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Engendering students' epistemic agency in a collaborative mathematics for educators' class at a university in South Africa

Aim of the project

Whereas knowledge building is a trait expected from students in higher education, the question asked by Engel (2013, p. 158) "is epistemic agency possible?" is still relevant because little is known of how it is stimulated and supported in classrooms. Hence, the project reported here sought to shed light on how epistemic agency is enacted in a collaborative mathematics for education class at a university in South Africa.

The word epistemic means knowledge building and its validation, while agency is a capacity to get things done. In the context of a classroom, epistemic agency "is about taking responsibility over one's own learning efforts and advancement of understanding" (Muukkonen, 2008, p. 6). It is a construct introduced into education by Scardamalia and Bereiter (1991) in their work on higher levels of agency in children's knowledge building. They said that epistemic agency can either be individual work or shared work in collaborative groups – shared epistemic agency. It is informed by socio-culturalism, takes place through participation in conversational interaction and, hence, is evidenced in collaboration.

In conceptualising shared epistemic agency, Damşa, Kirschner, Andriessen, Erkens and Sins (2010) framed it as having two dimensions, namely, the epistemic (knowledge related) dimension and the regulative (process related) dimension. Although they indicated that the boundaries between these two dimensions are fuzzy, they highlighted actions that are carried out in each dimension. These actions are summarised in the table below.

Table 1

Framework for shared epistemic agency

Epistemic dimension	Regulative dimension
Collecting information (i.e., scientific evidence) from various sources, concretized in the exploration of sources as a starting point in the process of creating one's own ideas	Common goal setting, making (long range) plans of action, displaying a proactive attitude
Sharing of ideas and knowledge through exchange of insights	Regulation of epistemic activities with some emphasis on coordination and monitoring of group activities and showing responsibility for own learning through monitoring the advancement of collective activities and overcoming challenges emerging in the process.
Structuring ideas to create the basis for further epistemic endeavours	Collaboration that values personal-relational aspects that mediate problem solving and mutually constructing knowledge
Producing new ideas through participation in epistemic collective discourse	

Damşa et. al (2010) refined the definition of shared epistemic agency to “a capacity that enables groups to deliberately carry out collaborative, knowledge-driven activities with the aim of creating shared knowledge objects” (p. 154). Their writing did not illuminate how epistemic agency is stimulated and supported, hence the need to demonstrate how epistemic agency is engendered in spaces of education.

Actions Taken to Investigate the Research Problem

This is a report on an ethnographic study that took place in my class as part of a study that sought to know what was happening in my lecture halls. As agency in educational settings is commonly investigated through an analyses of interactions (Wagner, 2007), ethnography allowed me to gain both an insider's and outsider's understanding of students' experiences through interactions that took place in the natural setting of lecture halls and also from emic (from participants') and etic (from observer's) perspectives, respectively (Morris, Leung, Ames, & Lickel, 1999). This approach also enabled me to be an active participant observer who wrote field notes through re-storying critical incidences of class occurrences as a habit I had developed in my quest to understand what happens in my, (i.e. an etic) perspective. The critical incidences were:

...distinct occurrences or events which involve two or more people; they are neither inherently negative nor positive, they are merely distinct occurrences or events which require some attention,

action or explanation; they are situations for which there is a need to attach meaning. (Fitzgerald, 2000, p. 190)

In this context, the incidences were unplanned and unanticipated events, where students took responsibility over their own advancement of understandings, which were remembered vividly, and used to illustrate emergence of epistemic agency in a mathematics for education classroom. This was a class of about 200 student teachers who co-constructed, integrated and modified ideas collaboratively, in groups. These student teachers were in their third year of study. The incidences were later analysed using Polkinghorne's (1995) analysis of eventful data. Using narrative analysis, I was able to make sense of particular experiences and narrate them in such a way that a reader could comprehend why and how things happened the way they did (Kim, 2015).

My Perspective on the Data Constructed

The narratives presented below show, firstly, an instance of enactment of agency that was mainly directed by students, while the second narrative had tensions that resulted from resistance to epistemic agency. In both instances, an analysis of how agency is engendered is done.

