would find it overly childish and be resistant to using it in lessons.

He actually began using Plickers in the final term of the 2020/21 academic year. He generally wrote four-question sets around a particular topic, along with one survey question. His students then did the same set of questions at the beginning and end of the lesson. He chose to share the overall class score but not the scores of individual learners. This worked well as a motivational tool and allowed the students to set themselves a target and then try to beat it at the end of the lesson. He was encouraged by the reception that Plickers got, even amongst

the classes that he had expected to be resistant. Students seemed to enjoy using it and asked to do so in future lessons. One class was initially resistant but gradually became keener on the idea the more they did it.

Building on last year, beginning in September the teacher started by assigning all the students Plickers cards on their folder. This showed the main barrier to entry – the process of printing off all the QR codes and sticking them onto the folders was quite time consuming, but once they were set up the time taken to write questions and use them in the lesson was very small. He initially tried to use the tool in the same way – as a pre-learning and comparable post-learning task. It quickly became clear however that with shorter lessons this year (90 minutes instead of 3 hours) this spent too much time assessing learning and not enough time actually doing learning. The teacher instead got into the pattern of doing a single quiz at the end of the lesson. This meant that progress could not be directly measured or shared with the students, but it did provide a record of attainment lesson-by-lesson.

This summative assessment has proved useful in a number of areas. He was able to use it to discreetly identify candidates who might be able to sit the higher-tier GCSE paper, including some who did not necessarily seem naturally able based on class discussion and contributions. It also has allowed him to build a summative achievement record. In the event of exams being cancelled again, this summative record will allow a much fuller picture of each student's ability than the limited number of written tests that we have been able to do.

Up to this point, he had only really explored the summative potential of Plickers. In the next cycle, the teacher wanted to like to experiment with it as an assessment for learning tool. In particular, there are a couple of uses he wanted to try. The first is to make the input of the lesson more interactive. He also wanted to explore the use of Plickers to scaffold longer-answer questions, as these are a particular challenge for attaining a grade 4 in maths.

Cycle 2:

Once cycle 1 was completed the action research group had a discussion as to which approaches seemed most appropriate and which students have shown interest in; which intervention was most useful to support the identifying and addressing skills gaps aim of our research project?

All interventions showed promise, but we felt that we needed to focus on one and the group agreed that the app seemed to have the most positive response from students overall in terms of engagement and feedback. It also would allow us as teachers to explore a potential new teaching tool. We therefore decided to explore Plickers further.

Due to time constraints and exams becoming the focus of our teaching, we discussed possible applications for Plickers. We decided that big mark questions are still proving to be difficult for students across all four colleges and we discussed how we could combine the two.

The group then chose five past exam questions (Appendix: Big Mark Questions) as well as five different delivery models in order to allow for some realistic comparisons. The five models chosen were: Chalk and Talk, Videos, Plickers app, Model answers (Appendix: Model answers) and break down answer strips (Appendix: Answer strips). This intervention was planned collaboratively with each group member preparing one of the four approaches as chalk and talk did not require any collaborative planning.

Plickers is a classroom assessment tool. It uses QR codes which can be given to the students and held in one of four orientations to answer multiple-choice questions. These are quickly scanned by a single device. The freeware version of Plickers allows for ‘sets’ of up to five questions, and does not allow sharing amongst users, whilst the full version allows for unlimited questions and sets that can be shared between users.

The Plickers app had previously been used at college 1, with the idea that it would provide a lower barrier to participation for less confident students; be a low-tech alternative to quiz apps like Kahoot and Socrative that require all the students to have internet-enabled devices; and allow progress to be identified and measured. The response was generally positive. Anecdotally, the students seemed to enjoy using it, and asked to do so in future lessons.

Using Plickers for summative assessment has proved useful in several areas during Phase 1. It allowed the lecturer to identify the more proficient students, including some who did not necessarily seem naturally able based on class discussion and contributions. It also enabled

building a summative achievement record in case of teacher-assessed grades being required for a third year.

The Plickers app was shared with the group during Phase 1, and it was decided to incorporate it into Phase 2 in all four colleges. In particular, it was decided to explore Plickers as a *teaching* tool rather than as an assessment tool.

‘Big Mark Questions’

It was decided to approach the particular challenge of student responses to ‘big mark questions,’ those GCSE questions requiring multiple steps and graded out of 3 or 4. The group shared their students' typical responses to these, and it was noted that they often proved intimidating to the students who often left them blank.

The task of training students to answer these questions poses a particular challenge: with many operations in mathematics, it is sufficient to teach a series of discrete steps that can be applied with little or no modification to unseen questions. There is sufficient variation however in longer-answer questions that this is not possible in this case. The student must learn to pass the questions for themselves and to recognise what maths is needed to solve them. The goal is not so much to train the students to answer a particular type of question as to enable the students *to see for themselves* how to break down a question that looks unfamiliar into a series of familiar steps.

Method

Each class attempted the same set of five questions in the course of one lesson. The students were given the opportunity to attempt the question on their own, and then the answer given using one of the five methods. At the end of the lesson, the students were asked to rank the five methods from most to least useful. The five methods were as described below:

> ‘*Chalk and talk’: A model answer was written on the board by the teacher who narrated as they went. Occasional trivial questions were asked of the students and the students were encouraged to work out each step before the teacher gave the answer.*
>
> *Plickers: Each question was converted into four or five single-step, multiple-choice answers using the Plickers app. Each question was presented by the teacher and answers collected by holding up Plickers cards. The answer to each step was then revealed and explained before the next step was undertaken.*
>
> *Videos: The students were shown on a single screen a video of a teacher solving the problem. Where possible, links were said to the student’s own devices so that they could watch the solution in their own time, but this was not widely taken up.*
>
> *Scaffolding strips: A model answer broken down into discrete steps was given to the students, with the steps in the wrong order. Students were encouraged to solve the*

question by numbering the steps. The correct order was then talked through by the teacher.

<u>Model answer:</u> A written model answer was provided on paper for the students to look at.

In College 1 and 2, each class was given a different pairing of questions with methods (see Table 1) so that it would be possible to judge methods independently of the questions. In Colleges 3 and 4, all the classes were given the same pairing of questions and methods.

Table 1: Pairing of questions and methods for colleges 1 and 2

College	Class	1	2	3	4	5
1	A	Scaffolding strips	Video	Plickers	Chalk & talk	Model answer
1	B	Video	Plickers	Chalk & talk	Model answer	Scaffolding strips
1	C	Plickers	Chalk & talk	Model answer	Scaffolding strips	Video
1	D	Model answer	Scaffolding strips	Video	Plickers	Chalk & talk
1	E	Plickers	Chalk & talk	Model answer	Scaffolding strips	Video
1	F	Chalk & talk	Model answer	Scaffolding strips	Video	Plickers
2	G	Video	Scaffolding strips	Model answer	Chalk & talk	Plickers
2	H	Plickers	Video	Scaffolding strips	Model answer	Chalk & talk
2	I	Chalk & talk	Plickers	Video	Scaffolding strips	Model answer

<u>Results</u>

The results were coded as follows. A response of ‘most useful’ was counted as 5 points, with the next most useful given 4 and so on down to the ‘least useful’ being coded 1 point. Where the questionnaire was completed improperly (for example, where more than one method was ranked as ‘most useful’), the results were coded as they had been given.

For College 1 and 2, each student was then counted as a fraction of the total number participating in that class so that the different combinations had an equal weighting, and the total scoring for each method was calculated for each class. For class C, the average score given to video was used.

The scores were then aggregated by method, once using the raw score (Figures 3 & 4), and once normalising by the corresponding question score (Figures 5 & 6).

For Colleges 3 and 4, the data was aggregated as two discrete groups in terms of the average raw score only (Figure 7 & 8).

The results were initially aggregated by question number independently of method (Figures 1 & 2), to ascertain whether the question itself caused some students to prefer a particular method. As can be seen from the figure, this was a significant factor that needed to be accounted for.

