The Way Out of Cognitive Conflict

A planning toolkit for teachers

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Introduction

Moments of cognitive conflict can occur at any time in the classroom when a learner is left hanging on the edge of uncertainty. Some might describe this quite simply as “being stuck”. The predicted course of events is disrupted by a contradiction or surprise and existing methods and tools are found to be insufficient. In struggling to resolve the conflict new learning takes place. Manufacturing a moment of cognitive conflict is a key element to any CAME (Cognitive Acceleration in Mathematics Education) lesson (Adhami, Johnson and Shayer, 1998) as it is only when existing mental structures are challenged that accommodation to the new data takes place, new links are made and learning moves on (Adhami, 2007). Provoking moments of cognitive conflict in lessons is always rewarding and can provide valuable insights into how learners understand their world.

Strategies to support planning for cognitive conflict are outlined in The Route to Cognitive Conflict available at https://www.ncetm.org.uk/enquiry/13310#Final. This is a companion document which provides information for teachers on how best to manage the moment of cognitive conflict so that learners gain maximum benefit from the experience. The examples and strategies outlined here are the result of observations of upper primary and secondary mathematics classrooms but could equally well be used generically to apply to other age groups and subjects.

The response to cognitive conflict
Learners respond to cognitive conflict in a variety of ways, but often the response is very emotive. For many the initial response to cognitive conflict is confusion. Words such as “intimidating; blind; annoyed; dazed;” have been used by learners to describe their feelings. Some are excited by the unknown way of working and others enjoy the feeling of freedom that this gives them.

For many the confusion stage is quickly followed by some attempt at resolution, the confusion having provoked further thinking. (The challenge to resolve the conflict is self imposed and this can be very motivating.) Learners might:

- Engage with someone else’s cognitive conflict to help them solve the problem.
- Try to find someone else with the same conflict as validation of their own thinking.
- Ask for help from other learners or the teacher.
- Prefer to work quietly on their own problem.
- Listen to others resolving their conflict.
- Explain their ideas to another.
- Draw on existing knowledge and try to fit the problem with systems already known.
- Feel the need to move around.

In some instances the learners can be hindered by the limitations of their own knowledge or by the imposed ways of working. They may:

- Feel the need to share their ideas with a wider audience but are unable to effectively put their thoughts into words.
- Rely so heavily on existing knowledge that any possible creativity is stifled. (This may be the case when there is a large body of existing knowledge, e.g. more able or older learners.)
• Become frustrated from having to work in a group where they feel bombarded by lots of different opinions.
• Become frustrated from wanting to talk to others when they are prevented from so doing.

Helpful ways of working

Because learners demonstrate such a wide variety of responses to cognitive conflict, it is important, where possible, to provide a variety of opportunities for ways of working so that learners are able to choose whichever suits them. Many learners enjoy the independence afforded to them by working to resolve their own cognitive conflict and this may be a result of being given choices of ways of working. However, it is worth noting that discussion plays a pivotal role for many learners in helping them to resolve their conflict and therefore the opportunity for discussion should remain at the core of any strategy employed.

**Individual work** – Often learners reported so many ideas flowing simultaneously that time was needed to decide which to pursue. For those who prefer to work alone and/or in silence, they should be able to do so, recognising that for many, after initial personal thinking time, those individual workers then feel the need to talk to others. It may be appropriate to structure in 10 minutes quiet individual thinking time for all before allowing any discussion. During this time, teachers should resist the urge to input their own ideas! Often it is the more able learners who are happier to work alone. Less able learners feel the need to consult with others.

**Paired work** – Many classes already make extensive use of paired work and providing free discussion is allowed this should suit the needs of many learners.

**Group work** – For some working in a small group of 3 or 4 relieves the accountability of the individual. They feel less exposed in putting forward new ideas and therefore may contribute to the group’s learning when they would feel uncomfortable in contributing to a whole class discussion.

**Whole class discussion** – The combined intellect of the group is greater than that of any individual and therefore the opportunity for learners hear the thoughts of their peers sitting across the classroom should always be allowed. Midway through a lesson this can help learners to identify a way out of their cognitive conflict.

**Allowing movement** – Learners often benefit from finding out how others are working. To a certain extent this can be achieved by a “think, pair, share” approach or “2, 4, 8” where individuals share in pairs, pairs double up to fours and fours double up to eights. But for many learners, the physical movement alone can be beneficial to their clarity of thinking. Opportunities for movement could be provided by allowing physical movement for a restricted time within a lesson. Alternatively, the number of learners moving could be restricted by allowing envoys from one group to visit another.