Using students' questioning to extend their knowledge

In the narrative that follows the class was discussing a problem that was brought to me by Hlako (a false name) because he did not understand how the partial sum of the series $\sum_{n=1}^{\infty} \left(\frac{1}{n} - \frac{1}{n+3} \right)$ is $s_n = \frac{11}{6} - \frac{1}{n+3}$. He had worked out the problem and found $s_n = 1 - \frac{1}{n+3}$. I did not work the problem out with him in order to shift authority on who creates knowledge but took the task to the next class for students to try and solve. The intention was to allow Hlako to compare his answer to the answer that his peers obtained. In addition, part of what I do with students is to try and avoid a situation where students view lecturers as consultants because I think that this would deny them their epistemic autonomy, which is not good for growing an epistemic community (Elgin, 2013).

The students in the next class worked out the problem and found the same answer as that provided by Hlako. During the rounds that I had taken as the students were solving the problem, either individually or as groups, I noticed that they expanded the series as follows

$$\sum_{n=1}^{\infty} \left(\frac{1}{n} - \frac{1}{n+3} \right) = \left(\frac{1}{1} - \frac{1}{4} \right) + \left(\frac{1}{2} + \frac{1}{5} \right) + \dots + \left(\frac{1}{n} - \frac{1}{n+3} \right) = 1 - \frac{1}{n+3}$$

This did not come as a surprise to me because the students drew on their deductive systems to do what they did. They had worked with similar tasks and, because of their periodicity for terms to cancel each other, they would get the desired outcome after one period of adding terms. I then wrote the common answer on the board so that I could check whether there was a different answer from this. Presumably this was the answer that most students obtained because it was a ‘met before’ from telescopic series - “what the individual thinks now as a consequence of experiences that have been met-before” (McGowen, & Tall, 2010, p. 169). In the context of agency, the student behaviour could result from expected patterns of actions that were established through harmonic series the students had been exposed to, i.e. disciplinary agency (Pickering, 1995).

As a result, I requested the students to observe what would happen if the series were to be expanded using more terms than the ones that they had used. With reluctance from a few, some students expanded the series further to the one below.

$$\sum_{n=1}^{\infty} \left(\frac{1}{n} - \frac{1}{n+3} \right) = \left(\frac{1}{1} - \frac{1}{4} \right) + \left(\frac{1}{2} - \frac{1}{5} \right) + \left(\frac{1}{3} - \frac{1}{6} \right) + \left(\frac{1}{4} - \frac{1}{7} \right) + \dots + \left(\frac{1}{n} - \frac{1}{n+3} \right) + \dots$$

At this stage students eagerly reported that, in this sum, the terms start cancelling in the fourth round. I asked them if that was all they observed. Ultimately many students became aware that the fixed terms were $1, \frac{1}{2}, \frac{1}{3}$ through the expansion below.

$$s_n = \left(\frac{1}{1} - \frac{1}{4} \right) + \left(\frac{1}{2} - \frac{1}{5} \right) + \left(\frac{1}{3} - \frac{1}{6} \right) + \left(\frac{1}{4} - \frac{1}{7} \right) + \left(\frac{1}{5} - \frac{1}{8} \right) + \left(\frac{1}{6} - \frac{1}{9} \right) + \left(\frac{1}{7} - \frac{1}{10} \right) + \dots + \left(\frac{1}{n} - \frac{1}{n+3} \right)$$

They wrote their sum as $s_n = \frac{11}{6} - \frac{1}{n+3}$. There was a group, Group A, that did not agree with this answer because their partial sum was $s_n = \frac{11}{6} + \frac{1}{n}$. They explained that, if they reversed the process of cancellation at the end of s_n in a similar way as they did at the beginning, then $\frac{1}{n+3}$ would cancel out and $\frac{1}{n}$ would remain. Immediately thereafter, without any further prompt from me, almost all students started writing to either justify the explanation or check its correctness. Such behaviour can be viewed as a social norm of interaction in this class, in other words, a sociomathematical norm. The same group later refuted their answer and changed it to $s_n = \frac{11}{6} - \frac{1}{n+3}$ and most students agreed with them. In solving the problem, another group, Group B, extended this response. They said that they partly agreed with Group A but conjectured that, since $\frac{11}{6}$ in the partial sum was obtained from the sum of three terms, they expected the last term of the partial sum to behave in a similar way. Using Mueller et al.’s

