Use of affect to identify pupil active goals formation during a Key Stage 2 mathematics lesson.

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Motivation in the form of goals is often considered a long-term trait. However, there is growing awareness of the presence of in-the-moment, or active goals during mathematics lessons. The affective domain permits identification of changing emotions during mathematics lessons, which I conjecture enables insight into active goal formation. This paper forms part of a PhD study where video stimulated recall interviews occurred with eight 9–10-year-old pupils, across two classes. This paper presents findings for one pupil, David, indicating a change in affective behaviour, resulting in identification of two active goal pathways: The teacher's pathway for David to adopt cognitive active goals and David's actual active goal pathway. The pathways indicate David's active goals at times varied from those of the teacher and include the addition of social cognitive goals. By the end of the mathematics lesson, David had aligned himself with the teacher's active goals for the lesson.

Keywords: motivation; active goal; affect; video stimulated recall interview

Introduction and background

Since the introduction of the new National Curriculum (DfE, 2013), mathematics teaching in England has focused on maths mastery where the teacher supports the child to cognitively 'keep up, not catch up', this will involve overcoming barriers to gaps in knowledge (NCETM, 2019). Barnes (2020) highlights how understanding active goals may aid a teacher to enable the overcoming of mathematical barriers. There is growing recognition that understanding how a child thinks, feels and acts collectively allows insight into a child's motivation within a lesson (Tait-McCutcheon, 2008). To date mathematical research has primarily focused on long-term motivational goals. This paper forms part of a PhD study seeking to understand the range and reason behind pupils' in-the-moment or active goal formation, that may occur during a Key Stage 2 mathematics lesson.

Goals can be considered from two perspectives. Trait, a long-term goal (Allen-Lyall, 2018; Drevon & Reynolds, 2018), or state, a shorter, in-the-moment, active goal (Hannula, 2011, p.45). When considered in the context of a single mathematics lesson, Hannula (2011) suggests that the in-the-moment goal prevails. For instance, within England, the maths mastery curriculum (DfE, 2013; NCETM, 2017) builds on a series of sequential steps of knowledge to support progress. These steps potentially allow teachers the opportunity to set a series of active, or in-the-moment, goals for the course of the lesson. These goals have the potential to be adopted by the pupil as active goals. For instance, a teacher may aim for a pupil to identify and apply multiplication facts. The pupil's active goal may be to initially identify multiplication facts. However, as the lesson progresses, the pupil's active goal may change to independently applying the multiplication fact pattern. Hannula (2012) calls for a greater understanding of the active goals phenomena. One aspect of this is to understand pupils' active goals and their formation. This paper seeks to respond to this call by reporting on the initial stages of the study: pupil active goal identification.

Mathematics lessons are a cognitively driven space (cognitive domain) within which Goldin et al. (2011) identified the presence of state affective pathways, showing unstable emotional responses (affective domain) to situations which resulted in behavioural changes (conative domain). Thus, showing congruence with the psychological tripartite of the Theory of Mind (Hilgard, 1980). The behavioural changes allow reasons for motivation to be deduced which in turn may allow active goal inference (Viitala, 2015). This paper conjectures that emotions show motivational presence which may be indicated through active goal formation. Therefore, a change in emotion and its resultant behaviour may specify a change in a pupil's active goal. Consequently, observation of pupil emotions could support identification of pupil active goals. This paper reports initial findings of active goal phenomena identification through an affective domain lens within a higher attaining pupil (David).

The Study

The study aimed to use affective behaviour as a means of identifying 9–10-year-old pupils' active goals within the situational context of a Key Stage 2 mathematics classroom. A case study of Key Stage 2 mathematics lessons in an English primary school was selected and two year 5 teachers were recruited. Within each of the two classes, four focus pupils were selected, by the class teacher, to represent the class academic range (6 girls, 2 boys). This paper focuses on data from a year 5 child in cycle 1- David.