The learning environment

If possible, the room should be physically arranged to facilitate discussion. Swan (2005) offers useful advice on managing discussions and suggests using a “horseshoe” or “double horseshoe” for paired or whole group discussions or arranging tables into blocks for small group work. The latter also allows for easy movement between groups if learners are keen to share their ideas with another group.

To benefit from discussions, learners need to be active listeners. This requires more of learners than simply remaining respectfully quiet whilst their peers contribute to a discussion. Learners should be able
to engage with and respond to ideas and feel comfortable that their own contributions will be valued by the group. A safe learning environment where everyone’s opinions are respected and learners do not fear ridicule will take time to develop if not already in place in the classroom.

The teacher’s role in helping to resolve conflict

Leading the discussion
The teacher should employ effective strategies for managing discussions (Swan, 2005). Revisiting questioning techniques would also prove helpful. Open and probing questions can be planned in advance but sometimes an unexpected response to a question can cause cognitive conflict for the teacher; you don’t always know what question you’ve asked until you get the response.

Motivation
Some learners are used to working “outside their comfort zone” and are motivated by the self-imposed challenge of cognitive conflict. Others will need lots of encouragement when working in this way to help maintain motivation. Praising learners for a variety of reasons, other than obtaining the right answer, is helpful in removing the fixation from “the answer” and refocusing on the thinking (de Geest, 2007). This helps learners to value the process of learning and learning gains more highly and is particularly helpful for those perceived to be “underachieving” (Boaler, 2009), or those who hold a belief that intelligence is fixed (Dweck, 2000) and who fear failure lest they be exposed as less smart than they thought they were.

Also, some learners may experience feelings of inadequacy if they see everyone else working when they feel unable to get started and some planned prompts may be useful in helping learners to overcome this.

Preparing the learners for cognitive conflict
Teachers should recognise that working in this way can be an emotional experience and therefore it is helpful if both learners and teachers are in the right frame of mind to work in this way and not to tired or jaded. Learners also need reassurance that that this is an effective way to learn as they may initially feel they are not making much progress or that this approach is “not proper work”. At the end of the lesson some learners are happy to be left pondering without a definitive answer to the problem. However, this can be de-motivating if it happens too often and learners can feel that they have “learnt nothing”.

Providing a common language
Learners are sometimes restricted in explaining their thinking by the language that is available to them and so a common language is needed for describing, explaining, discussing and listening. The teacher can be quite explicit in modeling this language and repeated use of sentence starters and useful phrases begins the process of embedding the correct vocabulary in learner responses.

Further reading

Cognitive Acceleration in Mathematics Education (CAME) is an approach to learning which capitalises on certain periods of increased physiological development in the brain to advance understanding in key
mathematical concepts. The structure of a CAME lesson is underpinned by an awareness of the hierarchy of difficulty in the concepts being learnt as first outlined by Piaget, (Bhattacharya & Hans, 2001, Wood et al), and the “acceleration” is then facilitated by peer interaction through discussion allowing individuals to contribute to, and thus enhance, the collective intellect and understanding (Vygotsky, 1978). It has been shown that regular use of CA (Cognitive Acceleration) raises attainment at GCSE by helping to move learners from concrete to abstract thinking, hence enabling them to more fully access the secondary curriculum. Adhami, Johnson and Shayer (1998) provide further detail of the approach and include lesson plans for provoking cognitive conflict.

Lessons containing moments of cognitive conflict are described by Swan (2006) as adidactical situations which “are chosen to cause students to act, think, speak and evolve through their own motivation, while the teacher refrains from interfering or suggesting knowledge that he or she wants to appear. This process generates contradictions, difficulties and disequilibria.” The state of disequilibrium is uncomfortable for the mind which provides the motivation to seek resolution. Parallels have also been drawn between cognitive conflict and cognitive dissonance, as detailed by Festinger and Carlsmith (1959) as the state which is brought about by the discomfort of holding two contradictory ideas simultaneously. It could be argued that in the case of cognitive conflict in the classroom as described here, there is only one existing belief which is adapted to accommodate the conflicting data causing the conflict. If the two terms are connected it could be possible that life-long learners, in making sense of the world, are actively engaged in seeking out opportunities for cognitive dissonance.