(2012) modes of collaboration, this was modification of arguments, since it was meant to augment what Group A had said. They requested to be given time to show that this was the case, an indication that the construction of knowledge and understanding lay with the students. It also showed that Group B was willing to justify their conjecture for other students to accept. Ultimately, the group showed that the partial sum ended with the sum $\frac{1}{n+1} + \frac{1}{n+2} + \frac{1}{n+3}$ that resulted from the expansion illustrated below.

$$\left(\frac{1}{n-5} - \frac{1}{n-2}\right) + \left(\frac{1}{n-4} - \frac{1}{n-1}\right) + \left(\frac{1}{n-3} - \frac{1}{n}\right) + \left(\frac{1}{n-2} - \frac{1}{n+1}\right) + \left(\frac{1}{n-1} - \frac{1}{n+2}\right) + \left(\frac{1}{n} - \frac{1}{n+3}\right)$$

By so doing, Group B showed that the obligation to author and critique students' ideas could come from students themselves. Additionally, this showed that the responsibility of coming up with more mathematically elegant solutions to tasks lay with students. The rest of the group started talking to each other about this response, while others copied it. While the students were busy deliberating among themselves on Group B's presentation, I waited until the discussions subsided. These deliberations between students in groups may be the mathematical neighbouring interactions that are required for mathematics classrooms to become mathematics communities (Davis & Simmt, 2003). We ended working on the problem by testing for convergence of the series $\sum_{n=1}^{\infty} \frac{3}{n(n+3)} = \sum_{n=1}^{\infty} \left(\frac{1}{n} - \frac{1}{n+3}\right)$ using the limit of its partial sums.

Resisting epistemic agency

In the following, I show how resistance is enacted as a result of a challenge that a student faced when working on an item from the activity that was given. Excerpt 1 shows how the conversation between the student and myself started.

Excerpt 1

- 1.1. S2: There is a problem in this manual which cannot be done.
- 1.2. L: Let us have a look at it
- 1.3. S2: (*reluctantly looks for it*). Will you show me how it is done?
- 1.4. L: no. I first have to see your attempts at it
- 1.5. S2: aah. (*showing some annoyance*)
- 1.6. S3: take it out. Let's show her

The conversation is initiated by S2, who had reached an impasse when working on an exercise that 'cannot be done'. Using the view that agency is the capacity to act in order to effect change, the gesture by S2 in initiating a conversation can be viewed as agentic. One gets an impression that he wants confirmation that exercise cannot be done. On the other hand, there seems to be an impression that he was not willing to show us how he reached the conclusion that the problem could not be solved. While S2 showed that he had made efforts towards some learning,

in the context of agency, he can be perceived as resisting ownership of his effort and advancing his understanding.

After this conversation, S2 claimed to have left his scribbler at home. I then requested him to write down his recollection of what he had done. In response, he claimed to have forgotten how to do it. This can be seen as an act of resistance of agency, i.e. resistance to be either engaged in solving the problem or being involved in getting to a solution. At this stage I left the group with the instruction that they should show me how they would work out the problem.

While this may be naively viewed as a situation of defiance by S2, this could be an instance in which a student falls short on expected student agency. This may be a result of genuine destabilisation of expectations that, if a problem is presented to a lecturer by a student, then the lecturer should work it out for the student. But this narrow view of interacting with students for repairing trouble sources is discouraged in learning spaces (van Lier & Matsuo, 2000). If left unchallenged, students may judge epistemic value as epistemically inappropriate (Riggs, 2003). On the other hand, the instruction that the students work on the problem may suggest that students were afforded a chance to learn from each other, in the hope that there may be a competent other in the group. Unfortunately, this approach to teaching may clash with students' approaches to learning.

Later, I returned to the group and requested to observe progress made, by the group, on the same problem. This time S2 showed me the equation that he could not do. The following is a conversation that transpired.