Due to the inferential nature of active goal identification a multi-method study design was implemented. The study consisted of three cycles each consisting of:

- **Pre-cycle teacher interview** exploring the rationale behind the plan for the observed lesson and identifying potential goals that may be available to pupils.
- **Videoing of focus pupils** in pairs during a typical mathematics lesson.
- **Researcher observations** noting episodes of changing affective behaviour and contextual information.
- **Video clip identification** immediately after the lesson. Four video clips of approximately 30-45 sec were selected by the researcher for each focus pair. Where possible, each clip portrayed a change of affective behaviour for both pupils. The clips spanned the main section of the mathematics lesson.
- **Pupil video stimulated recall interview (VSRI)** with each focus pupil pair. The study acknowledges the focus pupils are experts over their own behaviour (Clark, 2005) therefore, for each pair of focus pupils the pre-selected video clips were shared. The VSRI occurred on the same day as the lesson to maximise self-reflective recall. For each clip, pupils were asked to identify 'what they were doing', 'what they were thinking and why' and 'what they were feeling and why'.
- **Teacher video stimulated recall interview** with each class teacher. The study recognises the class teacher is the expert of interpreting their class behaviour (Blikstad-Balas, 2017). On the same day as the lesson, the pre-selected clips for that teacher's focus pupils were shared with the teacher. They were asked to infer based on the clip and their pre-existing knowledge of the pupils what each pupil was thinking and feeling, the goals each pupil had for that moment and finally the goals the teacher had for that moment.

Table 1 illustrates extracts of lesson observation, pupil and teacher VSRI data for David in cycle 1, showing the evidence used in inferring active goals, followed by interpretation of the data in the findings section.

1	**Time**	**Clip 1 – 8:40 minutes**	**Clip 2 – 15:55 minutes**	**Clip 3 - 25:50 minutes**	**Clip 4 – 40:45 minutes**
2	**Stills from video clips**				
3	**David's (red shirt) body language**	Sitting tall, looking across the desk, straight closed mouth, holding manipulative.	Leaning forward over exercise book, slightly angled away from Grace, writing.	Sitting tall, head down looking at exercise book with both hands up by his head.	Body turned towards Grace, one arm raised, wide upturned mouth and wide eyes.
4	**David's self-identified emotion**	Puzzled Confused	Confident	Hopeless bored	Tricked Interested
5	**Teacher active goal for David**	• Make 43 • Calculate times tables	• Refer to times tables • Make as close to 43 as possible	• Stick to the rules of the problem	• Identify 43 as prime number • Spot patterns of odd and even
6	**David's inferred active goal**	• Identify multiplication facts • Listen to Grace	• Write down times tables	• To make 43 or as close as possible • To share solution with Grace	• To share why he had not failed. • To teach about prime numbers
7	**Extracts showing supporting evidence for analysis – David, cycle 1** (O) Video clip transcript (P) Pupil VSRI (T) Teacher VSRI	• David looks towards Grace (O) • I was listening to Graces idea (P) • *'Wasn't there something about times 3?'* (O) • At first, I didn't fully know my 20 times table (P) • they are using their times tables knowledge (T)	• *'I'm going to write down the times tables right.'* (O) • I was focused on really writing down the times tables (P) • To write down the times tables (T)	• *'look two 9's is 18 add 6 is 24 add 20 is 44'* whispered to Grace (O) • I remember that at that time I got 44 and I wanted to take away nine but then I remembered that will be lower than 43 (P) • I think David is telling Grace 44 we can make 44 (T)	• *'No 43 is a prime number…. you can't make it'* (O) • *'A prime number is when you can only divide it, you can only multiply it, you can only divide it by itself and 1' (O)* • I looked at the learning objective and saw the word possible and I thought like they are testing us (P) • (David) then told partner … yes we can't make it because it is a prime number so I haven't failed. (T)

Table 1 –David's emotion, active goals, teacher goals and supporting evidence for a KS2 mathematics lesson. (Ethical approval granted by Cross Research Ethics Committee, University of Brighton and kind consent to share images by pupils, guardians and gatekeeper).

Findings from initial stage analysis of David, cycle 1

Identification of active goals relied on initial identification of pupil emotions. The initial emotional identification occurred through researcher inferential interpretation of body language. Table 1, line 2 and 3, shows a representative example of David's (in the red shirt) changing body language since the introduction of the mathematics lesson aim. The lesson was a problem-solving lesson where pupils were asked to make a product of 43 using multiples of 6, 9 and 20.