References:


Further information on CA materials for other year groups and subjects are available at: http://www.kcl.ac.uk/schools/sspp/education/research/projects/cognitive.html
Appendix 1: Case Studies

Points on a circular grid

Expected cognitive conflict
Where to plot points when faced with a grid other than the usual Cartesian one.

Prior learning needed
Plotting Cartesian coordinates.

Comfort zone
Previous exploration of the graphical representation algebraic relationships. The task was discussed using the circular grid displayed on the whiteboard so that everyone was clear what to do.

Exploration
Students were asked to plot (1, 3), (2, 6) and (3, 9) on the circular grid and then to consider looking at some sets of points with a common link.

Trigger
The usual rules for plotting points start to break down on the circular grid as there is scope for ambiguity in some cases.

Student response to cognitive conflict
Initial silence for 5 minutes before anything was said. Comments overheard included:

- Weird!
- Did you use the curves?
- Are you meant to follow a line or a curve?
- I don't understand. Oh, I get it.
- What are you meant to do?
- You can plot on the other side.
- I am so confused.

Written comments captured after the lesson included:

- Confusing at first but okay when I thought of a way to do it.
- There are so many different ways you can interpret it. What are they actually asking?
- I was dazed and confused. I felt like falling down a never ending hole.
- Confused and bewildered.
- I was confused because I thought I knew what I was doing but I actually didn’t.
- So confusing, but good though because everyone’s in the same position.
- A little frustrating. It seems a little pointless.
- Confused, new way of thinking.
- It felt weird, but it was really interesting. It was fun.
Simultaneous Equations

Expected cognitive conflict
Application of standard rules for solving equations to simultaneous equations.

Prior learning needed
Familiarity with the equation of a line in standard form and the related concepts of gradient and y axis intercept.

Comfort zone
Solution of single equations.

Exploration
Students were presented with a pair of simultaneous equations to solve, in this case deliberately arranged in non-standard form:

\[ 2x + y = 3 \]
\[ 3x = y + 7 \]

At first students tried to find the values of x and y using trial and improvement. The connection to straight lines was not made by the students until some wrote a list of ordered pairs satisfying each of the equations and hence discovered the patterns between x and y.

Trigger
Finding a simultaneous x and y value led to the search for more than one solution. Some tried to rearrange the equations into different forms to help find a solution. One value being negative created additional conflict for some.

Students’ response to cognitive conflict
1. What were your initial thoughts? How did you feel when you had no further instructions?
Most students expressed an initial apprehension but they agreed that it was good because it made them think:
   - I thought it was good that we had no instructions as it gave us a chance to work it out for ourselves.
   - Confused – I didn’t really know where to get started and what to do but that made it exciting.
   - It felt like we were blind because we had no idea what to do. It was also exciting trying to think what to do.

There were some responses showing that some of the students did not like a task that had no instructions:
   - I felt a little lost as I did not know what to do. I would prefer it if we were shown how to do it and then further examples were given for discussion. At least this way you would know where to start.
   - What have we got to do? A bit annoyed.
   - I was quite confused at first because I did not know what to do. It was slightly intimidating.
2. What did you do?
The responses showed a variety of approaches, illustrating that the students used their prior knowledge to manipulate the equations, to explore the patterns and to find the values that satisfied both equations. The responses given all related to mathematical methods.

- Our initial thought was to work out the value of x and y. We also used substitution and tried to think about other possibilities for the number and if it was a pattern.
- I worked out that one of them must be negative for both equations to work
- We tried looking into the relationship between them first as well as exploring and manipulating the equations separately. We thought they might be linked.

3. Did you find it useful to have someone else thinking about it and discussing it with you?
- Yes, because we could bounce ideas off each other and help get our heads around what its significance was. As we were unsure about the equation, it made it a lot easier. It also meant we could develop small ideas.
- I did as there were more points of view and ideas so we could join our thoughts to create interesting ideas.
- Yes, because we could work together. Also, I understood what I thought more because I had to explain it to someone else.
- Although I did enjoy sharing ideas, I would have rather worked alone right until the end as I am unsure who did all the calculation so I can’t feel proud of working out that sum.