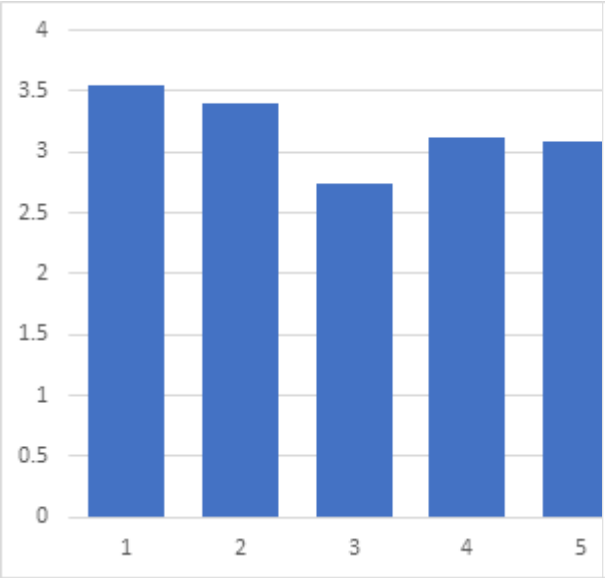


Figure 1: Average score by question number (College 1)

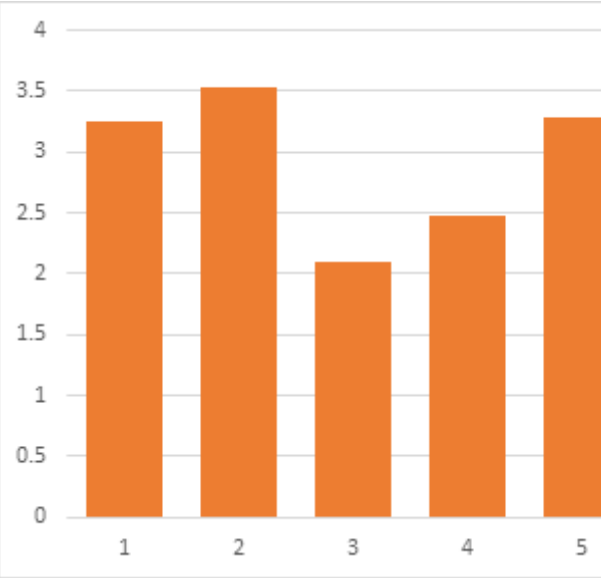


Figure 2: Average score by question number (College 2)

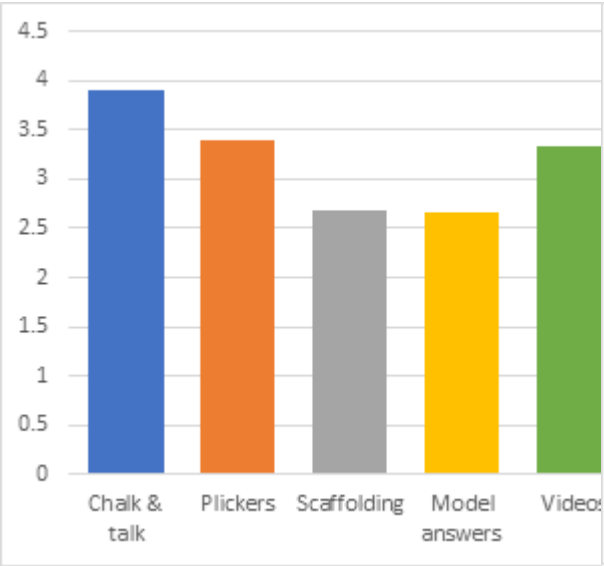


Figure 3: Average raw score by teaching method (College 1)

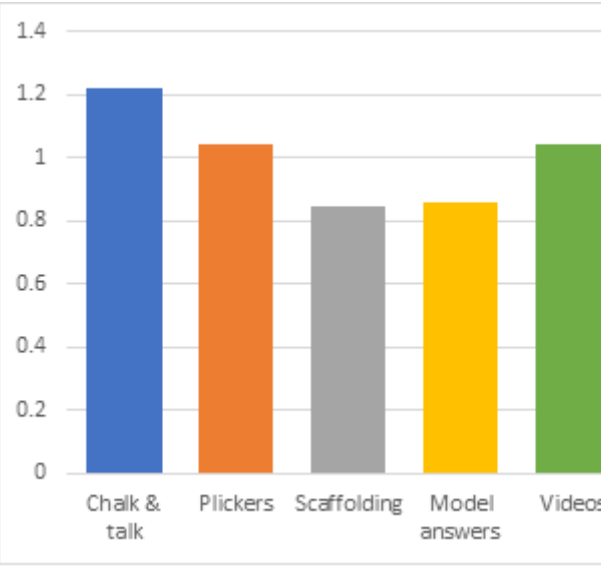


Figure 4: Average score by teaching method, normalised by popularity of question (College 1)

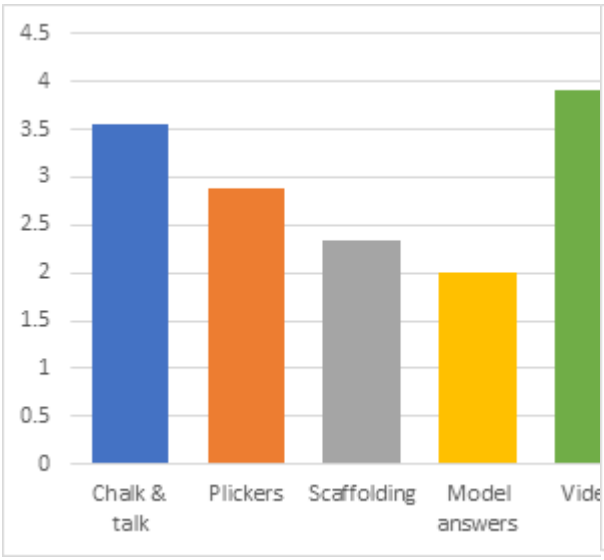


Figure 5: Average raw score by teaching method (College 2)

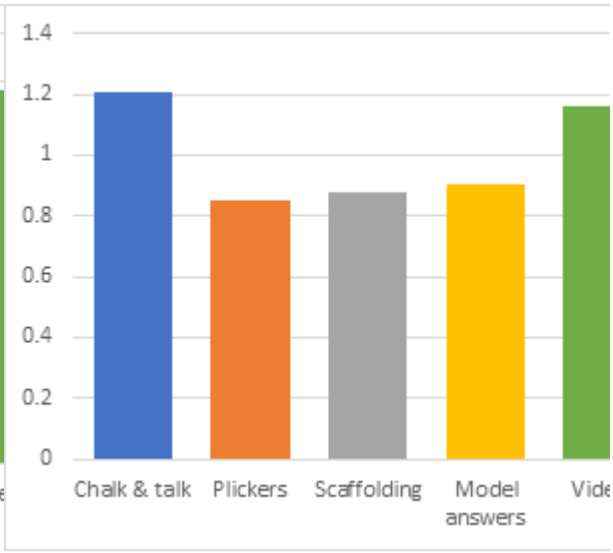


Figure 6: Average score by teaching method, normalised by popularity of question (College 2)

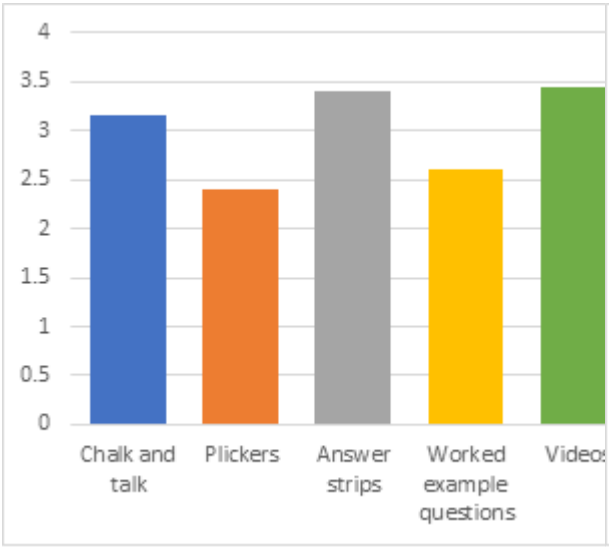


Figure 7: Average raw score by teaching method (College 3)

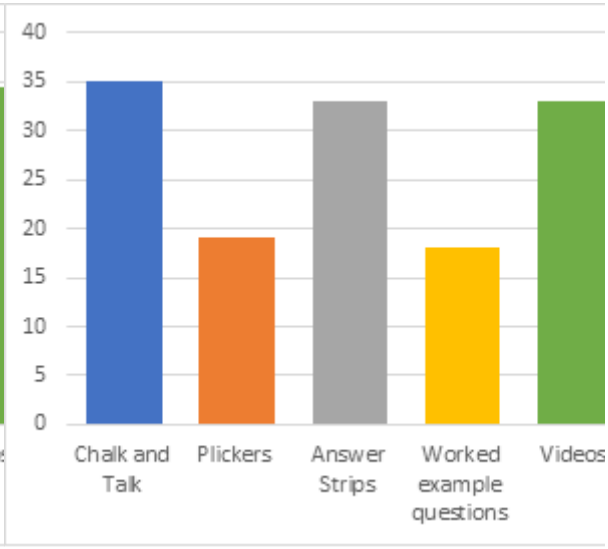


Figure 8: Average raw score by teaching method (College 4)

Conclusions and Recommendations

Conclusions

Perhaps the most surprising finding was the apparent enthusiasm of the students for ‘chalk and talk.’ This old-fashioned method is often disparaged as passive and didactic, and the graphological interaction of calcium sulfate and matte paint is generally not regarded as constituting edtech. The method however was apparently preferred by the students at colleges 1, 2 and 4 once question preference was considered. When one also considers the generally positive reception given to the video answers, it appears that the students in this study tended to prefer what might be regarded as direct methods of instruction (videos and chalk-and-talk).