Table 1, line 2, shows photos of David displaying a range of body language which may indicate a change in affective state; from looking away from his work with a neutral expression in clip 1 to leaning forward writing in clip 2, to hands by a downward facing head in clip 3, to angled body towards Grace displaying wide eyes and wide mouth in clip 4. David's reflections in the VSRI (Table 1, line 4) allowed personal insight into the emotions potentially underpinning the observed behaviour. This resulted in David self-identifying an emotional change from puzzled and confused to confident to hopeless and bored to finally tricked and interested. There is a clear change in self-declared emotions for David across the four clips, thus identifying an emotional pathway that is congruent with Goldin et al.'s (2011) work. Furthermore, the clear change of emotions in David confirms the clips selected correctly represented a change in affective behaviour thus allowing analysis to move to the next stage of potential pupil active goal identification.

The teacher VSRI enabled the teacher to reflect on the active goals available for David to adopt across the four clips (Table 1, line 5). To endeavour to identify David's actual active goals I analysed the video clip transcript, pupil and teacher VSRI. This muti-modal approach enabled an informed inferential judgment of David's active goals to form. Table 1, line 7 shows extracts used to create the inferential identification of David's active goal for each clip.

Table 1, line 5 shows that the teacher's active goals for David are all cognitively focused and change over the course of the main section of the mathematics lesson. These varying teacher active goals show there are changing opportunities for David to potential adopt the teacher's cognitive active goals. Table 1, line 6 further goes on to show David has changing active goals across the four clips. Each clip shows David has a cognitive goal and in three of the four clips an additional social cognitive goal. As a result, there are two pathways evident:

1. The teacher's cognitive active goal pathway available to David
2. The active goal pathway David adopted.

Table 1, line 5 and 6, reveals a misalignment between the two pathways. During clip 1, David's puzzlement of the problem caused him to recognise he needed to use multiplication fact knowledge but at that stage was unable to adopt the goal of calculating multiplication facts. In clip 2 the teacher presents David with the active goal of referring to multiplication facts. At this stage he appears to recognise the need to adopt the teacher's active goal in clip 1 and chooses to calculate and write down his multiplication facts. Clip 3 shows David combining the teacher's active goals from clip 2 and clip 3 as he refers to his multiplication facts and sticks to the rules of the problem. At this point he has now re-aligned himself with the teacher's active goals for the lesson. David then maintains congruence with the teacher as he identifies 43 as a prime number. Interestingly, David also adopted active goals of his own. These additional active goals all had a social cognitive element, where David actively tries to engage his partner in discussion or to impart knowledge. For example, in clip 4 David can be seen physically turned towards his partner as he shares his knowledge regarding prime numbers, thus displaying his cognitive knowledge within the social peer setting.

Conclusion

The data reveals changing affective behaviour during the mathematics lesson. The changing affective behaviour over the course of the mathematics lesson appears to indicate active goal presence. Active goal presence was inferred through researcher observation and pupil and teacher VSRI. Each video clip appeared to indicate active goal presence within David. This led to the identification of multiple active goals for David within a KS2 mathematic lesson. Thus, I draw the conclusion that affective behaviour is one mode to identify the unobservable phenomena of pupil active goals.

Two active goal pathways were identified; one the teacher makes available for pupil adoption and the pathway David actually adopts. This study identified the teacher's pathway of goals was not consistently adopted in the way the teacher anticipated. In this instance David showed a delay in adopting the teacher's active goals for himself, however by the end of the lesson congruence in the two pathways was evident. Additionally, David independently adopted social cognitive active goals where he engaged cognitively over the maths mastery problem with his partner.

Next steps

As indicated this paper represents initial findings of a PhD study on pupil active goal identification and formation. Work has begun on the clips for each focus pupil across each cycle to see if pupil active goal pathways can be identified in each instance. Should this be successful, work will be undertaken to establish if general pupil active goal pathways are present and how they compare to active goal pathways made available by the teachers. It is anticipated that analysis will develop understanding of why active goals form and change within pupils across a KS2 mathematics lesson.

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