Appreciating Productive Struggle: Educators' Experience of "Confusion to Clarity" During Professional Learning

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Productive struggle is a vital aspect of mathematics learning; consequently, how teacher educators can effectively communicate the power of this idea to classroom teachers should in itself be an important consideration. We argue that providing teachers with firsthand experience of learning mathematics through structured inquiry approaches (e.g., launch-explore-summarise/review) is vital for supporting their appreciation of productive struggle. To facilitate this, during professional learning workshops with primary school teachers and education support workers, we have introduced a reflective template (the "Confuse-o-meter") to enhance educator awareness of their own journey from "confusion to clarity" as work on a task unfolds. In this current Illustration of Practice, we draw on data collected from several workshops we recently facilitated, which focussed on introducing challenging tasks and the launch-explore-summarise/review lesson structure. Our purpose is both to demonstrate the importance of providing educators with first-hand experience of productive struggle, and to illustrate how the reflective template designed supports this process.

Keywords · mathematics teacher education research · productive struggle · structured inquiry · professional learning · primary education

A Lesson Structure to Support Productive Struggle

Supporting students to engage in productive struggle is viewed by many researchers and teacher educators as a central aspect of modern mathematics instruction (Hiebert & Grouws, 2007; Kapur, 2008). The notion of productive struggle forms part of a coherent set of beliefs about how mathematics is taught effectively and learnt that includes ideas such as:

- learning is most effective when students are engaged in higher order thinking;
- students are more likely to make sense of mathematics and remember what they have learned if they work on tasks that are appropriately challenging;
- students benefit when they persist with concepts and tasks that include concentrating, applying themselves, believing they can succeed and connect effort with learning; and
- students [benefit from] making their own choices of the type of solution or solution strategies when solving tasks. (Sullivan et al., 2020, p. 32)

Providing opportunities for students to struggle productively is one of the potential benefits to task-first lesson structures that focus on teaching mathematics through problem solving (Livy et al., 2018; Russo et al., 2020). One way to teach mathematics through problem solving is to use structured inquiry approaches where lessons follow models based on Stein et al.'s (2008) launch-explore-summarise/review or launch-explore-discuss phases. Teachers begin the lesson by launching the mathematical task using minimal explanation, and deliberately withholding a solution method for the students to follow. Students then have opportunities to explore the task, at first individually and then later collaboratively. During this time, the teacher monitors the mathematical work as it unfolds, and endeavours to make the student mathematical thinking as explicit and clearly articulated as possible. The final phase involves the teacher selecting specific students to present their responses to the task in

a specific order to scaffold a guided mathematical discussion, with the teacher actively making connections between the different student solution attempts and to the underlying mathematical learning focus (Stein et al., 2008).

Lessons that follow the launch-explore-summarise/review structure, where explicit teaching comes after students have had opportunities to experience the mathematics first for themselves, generally begin with students independently exploring a problem-solving task without access to supports for a pre-determined minimum period of time (e.g., five minutes). The intention of this strategy is to promote feelings of struggle and uncertainty initially, with the goal of encouraging students to draw on prior knowledge, take responsibility for their learning, and to develop persistence. Persistence is of course an academic and personal quality that is generally highly valued in a school environment (Vernon & Bernard, 2006), and, in this context, can be defined as the ability to direct concentrated and sustained effort to a task in order to achieve a particular goal, in the presence of some form of uncertainty and/or adversity. This period of quarantined independent time, when students are initially exploring a task with the goal of promoting productive struggle and persistence, has been referred to by many terms in the literature including: "controlled floundering" (Pogrow, 1988, p. 83), the "learning pit" (Nottingham, 2017), the "zone of confusion" (Clarke et al., 2014, p. 58), and, in our recent project, was often described by teachers as "sweaty brain time" (Russo & Hubbard, 2022, p. 19).

Students are typically offered a support in the form of an enabling prompt if they are continuing to have difficulty with a task while working on their own (Sullivan et al., 2006). Critically, after the initial independent time, students are then given opportunities to collaborate with peers, which often serves to provide additional clarification and validation, ensuring that a student is on the right track. In this manner, as the lesson progresses, the level of support offered to students increases. This approach of increasing the amount of support that is available to students as work on the task unfolds has been described as "reverse scaffolding" (Russo & Russo, 2022, p. 38), and is intended to move students from confusion to clarity through facilitating emotionally-salient insights into the mathematics being explored (i.e., "aha" moments).