It is interesting to note that whilst all members of the group reported a generally positive reception from the students to Plickers as an innovation, it did not score well. Members of the group reported unfamiliarity with the method as being a barrier, and this may well account for it scoring rather more strongly amongst college 1 students who had used it during Phase 1.
The apparent preference of the students for methods that might be characterised as direct instruction over discovery-based is noted, and this will inform future planning at the colleges.

Recommendations

This was an exploratory, small-scale action research project. The principal outcome of this project has been the sharing of methods amongst the group and the exploring of some different approaches to the particular challenge of modelling long-answer questions.

It should be noted that this project focussed primarily on student’s *preferences* towards learning, rather than attempting to measure effectiveness. A follow-up study might use focus groups to investigate why students prefer to learn in particular ways. To actually compare the effectiveness of methods on a quantitative basis, a much larger-scale study would be needed to allow other factors to be controlled in a way that is simply not possible with a small number of students.

The methods of data collection were limited by circumstances and design. Data was self-reported by the students via questionnaires. There was some variation in question design between colleges, with most ranking the methods in order and College 4 students ranking

each method on a scale of 1-5. Some students in any case did not fill out the questionnaire as intended, and this data had to be fitted into the model.

College 1 and College 2 varied the pairing of the questions with the methods, which was not possible at colleges 3 and 4 due to a small number of students.

References

Abrahamson, L. & Brady, C. (2014) *A Brief History of Networked Classrooms to 2013: Effects, Cases, Pedagogy, and Implications with New Developments*, International Journal of Quality Assurance in Engineering and Technology Education, 3(3), 1-54.

Aljaloud, A., Gromik, N., Billingsley, W. and Kwan, P. (2015) 'Research trends in student response systems: a literature review', *Int. J. Learning Technology*, Vol. 10, No. 4, pp.313–325.

Atkinson, D., & Lim, S. L. (2013). Improving assessment processes in Higher Education: Student and teacher perceptions of the effectiveness of a rubric embedded in a LMS. ("Rubrics | Curriculum and Instructional Support | Central ...") *Australasian Journal of Educational Technology*, *29*(5).

[v] Ball, D. L. (1992) Magical hopes: Manipulatives and the reform of math education, American Educator, 16(2), pp. 14; 16–18; 46–47.

[vi] Baroody, A. J. (1989) Manipulatives don't come with guarantees, Arithmetic Teacher, 37(2), pp. 4–5.

Ian D. Beatty & William J. Gerace, *Technology-Enhanced Formative Assessment: A Research-Based Pedagogy for Teaching Science with Classroom Response Technology,* J Sci Educ Technol (2009) 18:146–162 ("Technology-Enhanced Formative Assessment: A Research-Based ...")

Beatty, I. (2007) *Classroom Response Systems: In-class technology for engagement, interactivity, and formative assessment*, Scientific Reasoning Research Institute

Burton, S., Sudweeks, R., Merrill, P. and Wood, B. (1991) *How to Prepare Better Multiple-Choice Test Items: Guidelines for University Faculty,* Brigham Young University Testing Services and The Department of Instructional Science ("Exam Writing Slideshare")

Chow, J., Tse, A., & Armatas, C. (2018) "Comparing trained and untrained teachers on their use of LMS tools using the Rasch analysis." ("Comparing trained and untrained teachers on their use of ...") *Computers & Education*, *123*, 124-137.

[i] Douglas H. Clements and Sue McMillen (1996) Rethinking "Concrete" Manipulatives. Volume 2: Issue 5 Page(s): 270–279 - pubs.nctm.org

Donahoe, B., Rickard, D., Holden, H., Blackwell, K. and Caukin, N. (2019) *Using Edtech to Enhance Learning*, International Journal of the Whole Child , 4(2).

Ghanbari, M. and Bradley, T. (2011) 'An Introduction to Classroom Response Systems for Mathematics Teachers ', Resource & Research Guides Vol. 2 # 8, Microsoft Word - Classroom Response Systems for Maths Teachers (epistem.ie).

Hallal, K., HajjHussein, H., & Tlais, S. (2020) A quick shift from classroom to Google Classroom: SWOT analysis. *Journal of Chemical Education*, *97*(9), 2806-2809.

Hattie, J.; Timperley, H. (2007) *The Power of Feedback*, Review of Educational Research, March 2007, Vol. 77, No. 1, pp. 81-112

[iii] Heddens, J. W. (2005) Improving Mathematics Teaching by Using Manipulatives. Retrieved from http://www.hkame.org.hk/uploaded_files/magazine/4/88.pdf

[iii] Raphael, D. & Wahlstrom, M. (1989) The influence of instructional aids on mathematics achievement, Journal for Research in Mathematics Education, 20, pp. 173–190.

Reigeluth, C., Watson, W., Watson, S., Dutta, P., Chen, Z., & Powell, N. (2008) “Roles for technology in the information-age paradigm of education: Learning management systems.” (“Roles for Technology in the Information-Age Paradigm of ...”) *Educational Technology*, 32-39.

Seymour B. Sarason *et al., ANXIETY IN ELEMENTARY SCHOOL Children: A REPORT of Research*, New York, John Wiley & Sons, 1960

[iv] Suydam, M. (1986) Manipulative materials and achievement, Arithmetic Teacher, 33(6), pp.10, 32.

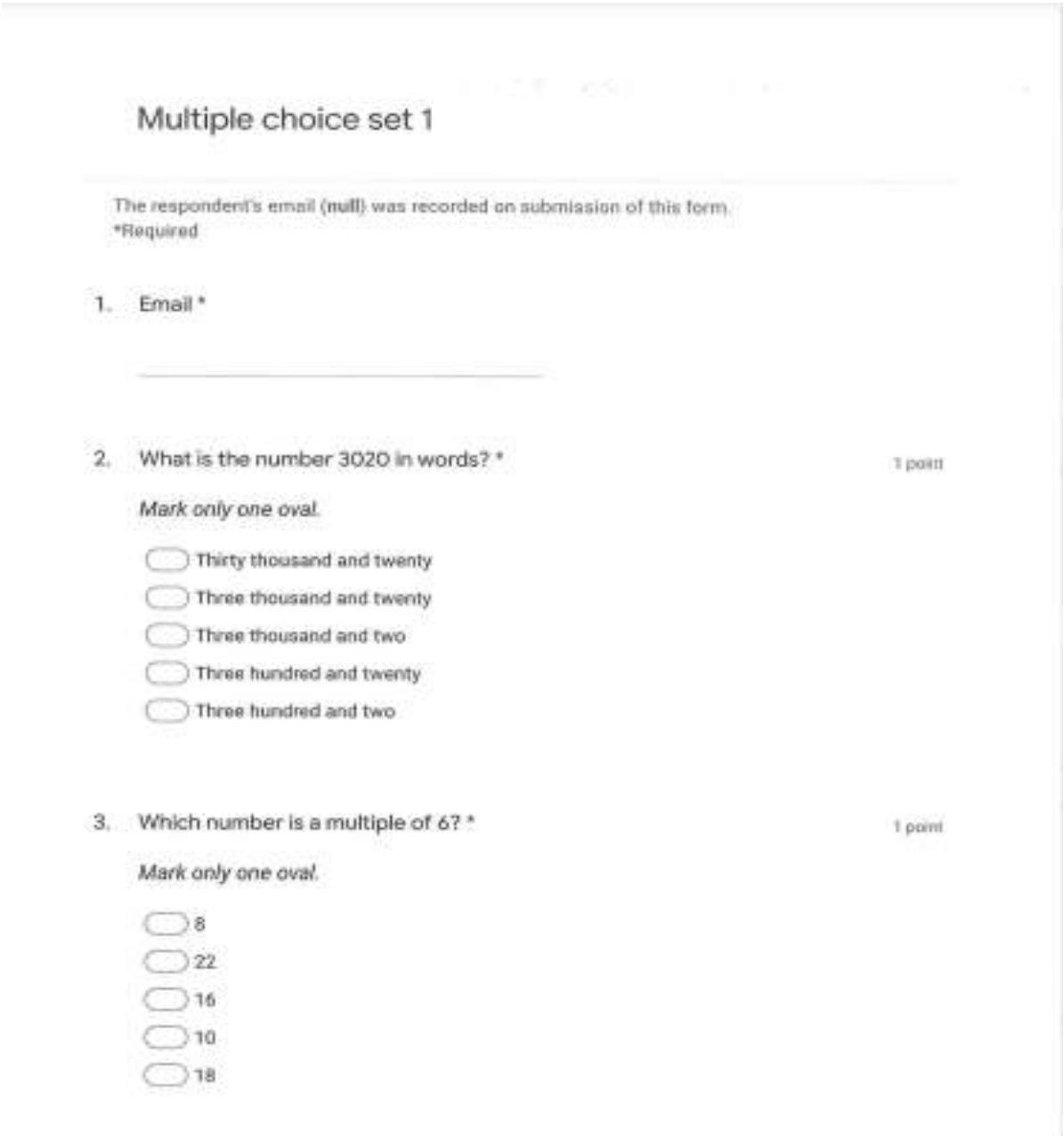
Wang, A. and Tahir, R. (2020) *The effect of using Kahoot! for learning – A literature review,* Computers & Education, Volume 149 (“What the Kahoot! - City of Glasgow College Blogs”).
Wood, T.; Brown, K., Grayson, J. (2017) *Faculty and Student Perceptions of Plickers*, ASEE Zone II Conference, The Citadel – The Military College of South Carolina.