Excerpt 2

2.1. S2: Okay. It is here

Show that $\frac{d}{d\theta}(\sin^3 x \cos x) = \sin^2 x (4 \cos^2 x - 1)$

2.2. S2: I tried it from the left hand side and the right hand side. It does not work

2.3. L: Let me see what does not work

2.4. S4: You are not going to see anything. (*this is said laughingly*)

2.5. L: Call me when you are ready.

2.6. S2: S4 has done something for us. I don't think you will accept it

2.7. L: why?

2.8. S2: I don't think it is right

2.9. S3: S4, show her what you did (*S4 takes out his work for me to see*)

$\frac{d}{d\theta}(\sin^3 x \cos x) = \frac{d}{d\theta} \sin x \sin x \sin x \cos x$

$= \sin x \sin x \cos x \frac{d}{d\theta} \sin x + \sin x \sin x \cos x \frac{d}{d\theta} \sin x + \sin x \sin x \cos x \frac{d}{d\theta} \sin x + \sin x \sin x \sin x \frac{d}{d\theta} \cos x$

$= \sin x \sin x \cos x \cos x + \sin x \sin x \cos x \cos x + \sin x \sin x \cos x \cos x - \sin x \sin x \sin x \sin x$

$= 3 \sin^2 x \cos^2 x - \sin^4 x = \sin^2 x (3 \cos^2 x - \sin^2 x) = \sin^2 x (3 \cos^2 x - (1 - \cos^2 x))$

$= \sin^2 x (4 \cos^2 x - 1)$

2.10. L: take me through this

2.11. S4: this is the product rule

2.12. S3: I don't understand this. It is too long.

2.13. S2: will you accept this?

2.14. L: why not?

- 2.15. S2: I have never seen such a product rule.
2.16. L: did you study what he did?
2.17. S2: but I did not do it this way
2.18. L: let's see what you did
2.19. S2: I do not get the answer
2.20. L: let's see

The excerpt begins with S2 as the interlocutor who initiated the conversation. This time he showed me the problem that he could not solve. S2 continued to claim that he worked on the problem but found that he could not show that the equality of the equation holds. He still did not want to show me his written work, which is a possible indication of poor self-image caused by discomfort with the content knowledge he needed to do the work. S2's involvement in this interaction can be said to be transactional as he was not engaged in the process of learning. Appropriating from the van Lier (2008) definition of agency, S2's actions and the initiative are not conducive for his learning to occur. Hence S2 hindered the emergence of individual epistemic agency, which possibly resulted from S2 not valuing inquiry as an epistemic goal (Duschl, 2008)) and, thus, resisting the expression of his epistemic agency.

As I was about to leave the group again, S2 invited me to evaluate what one of the students in the group, S4, had done for them. The use of the phrase "for us" by S2 may suggest that the solution was a collaborative output. All the same, S2's utterance showed that he did not expect me to agree with the answer shown because he did not necessarily agree with knowledge that the group generated. He did not construct his disagreement but seemed to expect me to resolve it, an indication of the promotion of epistemic authority to a teacher. This can be viewed as another instance where S2 refrained from carrying out actions that would provide him an opportunity to demonstrate epistemic responsibility. He did not engage in a negotiation of meaning, so that which was not comprehensible could be comprehended. It can thus be asserted that S2 was not able to see the opportunity to communicate his ideas that was offered to him by moving out of initiation-response-feedback (Waring, 2009).

The conversation in the excerpt continues in the same vein of disagreeing with what S4 had presented to the group. This, regardless of the nature of the problem, afforded the participants an opportunity to master a solution that required complex higher order mathematical thinking. Furthermore, the solution presented, afforded the two students an opportunity to share their thinking, reasoning and, thus, expand their understanding of the product rule of differentiation. Nevertheless, the interlocutors, S2 and S3, were not receptive to the procedure that S4 offered because it was either too long (S3) or because they had never seen the rule of differentiating products extended to four functions (S4). When encouraged to study the solution, S3 was reluctant to do so because the solution was not the same as his solution. These occurrences,

that could result from either an inappropriate level of required knowledge (Brookfield, 2015) or attributional biases (Choo, 2016), can be perceived as closing affordances for epistemic agency to emerge, i.e. resistance. Such resistance is a hindrance to shared epistemic agency, defined as the “capacity that enables groups to carry out collaborative knowledge-based activities that lead to a shared outcome” (Damsa, et. al., 2010, p. 154)