5. What did you like about it?
- The fact that we did it ourselves and not the teacher just explaining the equations as that would be boring.
- I enjoyed the fact that there were endless possibilities.
- It was interesting as we were given no instructions and useful to myself to know that I can do things like this.
- It was fun to work it out in groups and not to have to do set questions.
- That we had to be independent as a group.
- It challenged me, and was interactive. Everyone had a say.
- I liked the way that at the end we understood it but at the beginning we didn’t.

Teacher’s response
It was important to reassure those students who felt they had not made relevant progress. In fact one group who had experimented with the re-arrangement of the equations proved most helpful in deriving algebraic methods of solution in follow-up lessons. Examining the set of x and y values that satisfied both of the equations also proved fruitful as the students were able to make the link to straight lines and realised why there was only one pair of values that could satisfy both equations. They were also able to see that for the pair of equations that represented parallel lines a solution was not possible.
This approach to simultaneous equations proved very successful. The students were happy to try different ways of eliminating one of the variables and they did not need much guidance.
Appendix B: A timeline for developing the use of cognitive conflict in the classroom

Cognitive Conflict can be a rich and powerful learning tool, but it can also lead to frustration. Our work during this project has led to us reflecting a lot on how learners respond to CC and how to help them use it successfully to enhance their learning. If you are interested in exploring the use of CC in your classroom, the following ‘timeline’ and prompts for reflective practice may help you. One of the richest parts of this project for us was working together as a group to reflect on our experiences – if you are able to persuade other colleagues to work with you on developing your use of CC in the classroom, you too may have a richer experience. The timings below hopefully allow plenty of time to reflect on ideas thoroughly, however you do not need to stick to them slavishly – they are merely provided to help keep a focus as you work through the key stages in developing your use of CC.

0 – 6 weeks

- Re-read ‘The Route to Cognitive Conflict’ to refresh your memory about how to successfully set up moments of CC in the classroom.
- Identify a class/group of children with whom you feel comfortable to try out CC
- Identify some key learning points for these children that can be explored through CC & plan activities (aim for one activity every 2 weeks – could be a CAME lesson, a starter/plenary or full lesson, or just a short ‘interesting’ activity that you think the learners will find interesting)
- Use activities – remember to be honest with learners and let them know that you are trying to learn about using CC as a T&L methodology.
- Reflect on how these activities have worked.

Reflective practice - questions to ask yourself

- How did the learners engage with the CC?
- How did the learners overcome the CC?
- What impact did overcoming the CC have on them?
- What did I do in the lesson – did I step back or take over?
- How did I facilitate discussion?
- What different ‘types’ of students are emerging in the class (e.g. dominant, bright sparks, learners who develop others’ ideas, quiet learners)
- Did learners feel comfortable using CC?
6 – 10 weeks

- Plan another CC-based lesson (full lesson)
- Use the ‘Student Questionnaire’ (adapt as needed) within this activity – it should form an integral part of your lesson plan
- Read through student’s responses & take time to reflect on the implications of them for future CC-based learning activities.

Reflective practice - questions to ask yourself

- Read the student’s responses – what do they value and what frustrates them within CC activities?
- How do their responses inform your future planning when using CC?
- Do you have any key ‘types’ of learners e.g. the quiet learner, the learner who is frustrated at not knowing ‘the answer’, the learner who is unwilling to listen to others etc.
- Do the students’ responses suggest any ways to arrange groups of students in class to help them benefit more from CC activities?
- What seems to be the main ‘issues’ you face when using CC-based learning activities with this class?
- Look at ‘case studies’ – do these help?

10 – 18 weeks

- Identify a key issue that you would like to work on (e.g. getting quieter learners to join in, getting learners to try out other people’s ideas, getting learners to pose their own questions, what effect has continued ‘exposure’ to CC been having on different students over the longer term?)
- Plan CC activities – within your plan, allow yourself opportunities reflect on your ‘key issue’ e.g. plan to ensure you have time to observe/work with/talk to key students during lesson
- If possible, find a ‘buddy’ who could observe learning – remember to arrange a pre-observation meeting to let ‘buddy’ know what you would like them to focus on, and also a time to feedback/discuss

Reflective practice - questions to ask yourself

- What strategies did you employ to help resolve your ‘key issue’?
- What other strategies could you develop to help?
- If you have focussed on a particular group of learners, how have their attitudes to CC-based learning developed? How can you build on this in future CC lessons?

18 weeks onwards

- Keep experimenting with CC in the classroom!