Giving Educators a First-Hand Experience of Productive Struggle

Although productive struggle is a vital aspect of mathematics learning, teachers may be reluctant to embrace it, believing that it is instead their role to steer students, particularly low-achieving students, away from what they would consider uncomfortable and potentially confusing learning experiences (Ingram et al., 2020). Consequently, how to effectively communicate the power of productive struggle to teachers is a non-trivial consideration.

In order to illustrate the power of learning through the experience of confusion to clarity, we have attempted to replicate a modified version of the launch-explore-summarise/ review lesson structure in our whole-school professional learning workshops with in-service primary school teachers and education support workers (collectively referred to as "educators" hereon). Specifically, educators are presented with a task and encouraged to independently "have a go" for three minutes (Time 1), being reassured that:

- there is no expectation they will answer the task in this first three minutes; and
- after this period, they will be provided with additional support should it be required.

After this simulated lesson launch, the facilitator provides all educators with an enabling prompt (Sullivan et al., 2006), or "spotlights" a partial solution from one of the educators to share a particular way of approaching the task (Time 2) (Hubbard et al., 2023). After a further three minutes or so of additional time working independently on the task, educators are provided with a few minutes to then collaborate in small groups to discuss their thinking (Time 3). The mathematical work closes with the facilitator choosing approximately three educators (or groups of educators) to share their solution/strategies with the broader group, each of which selected to illustrate a different way of approaching the problem. The whole group discussion then turns to reflecting on the learning experience. It is important to acknowledge that this represents a truncated version of the lesson

structure in terms of how it would actually unfold in a mathematics classroom. Truncating the process in this manner is both expedient in terms of illustrating the experience for the purpose of professional learning and ensures that the majority of educators do not exhaust all of the mathematics in the task (i.e., fully solve the task) in the initial period of independent work.

Supporting Educator Reflection and the "Confuse-o-meter"

