Letting Mechanistic Reasoning Emerge: Pre-Service Teachers' Scaffolding Strategies in Primary School Classrooms

Víctor Grau-Torre-Marín, Isabel Jiménez-Bargalló, Jordi Martí-Feixas

Universitat de Vic-Universitat Central de Catalunya, CODI Research Group

Abstract

This preliminary study explores the opportunities that pre-service teachers (PSTs) give to primary students (PS) to use mechanistic reasoning to give causal explanations of investigated phenomena. Last year undergraduate PSTs performed short inquiries with primary school children within the facilities of the University. Those classroom inquiries were systematically videotaped and used for developing students' self-reflection to foster their professional development. For the pursuit of this study we analyzed videos from these classroom inquiries where PSTs and PS interactions aimed at constructing explanations of observed phenomena. Specifically, our analysis focused on: (a) what makes mechanistic reasoning appear; (b) which kind of pedagogical moves, responses and resources did or use PSTs in these moments to support and scaffold this kind of reasoning. Results provide insights on characteristics of those interactions helping to determine how they can expand, maintain or shut down opportunities for PS' mechanistic reasoning. Implications for further research are presented.

Keywords: primary school science; pre-service teachers; responsive teaching; mechanistic reasoning

1. Theoretical framework

Many international reports on the state of science education highlight the role of scientific reasoning and explanations in primary school science [e.g. 1]. In this study we focus on one particular type of explanation and reasoning appropriate for scientific understanding: that involving causal mechanism.

Mechanistic explanations are non-teleological explanations, which focus on the cause-effect relationships underlying a phenomenon, and thereby take into account how the activities and properties of the constituent components influence one another [2]. Mechanistic is a powerful thinking strategy, since it allows constructing scientific explanations and make testable predictions about natural phenomena. Supporting student in using such reasoning skills helps, therefore, in the development of scientific work and the knowledge building [2, 3].

All students come to school with resources for understanding and using scientific knowledge, reasoning scientifically, and participating in scientific practices and discourse [4]. Specifically, research with children affirms that mechanistic reasoning is present and episodic even in the discourse of young students [2]. However, their progress depends, largely, on whether and how teachers pay and give attention to these resources. In this sense, there is growing consensus on the importance of teachers having the ability to elicit, recognize, interpret and leverage student thinking by tailoring instruction to these leaner's ideas [2,5]. This approach is characterized as "responsive teaching" [5, 6].

It is not easy to establish a classroom dynamic through which children's reasoning becomes the building blocks for scientific understanding. A growing number of studies acknowledge the challenges and tensions teachers face when having to attend and respond to their students' thinking in science primary classrooms [6,7,8]. Since these difficulties occur, it is essential to intervene at an early stage, providing opportunities for PSTs to learn such skills at their university courses. Research to understand how teacher's responsiveness evolves and how to support it is also required.

2. Objectives

This exploratory study examines PSTs' responsiveness by exploring their abilities and/or difficulties to make explicit, recognize, interpret and support PS's mechanistic reasoning while teaching science. It adds to the literature available by answering the following related questions: (a) what patterns of classroom interactions do emerge when PSTs try to attend student thinking aimed at constructing explanations of observed phenomena? (b) what makes mechanistic reasoning appear?; (c) which kind of pedagogical moves, responses and resources use PSTs in these moments to support and scaffold this kind of reasoning?

3. Methodology

3.1 Context of study

This study is part of a larger ongoing investigation on responsive teaching, which has been carried out within the framework of the "Escola-Universitat" project performed by the Universitat de Vic-Universitat Central de Catalunya. Within this project, 143 PST's performed short inquiries with primary school children within the facilities of the University. Those classroom inquiries were systematically videotaped and used for developing students' self-reflection to foster their professional development.

3.2. Data sources and analysis

Data presented here illustrate two representative classroom dynamics. CASE A exemplifies a typical responsive dynamic. On the contrary, CASE B depicts a poor one. In case A PSTs prepared and conduct a short inquiry cycle to explain natural phenomena regarding air pressure. The scientific concept underlying the investigations in case B was thermal conductivity of different materials. In both cases participants were 8-9 years old PS of two different schools who were observed, videotaped and audiotaped over four 1h sessions.