Ultimately, with extended waiting time, (Ingram, & Elliott, 2016) by both the group members and myself, S2 showed us what he had done, as follows.

$$\begin{aligned}\frac{d}{d\theta}(\sin^3 \theta \cos \theta) &= \cos \theta \frac{d}{d\theta} \sin^3 \theta + \sin^3 \theta \frac{d}{d\theta} \cos \theta = \cos \theta 3 \sin^2 \theta \cos \theta - \sin^3 \theta \sin \theta \\ &= 3 \sin^2 \theta \cos^2 \theta - \sin^3 \theta \sin \theta\end{aligned}$$

The presented solution, though correct, was not sufficient to solve the given problem. Apparently S2 could not simplify the expression he ended with and, thus, perceived that the problem could not be solved. The interaction in Excerpt 3 followed after the group studied S2’s solution.

Excerpt 3

- 3.1. S2: this is what I got
- 3.2. L: but you have done it
- 3.3. S2: no
- 3.4. L: yes
- 3.5. S4 *laughs endlessly till he says:* you want her to complete it for you. You have the answer. Look at it.
- 3.6. S3: L, go. I will show him what to do
- 3.7. S2: No. I know what to do. Eish.
- 3.8. L: what was your problem?
- 3.9. S2: I don’t know. I just thought I was wrong. I thought I could not go any further.
- 3.10. L: what was your problem?
- 3.11. S2: I could not go any further. I wanted to work with the right hand side. I wanted to do what is right.

By showing the group what he had written, S2 offered himself an opportunity to participate in the learning process (Geeslin, 1977). Initially he did not accept that what he had done was mathematically acceptable. It can be claimed that this resulted from close-mindedness on his part, an epistemic vice that hypothetically misrepresents ones motivation for knowledge, thus compromising successful knowledge development that is dependable (Choo, 2016).

Project outcomes

The study reported here was conducted to shed light on how epistemic agency is enacted in a collaborative mathematics for education class at a university in South Africa. The first critical incident shows collaboration efforts that can be classified as agentic as a result of collaborative construction of knowledge (Mueller et al., 2012). Such knowledge was advanced when students worked together to co-construct, modify and integrate their ideas. This process allowed the

students to assess each other's ideas, which is a requirement for epistemic responsibility (Morton, 2014). This display of self-efficacy, i.e. an ability to meet challenges and complete tasks (Akhtar, 2008) as well as the display of conceptual agency (Pickering, 1995), was enabled as the traditional lecturer's role was dispensed with in order to allow students to take charge of decision making. This is in line with Scardamalia's (2002) observation that, in order for students to be able to actively participate in knowledge production, they should be expected to take control of the strategic activities involved in learning.

The second critical incident epitomised an epistemic disclaimer (Lindström, & Karlsson, 2016), evidenced in one student's refusal to show their work. This did not mean that the student did not know anything but, as Lindström and Karlsson argued, this showed resistance to something where the disclaimer serves as a border. The narrative of the incident shows that one of the ways of working with an epistemic disclaimer is waiting time (Rowe, 1972), which is beneficial in encouraging students to overcome epistemic resistance. Though there are counter arguments for extended waiting time, this study showed that, in instances where epistemic responsibility is engendered among agents, waiting time can be longer than the recommended time of one to three seconds that is recommended in the Initiation–Response–Feedback framework (Ingram, & Elliott, 2016).

It should be notable that I did not orchestrate either of the critical incidences. As such the traditional role of authoring what knowledge should be built and lecturer serving as a consultant to students was traded off to enable enactments of epistemic agency. The project has made me aware of possible affordances and hindrances in creation of higher education classroom learning environments that promote epistemically responsible students. Similar projects may propose explicit ways to deal with them. All the same I acknowledge that studying one's own classroom is a daunting experience that requires shedding one's inhibitions.

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