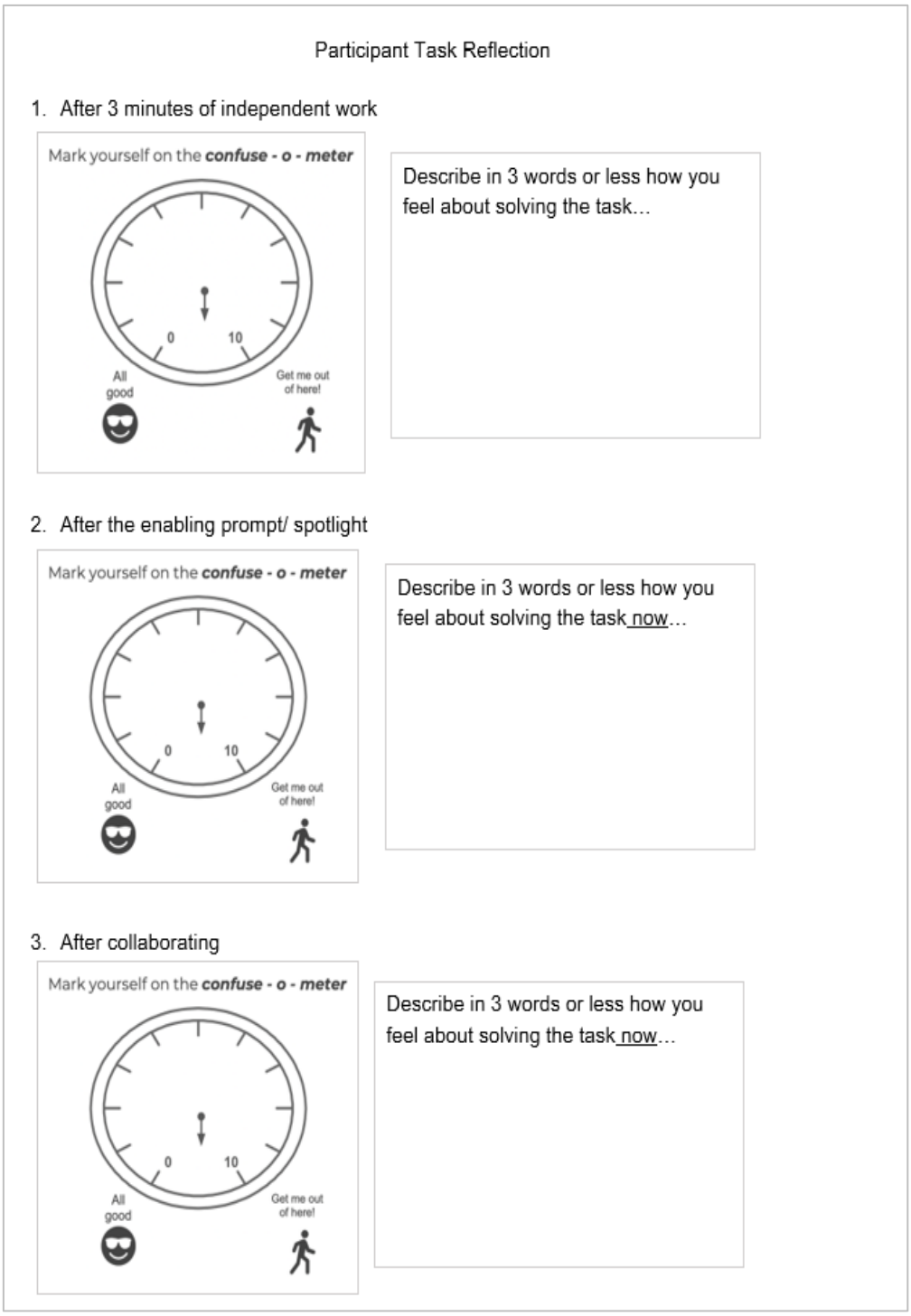

Figure 1. The Confuse-o-meter worksheet

One of the tools we use to support educator reflection is to ask them to record how they are feeling about a task on the "Confuse-o-meter" worksheet (see Figure 1) at three points in the learning experience: after the initial three minutes of independent work, after the enabling prompt or spotlight has been administered, and after they have had an opportunity to collaborate with colleagues. Note that we have used this tool both concurrent to educators working on the task (i.e., asking them to complete the relevant Confuse-o-meter in real-time after each of the three stages of the learning experience), as well as retrospectively (i.e., asking them to complete the entire worksheet after the learning experience has been completed). Generally, a concurrent administration is appropriate when using this reflection for a less demanding mathematical task (e.g., Lucky Dice, see Figure 2). A retrospective administration may be more appropriate when the task is more demanding (e.g., Man with the Money, see Figure 2), given that the task switching involved in reflecting on their learning experience may disrupt the actual mathematical work.

Lucky Dice Task (Russo, 2020)
My dad offered me a deal. I choose any number on a hundreds chart. He'd then roll a 6-sided dice, and we'd count by whatever number he rolled (from zero). If we land on my number, he'd give me 10 dollars. If we skip my number, I'd give him 10 dollars. What are some good numbers I could choose? Should I take the deal?

Man with the Money Task (Clarke & Clarke, 2003)
A man goes into a store and says to the owner "Give me as much money as I have with me and I will spend $10." It is done, and the man does the same thing in a second and third store after which he has no money left. How much money did he start with?

Figure 2. Tasks to support productive struggle during professional learning.

Completing a Confuse-o-meter at various stages in the simulated lesson experience requires the educator to give themselves a score of between 0 and 10 reflecting how "confused" they are about the task, as well as providing them with the opportunity to briefly describe how they feel about working on the task. At the conclusion of the learning experience, educators are given an opportunity to provide a more elaborate overall reflection by completing the additional prompts:

- What are your thoughts about deliberately structuring a lesson to try and move students from confusion to clarity? What do you think about the counterpoint that it is better just to try and promote clarity to begin with and maintain clarity throughout the lesson?
- In your view, what are the benefits associated with promoting productive struggle in the mathematics classroom more generally? Are there any risks associated with promoting productive struggle?

Examining Data Collected from Professional Learning Workshops

In this section, we present a summary of data collected during a series of one day professional learning workshops across several Catholic primary schools in Melbourne, Victoria, where we administered the Confuse-o-meter worksheets. The aim of each of these one-day workshops was to provide participants with an overview of the launch-explore-summarise/ review lesson structure, how to teach mathematics through challenging tasks, and the role of productive struggle in supporting learning.

Overall, it is evident that educators who attended these workshops did in fact experience "confusion to clarity" as they worked on the Lucky Dice and Man with the Money tasks (see Figure 3). Specifically, average reports of subjective levels of confusion in relation to both tasks declined between Time 1 and Time 2, and then again between Time 2 and Time 3.