Zeidner, M. (1998). *Test anxiety: The state of the art.* Plenum Press.

Appendix/Appendices

College 1 – Cycle 1

1. **Google forms**



Multiple choice set 1

The respondent's email (null) was recorded on submission of this form.
*Required

1. Email *

2. What is the number 3020 in words? * 1 point

Mark only one oval.

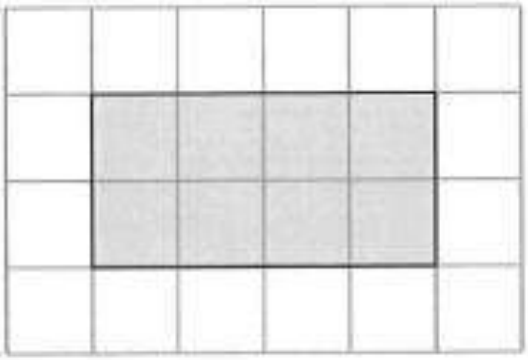
- Thirty thousand and twenty
- Three thousand and twenty
- Three thousand and two
- Three hundred and twenty
- Three hundred and two

3. Which number is a multiple of 6? * 1 point

Mark only one oval.

- 8
- 22
- 16
- 10
- 18

4. Here is a shaded rectangle on a centimetre grid. What is the area of the shaded rectangle? * 1 point



Mark only one oval.

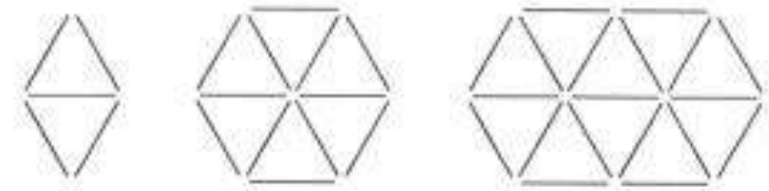
- 24cm²
- 14cm²
- 12cm²
- 8cm²
- 6cm²

5. In one week 9786 people visited a museum. The number 9786 rounded to the nearest ten is: * 1 point

Mark only one oval.

- 10000
- 9700
- 9790
- 9780
- 9800

6. Here is a sequence of patterns made from sticks. What is the number of sticks needed for pattern 4? * 1 point



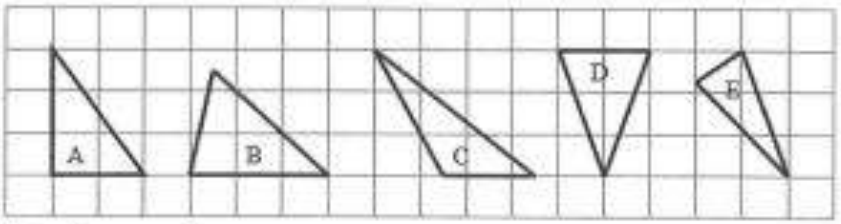
Pattern 1 Pattern 2 Pattern 3

Pattern	1	2	3
Number of sticks	5	12	19

Mark only one oval.

- 26
- 33
- 24
- 27
- 25

7. Which triangle is an isosceles triangle? * 2 points



Mark only one oval.

- A
- B
- C
- D
- E

8. Here are the first four numbers in a sequence: 4, 9, 14, 19 The next number in the sequence is * 1 point

Mark only one oval.

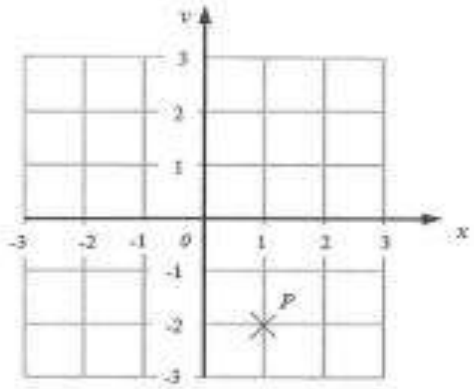
- 29
- 24
- 23
- 22
- 20

9. Here is a list of decimal numbers: 2.3, 2.41, 2.39, 2.389, 2.4 Robert is going to write the numbers in order of size. He writes down the smallest number. Which number should he write down? * 1 point

Mark only one oval.

- 2.3
- 2.41
- 2.39
- 2.389
- 2.4

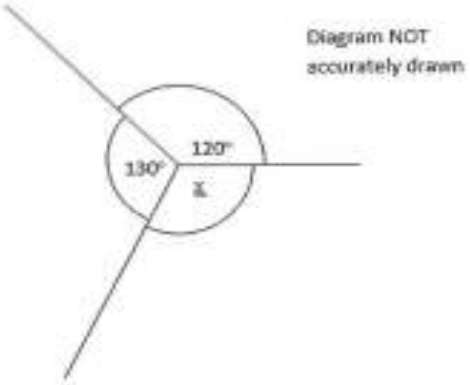
10. What is the co-odrinate of point P? * 1 point



Mark only one oval.

- (1, -2)
- (-2, 1)
- (2, 1)
- (-1, -2)
- (1, 2)

11. What is the size of the angle marked x? * 1 point



Mark only one oval.

- 120°
- 60°
- 110°
- 50°
- 130°

12. Which number is a prime number? * 1 point

Mark only one oval.

- 4
- 9
- 15
- 12
- 7

13. Which fraction is equal to 4/5 ? * 1 point

Mark only one oval.

- 7/8
- 2/10
- 16/20
- 20/30
- 12/20

Set 2

The respondent's email (null) was recorded on submission of this form.
*Required

1. Email *

_____

2. Here is a rectangle. What is the perimeter of the rectangle? * 1 point

Diagram NOT accurately drawn

Mark only one oval.

- 12cm
- 49cm
- 6cm
- 14cm
- 7cm

3. Here are he first six terms in a sequence. 4, 7, 11, 14, 18, 21. What is the 9thterm of this sequence? * 1 point

Mark only one oval.

- 32
- 29
- 31
- 30
- 28

4. A train leaves London at 16:50. It arrives in Manchester at 19:15. How long does the journey take? * 1 point

Mark only one oval.

- 2 hours 25 minutes
- 1 hour 35 minutes
- 2 hours 35 minutes
- 3 hours 25 minutes
- 3 hours 35 minutes

5. PQR is an isosceles triangle. QP = QR. Angle Q = 50°. What is the size if the angle marked x? * 1 point

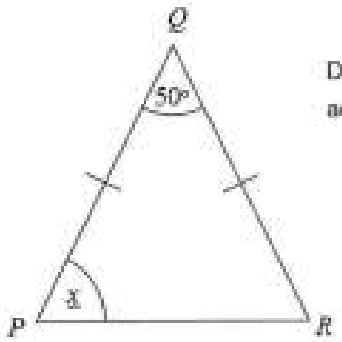


Diagram NOT accurately drawn

Mark only one oval.

- 50°
- 25°
- 130°
- 65°
- 60°

6. What fraction is the largest? * 1 point

Mark only one oval.

- 11/15
- 4/5
- 9/10
- 13/20
- 53/60

7. What is -7 added to -3? * 1 point

Mark only one oval.

- -4
- +4
- +10
- +21
- -10

8. A shop sells CDs for x pounds each. Darren buys 8 of these CDs. What is the expression, in terms of x, for the total cost of 8 CDs? * 1 point

Mark only one oval.

- 8 + x
- x
- 8/x
- 8x
- x/8

9. RST is an equilateral triangle. What is the size of the angle marked x? * 1 point

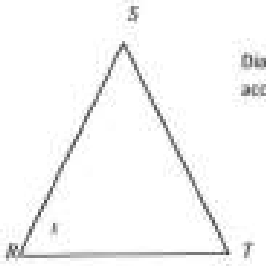


Diagram NOT accurately drawn

Mark only one oval.

- 50°
- 45°
- 40°
- 30°
- 60°

10. 487 is divided by 23. What is the remainder? * 1 point

Mark only one oval.

- 16
- 4
- 3
- 6
- 0

11. The Highest Common Factor (HCF) of 16 and 36 is * 1 point

Mark only one oval.

- 4
- 144
- 576
- 8
- 72

12. The diagram shows a rectangular floor. The length of the floor is 3 m. The width of the floor is 2 m. Jane is going to cover the floor with tiles. Each tile is a square of side 50 cm. Jane wants to cover the floor completely. How many tiles does she need? * 1 point

Diagram NOT accurately drawn

Mark only one oval.

- 24
- 12
- 10
- 20
- 6

Set 3

The respondent's email (**null**) was recorded on submission of this form.
*Required

1. Email *

2. What is the value of the 7 in the number 32 715? * 1 point

Mark only one oval.

- ◯ 7000
- ◯ 70,000
- ◯ 700
- ◯ 7
- ◯ 70

3. A bus leaves Abbots Way at 10.45 At what time does it arrive at Chethams? 1 point *

Abbots Way	10	15	10	45	11	20
Beadey Hill	10	19	10	49	11	23
Chethams	10	26	10	56	11	30
Dove Holes	10	42	11	10	11	45

Mark only one oval.

- ◯ 11:10
- ◯ 10:56
- ◯ 10:49
- ◯ 10:26
- ◯ 11:30

4. Here are five angles. Which marked angle is an acute angle? * 1 point

Mark only one oval.

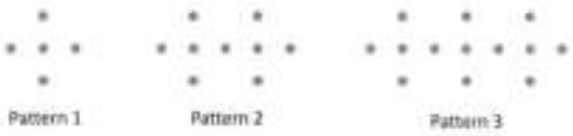
- A
- B
- C
- D
- E

5. 13 557 people watched a football match. What is the number 13 557 when rounded to the nearest hundred? * 1 point

Mark only one oval.

- 13,600
- 14,000
- 13,500
- 13,560
- 13,000

6. This is a sequence of patterns made from dots. How many dots are there in pattern 4? * 1 point



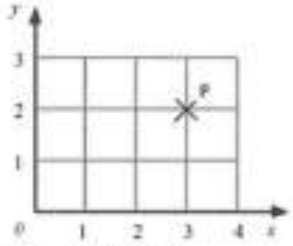
Pattern 1 Pattern 2 Pattern 3

Pattern	1	2	3
Number of dots	5	9	13

Mark only one oval.

- 19
- 21
- 17
- 14
- 16

7. What are the coordinates of the point P? * 1 point



Mark only one oval.

- (3,0)
- (2,0)
- (0,2)
- (3,2)
- (2,3)

8. Look at the number line below. What value is shown by the arrow? * 1 point

Mark only one oval.

- 2.2
- 2.25
- 2.24
- 2.21
- 2.22

9. Here is a list of temperatures 3°C 8°C 1°C -7°C -4°C Bob is going to write these temperatures in order. He writes down the lowest temperature. Which temperature should he write next? * 1 point

Mark only one oval.

- 3°C
- 8°C
- 1°C
- -7°C
- -4°C

10. What is the size of the angle marked x? * 1 point

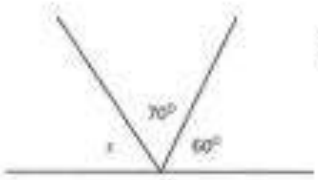


Diagram NOT accurately drawn

Mark only one oval.

- 30°
- 70°
- 130°
- 50°
- 60°

11. Here are the first five terms in a sequence. 6 10 14 18 22 What is the 9th term of this sequence? * 1 point

Mark only one oval.

- 30
- 26
- 9
- 34
- 38

12. $13 - 3 \times 4 \div 2 =$ * 1 point

Mark only one oval.

- 42
- 60
- -5
- 3
- -1

13. Here is a rectangle. The area of the rectangle is: * 1 point

Diagram NOT accurately drawn

Mark only one oval.

- 7.5cm2
- 4cm2
- 16cm2
- 15cm2
- 8cm2

Coaching Session Survey

Name:

Date:

Topic you worked on:

How do you feel about this topic after your session? (Circle one)

Better The same Worse

3. Data

Student number:	Skills gap identified (29/11/21):	Date of coach session:	How they feel about the topic after coaching: Better, same, worse	Skills gap identified (13/12/21):	Date of coach session:	How they feel about the topic after coaching: Better, same, worse	Skills gap identified (10/01/22):	Date of coach session:	How they feel about the topic after coaching: Better, same, worse
1	Averages	X	X	X	X	X	Perimeter	14/01/2022	Better
2	Fractions/decimals/percentages	X	X	Words and figures	14/12/2021	Worse	Sequences	X	X
3	Mixed numbers	06/12/2021	Better	Ordering decimals	14/12/2021	Better	Angles in triangles	11/01/2022	Better
4	Mixed numbers	06/12/2021	Better	X	X	X	Ordering fractions	14/01/2022	Better
5	Percentages	08/12/2021	Same	Co-ordinates	15/12/2021	Better	Negative numbers	X	X
6	Percentages	08/12/2021	Same	Ordering decimals	14/12/2021	Better	Forming equations	13/01/2022	Better
7	Perimeter	06/12/2021	Better	Equivalent fractions	X	X	Division	12/01/2022	Better
8	Perimeter	06/12/2021	Better	Ordering decimals	16/12/2021	Same	HCF	12/01/2022	Better
9	Perimeter	06/12/2021	Same	Ordering decimals	16/12/2021	Better	Area	X	X
10	Best buys	07/12/2021	Better	Words and figures	14/12/2021	Same	HCF	12/01/2022	Same

11	Best buys	07/12/2021	Better	Words and figures	14/12/2021	Better	HCF	12/01/2022	Better
12	Fractions	07/12/2021	Same	Co-ordinates	15/12/2021	Better	Area	11/01/2022	Better
13	Fractions	09/12/2021	Better	Co-ordinates	15/12/2021	Same	Division	12/01/2022	Better
14	Fractions	09/12/2021	Better	Ordering decimals	14/12/2021	Better	Negative numbers	13/01/2022	Better
15	Fractions	07/12/2021	Better	Ordering decimals	14/12/2021	Better	Negative numbers	12/01/2022	Better
16	Fractions	07/12/2021	Better	Equivalent fractions	15/12/2021	Better	HCF	13/01/2022	Better
17	Fractions	X	X	X	X	X	Forming equations	13/01/2022	Better
18	Ratio	09/12/2021	Same	Ordering decimals	14/12/2021	Same	Forming equations	X	X
19	Ratio	09/12/2021	Same	Co-ordinates	15/12/2021	Better	Ordering fractions	14/01/2022	Better
20	Ratio	09/12/2021	Better	Equivalent fractions	15/12/2021	Same	Area	11/01/2022	Better
21	Ratio	07/12/2021	Better	Co-ordinates	15/12/2021	Better	Area	12/01/2022	Better
22	Ratio	09/12/2021	Better	Equivalent fractions	14/12/2021	Same	HCF	12/01/2022	Better
23	Ratio	07/12/2021	Better	Ordering decimals	16/12/2021	Same	Sequences	11/01/2022	Better
24	Ratio	09/12/2021	Better	Equivalent fractions	14/12/2021	Better	Angles in triangles	11/01/2022	Better
25	Area	06/12/2021	Better	Equivalent fractions	15/12/2021	Better	Angles in triangles	11/01/2022	Better

26	Area	06/12/2021	Better	Co-ordinates	16/12/2021	Better	Ordering fractions	14/01/2022	Better
27	Area	06/12/2021	Same	Co-ordinates	X	X	Ordering fractions	14/01/2022	Better
28	Area	09/12/2021	Same	X	X	X	Area	12/01/2022	Same
29	Area	09/12/2021	Same	Words and figures	14/12/2021	Better	HCF	X	X
30	Area	X	X	Ordering decimals	16/12/2021	Better	HCF	13/01/2022	Better
31	Mixed numbers	06/12/2021	Better	Ordering decimals	14/12/2021	Better	Forming equations	12/01/2022	Same
32	Mixed numbers	06/12/2021	Better	Equivalent fractions	14/12/2021	Same	Perimeter	14/01/2022	Better
33	Mixed numbers	06/12/2021	Better	Co-ordinates	15/12/2021	Same	Negative numbers	12/01/2022	Better
34	Percentages	09/12/2021	Better	Equivalent fractions	14/12/2021	Better	Area	12/01/2022	Better
35	Percentages	09/12/2021	Better	Ordering decimals	16/12/2021	Better	Negative numbers	12/01/2022	Same
36	Area	07/12/2021	Better	Words and figures	14/12/2021	Better	Perimeter	14/01/2022	Better
37	Area	07/12/2021	Better	Ordering decimals	16/12/2021	Better	Angles in triangles	12/01/2022	Better
38	Area	07/12/2021	Better	Co-ordinates	16/12/2021	Better	Sequences	11/01/2022	Better
39	Area	X	X	Ordering decimals	X	X	Division	X	X
40	Area	X	X	Equivalent fractions	14/12/2021		Forming equations	X	X