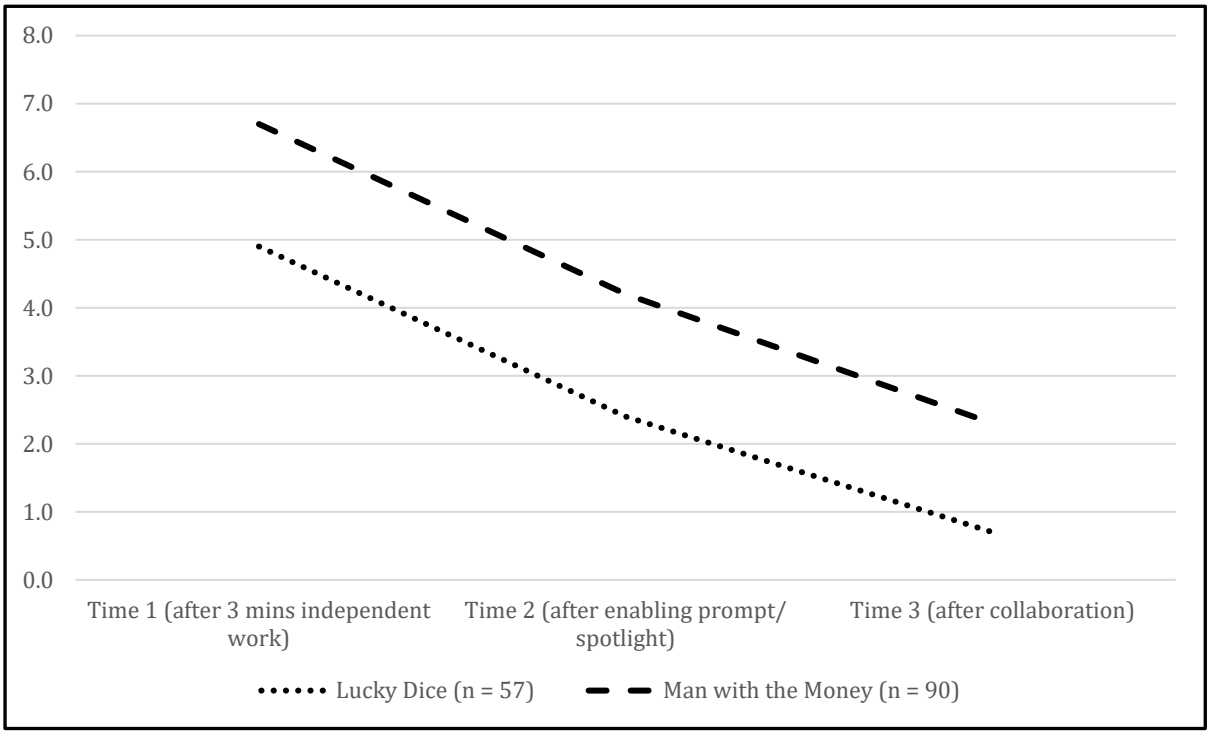

Figure 3. Mean levels of confusion when working on Lucky Dice and Man with the Money.

Tables 1 and 2 consider the various profiles of educators in terms of how their level of confusion changed whilst working on the task. It is clear that the majority of educators moved from confusion to clarity when working on the Lucky Dice Task (86%) and the Man with the Money Task (62%), with most doing so in a linear manner. This suggests that the process was modelled as intended, and the chosen tasks were sufficiently challenging and novel for educators to authentically engage in a truncated version of the problem-solving process as learners. It is worth noting that the Man with the Money task remained notably more challenging for educators than the Lucky Dice task, even at the end of the learning experience, with approximately one-third of workshop participants remaining at least somewhat confused even after collaborating with other educators. Follow-up discussions with these educators indicated that approximately a further half achieved "clarity" only after working on the consolidating task (note that the consolidating task was identical to the original task in all respects, except the amount spent in each store was $8).