41	Area	10/12/2021	Same	Equivalent fractions	15/12/2021	Same	Angles in triangles	12/01/2022	Same
42	Area	10/12/2021	Better	Co-ordinates	16/12/2021	Better	Angles in triangles	12/01/2022	Better
43	Area	10/12/2021	Better	Equivalent fractions	15/12/2021	Better	Better	14/01/2022	Better
44	Mixed numbers	X	X	Equivalent fractions	15/12/2021	Better	Division	14/01/2022	Better
45	Mixed numbers	X	X	Ordering decimals	16/12/2021	Same	Ordering fractions	X	X
46	Mixed numbers	X	X	Equivalent fractions	14/12/2021	Better	Forming equations	12/01/2022	Same
47	Perimeter	07/12/2021	Better	Equivalent fractions	14/12/2021	Better	Division	12/01/2022	Better
48	Perimeter	07/12/2021	Better	Words and figures	X	X	Division	14/01/2022	Better

College 2 – Cycle 1

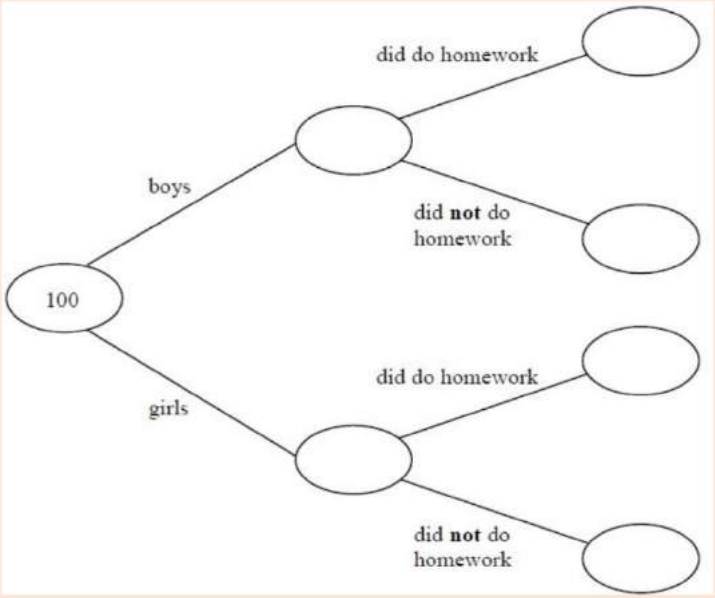
Print outs provided to students

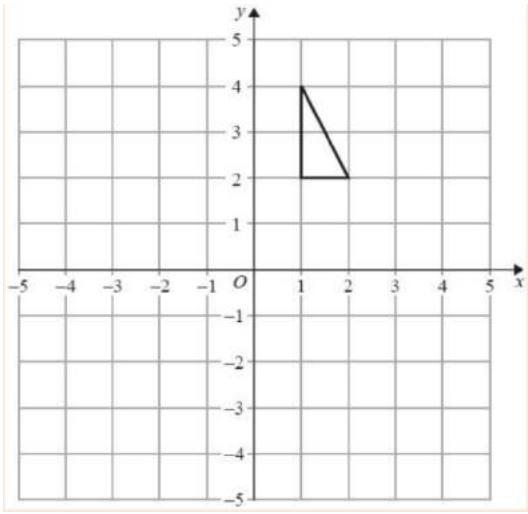
$2x \times 3 = 5x$

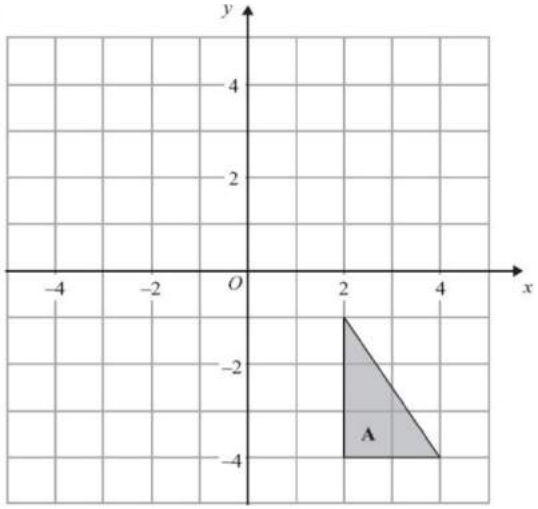
$3a + 4b + 2a = 4a + 5b$

$3y \times 3 = 9y$

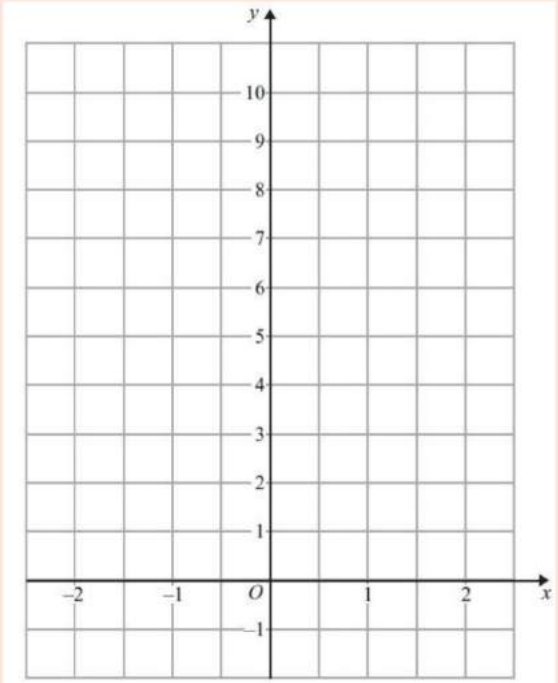
$c + 6b - 3b = c + 9b$




y
x
O
5
4
3
2
1
−1
−2
−3
−4
−5
−5
−4
−3
−2
−1
1
2
3
4
5


y
x
O
4
2
−2
−4
−4
−2
2
4
A

x	–2	–1	0	1	2
y	1		5	7	



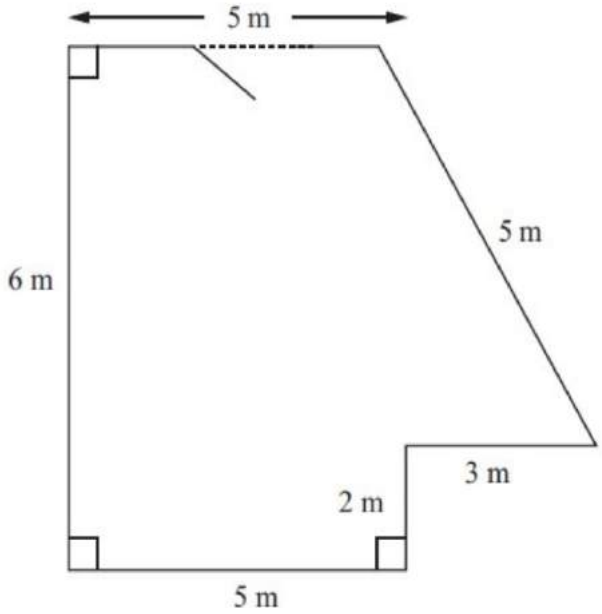
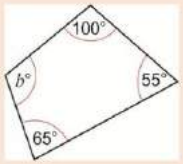


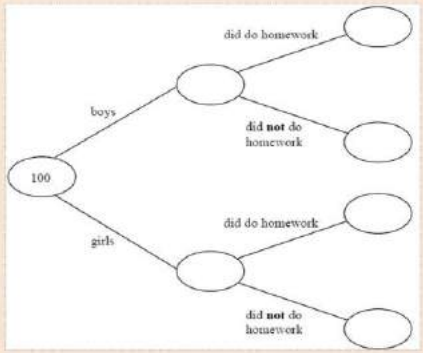
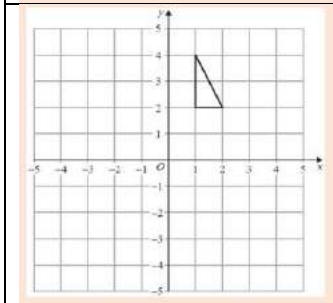
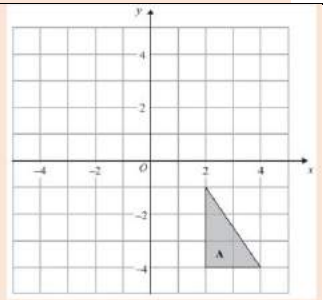
Diagram **NOT** accurately drawn

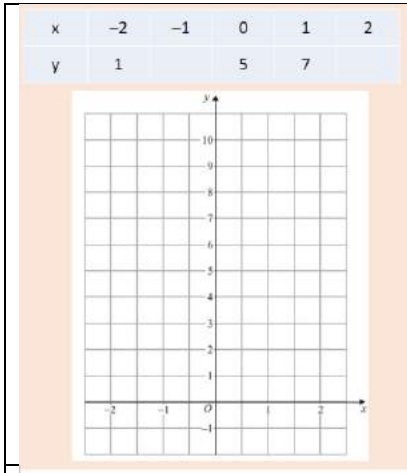
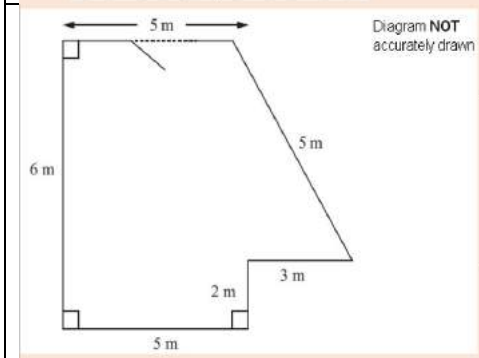
Marking Sheet

Name _____ Lecturer _____ Group _____ Date _____

QUESTION	MARKS AVAILABLE	MARKS AWARDED
Ali, Ben and Carl share £300 in the ratio 2 : 3 : 5 How much money does Carl get?	1 mark – any attempt to work out the ratio **OR** correct answer only **OR** 2 marks – working out and correct answer	
<table><tr><th></th><th>Yellow</th><th>:</th><th>Blue</th></tr><tr><td>Green A</td><td>2</td><td>:</td><td>5</td></tr><tr><td>Green B</td><td>4</td><td>:</td><td>9</td></tr><tr><td>Green C</td><td>2</td><td>:</td><td>3</td></tr></table> Carol mixes yellow and blue paint to make different shades of green paint. Which paint has the most blue paint, compared to yellow?	1 mark – any valid attempt to work out answer **OR** correct answer only **OR** 2 marks – working out and correct answer	
 Give the mathematical name for this angle. Estimate its size. Why do you think this?	1 mark – for estimate between 100 and 140 degrees 1 mark - for correctly naming angle in 1 mark – sensible justification	

 Work out the size of angle b. Show your workings.		1 mark – evidence that they are aware of the quadrilateral being 360 in total 1 mark – calculations 1 mark – correct answer	
$2x \times 3 = 5x$ $3a + 4b + 2a = 4a + 5b$ Which one of these equations is correct? Can you show how you know? $3y \times 3 = 9y$ $c + 6b - 3b = c + 9b$		1 mark – correct answer 1 mark for evidence of each equation checked (1 mark per equation)	
Three of these fractions are equivalent. Which is the odd one out? $\frac{6}{8}$ $\frac{18}{24}$ $\frac{24}{32}$ $\frac{28}{36}$		1 mark – evidence of working with fractions 1 mark – correct answer	
Helen scored 36 out of 50 possible points in a quiz. Write Helen's score as a percentage.		1 mark – correct answer 1 mark – evidence of working out	

 100 students had some homework. 42 of these students are boys. 8 of the 100 students did **not** do their homework. 53 of the girls did do their homework. One of the girls is chosen at random. Complete the frequency tree and use it to work out the probability that this girl did **not** do her homework.	1 mark – partially completing the frequency table **OR** 2 marks – fully completing the frequency table 1 mark – correct answer for probability	
 On the grid, rotate the triangle 90° clockwise about (0, 1).  Reflect triangle **A** in the *x*-axis.	1 mark – rotating the shape 90 degrees but not around correct point **OR** rotating around the correct point but not 90 degrees **OR** 2 marks – correct answer 1 mark – reflecting the shape but not in the x axis **OR** reflecting in the x axis but not the correct shape **OR** 2 marks – correct answer	

 Complete the table of values for $y = 2x + 5$. Then draw the graph of $y = 2x + 5$ for values of x from $x = -2$ to $x = 2$ on the grid.		1 mark – completing table correctly 1 mark – plotting points correctly 1 mark – joining up correctly plotted points	
 Diagram **NOT** accurately drawn Fran is decorating her bedroom. She is going to put a border all around the top of the bedroom walls. This diagram shows a plan of the bedroom. Border rolls are sold in 4 m lengths. Work out the number of border rolls Fran will need to buy.		1 mark – correctly calculating the perimeter of the room 1 mark – Dividing the perimeter by 4 1 mark – correct answer	

TOTAL MARKS AVAILABLE: 29

TOTAL MARKS ACHIEVED: `

STAR – self assessment

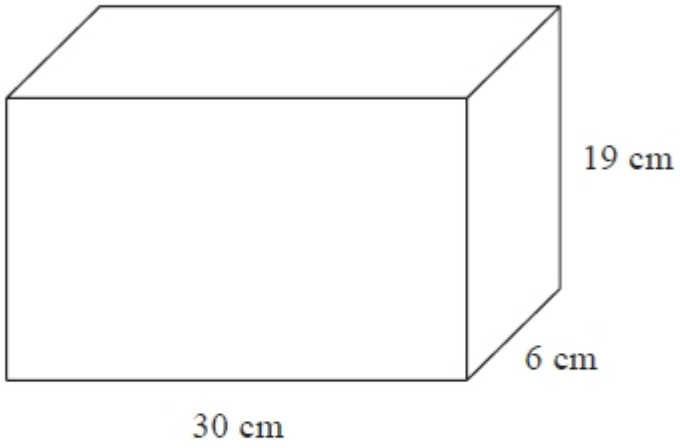
Strengths	Targets
Areas for improvement	Reflection

Cycle 2:

1. Big Mark Questions

Q 1 (calculator)

A container is in the shape of a cuboid.



The container is $\frac{2}{3}$ full of water.

A cup holds 275 *ml* of water.

What is the greatest number of cups that can be completely filled with water from the container?

Q2 (calculator)

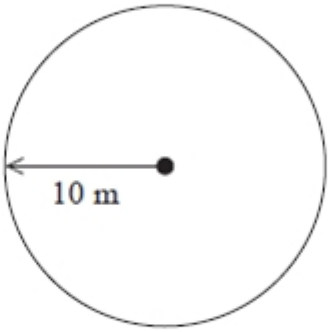
Neil buys 30 pens, 30 pencils, 30 rulers and 30 pencil cases.

Price list	
pens	6 for 82p
pencils	15 for 45p
rulers	10 for £1.25
pencil cases	37p each

What is the total amount of money Neil spends?

Q3 (non-calculator)

Balena has a garden in the shape of a circle of radius 10 m.
He is going to cover the garden with grass seed to make a lawn.



Grass seed is sold in boxes.
Each box of grass seed will cover 46 m^2 of garden.

Balena wants to cover all the garden with grass seed.

(a) Work out an estimate for the number of boxes of grass seed Balena needs.

You must show your working.

(b) Is your estimate for part (a) an underestimate or an overestimate?

Give a reason for your answer.

.....

.....

.....

.....

Q 4 (non-calculator)

Renee buys 5 kg of sweets to sell.
She pays £10 for the sweets.

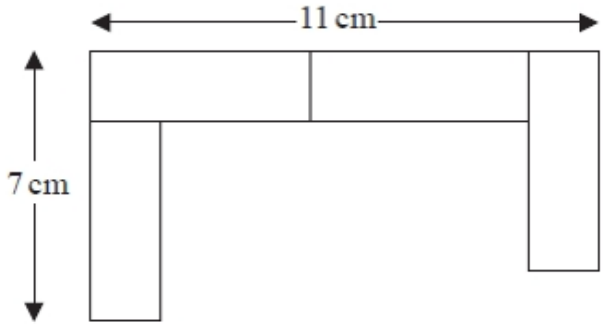
Renee puts all the sweets into bags.
She puts 250 g of sweets into each bag.
She sells each bag of sweets for 65p.

Renee sells all the bags of sweets.

Work out her percentage profit.

Q 5 (non-calculator)

A pattern is made using identical rectangular tiles.



Find the total area of the pattern.

..... cm^2

2. Model answers

Q2 (calculator)

Neil buys 30 pens, 30 pencils, 30 rulers and 30 pencil cases.

Price list	
pens	6 for 82p
pencils	15 for 45p
rulers	10 for £1.25
pencil cases	37p each

What is the total amount of money Neil spends?