Table 1
Educator Confuse-o-meter Profiles: Lucky Dice Task (n = 57)

Profile	*n* (%)
Never confused	5 (9%)
Confusion to clarity (initial confusion > 3; final confusion 0, 1, 2)	49 (86%)
Linear	38 (67%)
Clarity through enabling prompt/ spotlight only	7 (12%)
Clarity through collaboration only	4 (7%)
Confusion reduced (final confusion 3, 4, 5 after being higher)	2 (4%)
No change, still somewhat confused (final confusion 3, 4, 5 with no change)	0 (0%)
Still confused (final confusion 6 and above)	1 (2%)

Table 2
Educator Confuse-o-meter Profiles: Man with the Money Task (n = 90)

Profile	n (%)
Never confused	1 (1%)
Confusion to clarity (initial confusion > 3; final confusion 0, 1, 2)	56 (62%)
Linear	40 (44%)
Clarity through enabling prompt/ spotlight only	10 (11%)
Clarity through collaboration only	6 (7%)
Confusion reduced (final confusion 3, 4, 5 after being higher)	23 (25%)
No change, still somewhat confused (final confusion 3, 4, 5 with no change)	2 (2%)
Still confused (final confusion 6 and above)	8 (9%)

Finally, Table 3 includes several illustrative quotations from participants who described their feelings across the three time periods whilst working on the Man with the Money task. These specific quotations were chosen as they were broadly representative of the full scope of responses provided by those participants (n = 56) who were categorised as moving from 'confusion to clarity' as work on the task unfolded. It is clear that there is variation in how participants experienced the period of initial "confusion" after working on the task independently, with some educators using positive language to describe how they were feeling (e.g., Participant 1: "intrigued, puzzled, exited"), and other educators using more negative language (e.g., Participant 8: "confused, stressed, overwhelmed"). By contrast, there was convergence in participant reflections after they had an opportunity to collaborate on the task, with almost all participants using positive language (e.g., Participant 1 and Participant 8: "confident").

Table 3
Feelings Towards the Man with the Money Task: Illustrative Quotations

No.	T1 (After 3 minutes of independent work)	T2 (After enabling prompt/ spotlight)	T3 (After collaborating)
1	Intrigued, puzzled, excited	Validated, but still unsure of strategy	Confident of strategy, interested in others
2	Puzzled, stuck, challenged	Reassured, determined, clearer	Happy, relieved, completed
3	Stressed, worried, felt like giving up	Small hope, there is a way to solve this	All good
4	Why isn't this working?	Still not getting it	Ohhh …
5	Puzzled, good feeling	Affirming	So much fun
6	Little clue, rattled	Had an idea	Comfortable, supported
7	Stressed, confused, sweaty-brain	Struggle, stretched, empowered	Confident, justified, powerful
8	Confused, stressed, overwhelmed	Confident, excited, thinking	Clear minded, confident, validated

Concluding Remarks

This article has illustrated an approach to professional learning where educators are placed in the role of students by being invited to work through a task that they find initially challenging. In our experience, there are multiple benefits to this approach. First, working through the task in this manner helps educators to internalise the various phases of a structured inquiry lesson in preparation for enacting this approach in their classroom with their students. Second, it provides educators with a firsthand experience of moving from "confusion to clarity", helping to communicate the power of productive struggle and "aha" moments for making learning emotionally salient and memorable. It is important to note that the effectiveness of this approach is likely contingent on educators experiencing the task as

sufficiently challenging and novel to allow for genuine engagement and to facilitate "sweaty brain time", highlighting the importance of task selection even in a professional learning context.

Furthermore, our use of the Confuse-o-meter tool illuminated the varying emotional experiences of participants. As educators navigate their own journey from confusion to clarity, some exhibit more negative responses initially, while others lean towards intrigue and excitement, with most eventually converging towards a sense of confidence. This variation parallels the variety of student experiences in the classroom. It helps to reassure educators that, although students all start at different places, and some might be initially anxious about the level of challenge offered, students of varying mathematical competency levels and dispositions can experience success.

Moreover, this experience at the beginning of the workshop serving as a touchstone for the remainder of the session is an important element. We were able to repeatedly refer back to it throughout the professional learning day to emphasise various pedagogical aspects, and educators centred subsequent discussions around it. This dynamic interaction between the experience and reflection offered an opportunity for educators to bridge the gap between anticipating their students' experiences and the key ideas being explored in the workshop. Conversely, in other settings, when we have introduced tasks without the subsequent structured reflection provided by the Confuse-o-meter, it has not stimulated the same level of overall engagement and response.

We believe that the professional learning approach outlined here—giving educators a firsthand experience of structured inquiry and the experience of "confusion to clarity"—offers a promising model for future professional development programs. It helps to embody how struggle and confusion, when navigated appropriately, can serve as vital stepping-stones towards learning and clarity.

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Competing interests

The authors declare there are no competing interests.

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