P1	Start of the process for at least 3 of the items Eg 6 x 5 = 30 or 30 / 6 = 5; 15 x 2 = 30 or 30 / 15 = 2
P1	Find the cost of 1 item, eg 5 x 82 (410) or 5 x 0.82 (0.41)
P1	Find the cost of 2 items
P1	Adding at least 3 different costs (may be a mixture for money units)
P1	Correct answer

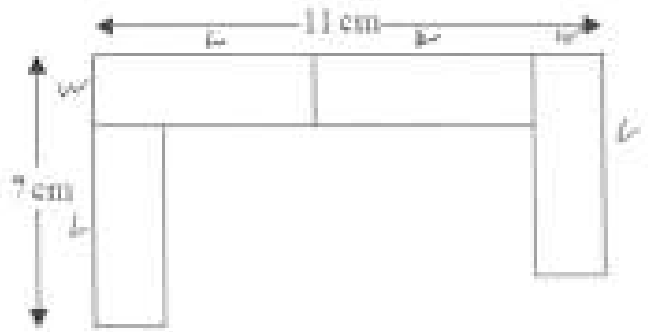
PENS (30 ÷ 6 = 5) (5 × 0.82 = 4.10)
PENCILS (30 ÷ 15 = 2) (2 × 0.45 = 0.90)
RULERS (30 ÷ 10 = 3) (3 × 1.25 = 3.75)
CASES (30 × 0.37 = 11.10)

4.10
0.90
3.75
11.10
19.85
1

£ 19.85

Q 5 (non-calculator)

A pattern is made using identical rectangular tiles.



Find the total area of the pattern.

P1 Find the value of the length as 4 using subtraction (2l + w = 11) – (l + w =7)

P2 Find the value of the width as 3 (4 + w = 3)

P3 Find the area of 1 tile using multiplication 4 x 3 = 12 cm squared

P4 Find the area of the pattern 4 x 12 = 48 cm squared

1/ $2L + w = 11$ −
$L + w = 7$
$L = 4$

2/ $4 + w = 7$
$w = 3$

3/ Area of 1 tile
$4 \times 3 =$
$12\ cm^2$

4/ Area of pattern
$4 \times 12 =$
$48\ cm^2$

48 ..... cm^2

Q 4 (non-calculator)

Renee buys 5 kg of sweets to sell.
She pays £10 for the sweets.

Renee puts all the sweets into bags.
She puts 250 g of sweets into each bag.
She sells each bag of sweets for 65p.

Renee sells all the bags of sweets.

Work out her percentage profit.

P1 Show number of bags sold eg 5 x 1000 divided by 250 = 20

P1 Number of bags 20 x 0.65 (or 65) = £13

P1 Find the percentage profit (13 – 10 divided by 10 x 100

P1 Correct final answer 30 %

1 kg = 1000g

Sweets in grams = 5 × 1000 = 500

n° of bags = 5000 ÷ 250 = 20

Sales 20 × 65p = 1300p = £13

% profit $\frac{\text{sales} - \text{cost}}{\text{cost}} \times 100$

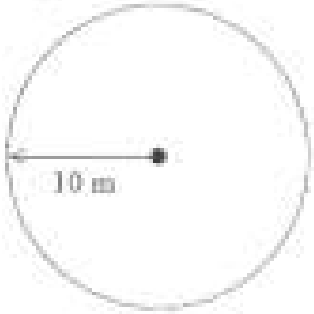
$= \frac{13-10}{10} \times 100 = \frac{3}{10} \times 100 = 3 \times 10$

30 ..... %

Area = πr^2
$= \pi (10^2)$
$= 100\pi$
$= 100(3)$
$= 300\ m^2$
Each Box = $50\ m^2$
$\frac{300}{50} = 6$ Boxes

Q3 (non-calculator)

Belena has a garden in the shape of a circle of radius 10 m.
He is going to cover the garden with grass seed to make a lawn.



Grass seed is sold in boxes.
Each box of grass seed will cover 46 m^2 of garden.

Belena wants to cover all the garden with grass seed.

(a) Work out an estimate for the number of boxes of grass seed Belena needs.

You must show your working.

P1 Estimating the value of pi (3)

P1 Find the area of the garden
Eg 3 x 100 or 3.1 x 10 squared
P1 Estimating the number of boxes 300 / 42 or multiple additions of 42
P1 Obtaining the correct answer

6

(4)

(b) Is your estimate for part (a) an underestimate or an overestimate?

Give a reason for your answer.

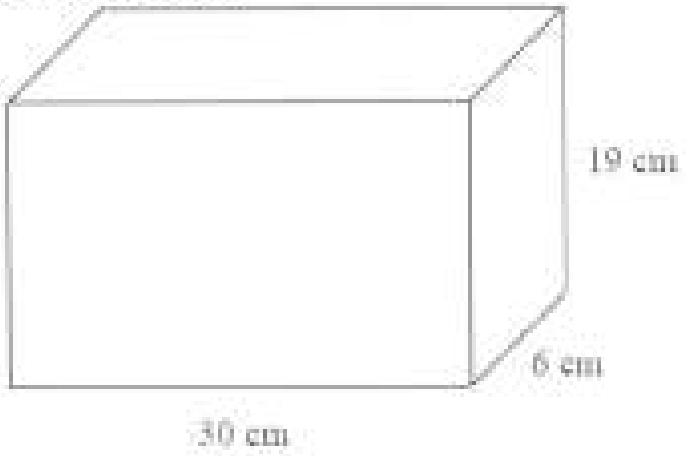
UNDERESTIMATE

P1 Correct answer of underestimate because pi has been rounded down just Boxes rounded up

(1)

Q 1 (calculator)

A container is in the shape of a cuboid.



The container is $\frac{2}{3}$ full of water.

A cup holds 275 ml of water.

What is the greatest number of cups that can be completely filled with water from the container?

P1 Find the Volume of the cuboid $30 \times 6 \times 19 = 3420$

P1 Divide it by 3 then times by 2 = $\frac{3420}{3} \times 2$

P1 [redacted] divided by 275 = [redacted] 8.29

P1 [redacted] cups

8

1/ Volume of cuboid

$30 \times 6 \times 19 = 3420\ cm^3$

2/ $\frac{3420}{3} \times 2 = 2280$

3/ $\frac{2280}{275} = 8.29$

8

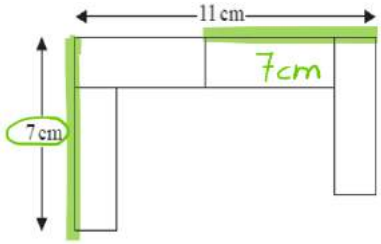
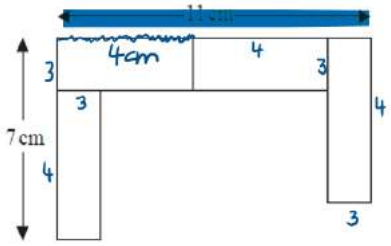
3. Answer strips

Read the question carefully.
Work out the volume of the container.
V = b x h x l
V = 30 x 19 x 6 = 3420 cm³
Work out $\frac{2}{3}$ of the Volume of the container.
3420 ÷ 3 = 1140 x 2 = 2280 cm³
Convert cm³ into ml.
1 cm³ = 1 ml
Divide $\frac{2}{3}$ of the volume of the container by 275ml.
2280ml ÷ 275 = 8.290 cups
Round to the full number of cups.
8.290 cups = 8 full cups
Read the question again to make sure you have answered it fully.

Read the question carefully.
Work out how many packs of pens you need.
Work out 5 x £0.85
Work out how many packs of pencils you need.
Work out 2 x £0.45
Work out how many packs of rulers you need.
Work out 3 x £1.25
Work out how many pencil cases you need.
Work out 30 x £0.37
Add your total pens, pencils, rulers, and pencil cases.
What is the total amount?
Read the question again to make sure you have answered it fully.

Read the question carefully.
Round numbers to make it easier to work with without a calculator.
Work out the Area of a circle.
$A = \pi r^2$
$\pi = 3.14$ (round to 3)
$A = 3 \times 10^2 = 3 \times 100 = 300\ m^2$
Area of grass covered by each box = 46 m^2 (round to 50)
Divide area of circle by the area each box covers.
$300\ m^2 \div 50\ m^2 = 6$ boxes
Answer question a.
Did you round up or did you round down?
Read the question again to make sure you have answered it fully.

Read the question carefully.
Convert 5kg into g
Divide overall weight of sweets by weight per bag.
5000 ÷ 250 = 20 bags
Multiply the number of bags by the price per bag.
20 x £0.65 = £13.00
Calculate percentage profit.
% profit = $\frac{difference\ between\ original\ amount\ and\ new\ amount}{original\ amount}$ **x 100**
% profit = $\frac{13-10}{10}$ **=** $\frac{3}{10}$ **x 100 = 30%**
Read the question again to make sure you have answered it fully.

Read the question carefully.
Look at the diagram and add any lengths or widths you already know.

Take away the overall height from the overall width.

Add all the measurements you have worked out to the diagram.
Work out the area of one rectangle.
A = l x w
A = 3 x 4 = 12 cm²
Multiply the area of the rectangle by 4.
12 cm² x 4 = 48 cm²
Read the question again to make sure you have answered it fully.