Transcripts of all class periods were prepared and analysed in a series of iterative cycles. Since our interest relies on pre-service responsiveness, only whole group talk is considered here. We used Russ's framework [2] to identify mechanistic reasoning and its quality. We also coded the transcripts using Michaels and O'Connor framework [9] to identify goals of conversation and talk moves that could allow us to identify: (a) what makes mechanistic reasoning appear and (b) which kind of pedagogical moves, responses and resources use PSTs in these moments to support and scaffold mechanistic reasoning. Authors independently coded transcripts and discussions were held until consensus was reached on definitions of patterns and coding text.

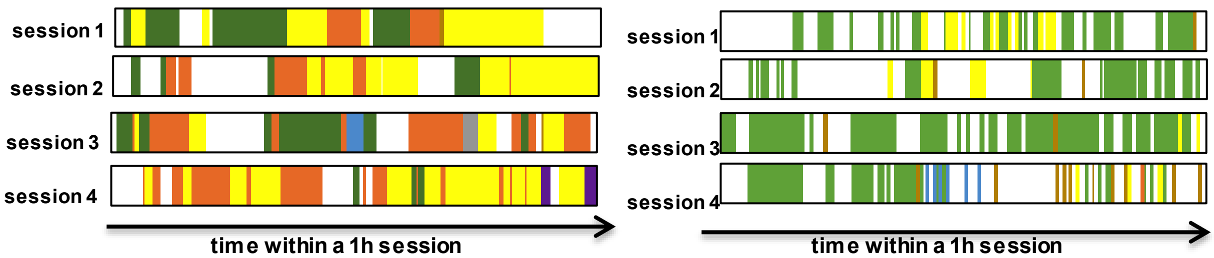
4. Results-discussion

Analysis allowed to identify 8 different patterns of classroom interaction, described in table below.

Colour	Description	Example
(green)	Conversations that led to the establishment of observable relationships between variables (pattern seeking). Such conversations begin after a "what happens" or a "why does it happen" PSTs demand.	*Case A, session 2, trying to explain why can we inflate a balloon within a bottle with a hole but we cannot inflate it when there's no hole.* - ***PST**: (…). Ok, then, does someone know why does it happen? [different students rise hands] Someone who hasn't talked before…* - ***Student N:** it happens because the bottle…* ...[6" pause]… *without a hole, air cannot go out.*
(yellow)	PT support and build on PS' ideas to construct mechanistic explanations by helping them to identify entities, properties and/or activities involved in phenomena and to promote chaining in explanations.	*Case A, session 3, trying to explain why can we inflate a balloon within a bottle with a hole but we cannot inflate it when there's no hole. In this example, student establishes an initial relationship and PSTs intervention aim to identify entities involved in phenomena.* - ***PS M:** that the balloon inflated, and squeezed the bottle where there was air inside… and it [referring to the air] went out.* - ***PST**: why did it "squeezed" the bottle?* - ***PS M:** it pushed down…* - ***PST**: but, what were we doing? [pointing a kid who rising his hand]* - ***PS F:** inflate the balloon* - ***PST**: ok… then, what did we put into the balloon?* - ***PS F:** air* *(…)*

	PS expose mechanistic explanations for a phenomenon at request of PSTs. There's not a follow -up conversation guided by PSTs to complete or expand this mechanistic reasoning but just to make it clear and shared. -	*Case A, session 3, student tries to explain why a cardstock paper stuck at the bottom of an upside down glass of water by establishing a balance between air pressures* - ***PST****: (…) why do you think the cardstock stuck or doesn't stuck? [pointing at a student] just say! Laud… so that anyone can hear [student does not say anything] Whoever wants…* - ***PS L:*** *Air pressure…. air pressure outside the cardboard makes it stick a little… and air inside presses out, towards water…* - ***PST****: which one, outside, this one? [pointing at a schema made previously on board by students]* - ***PS L:*** *Yes, this one!! It also makes pressure towards cardboard and it is more or less equal, and when we press the cardboard a little bit it stuck…* - ***PST****: ok, then, this force [drawing arrows indicating pressure towards cardboard]… like this?* - ***PS L:*** *The over from top to bottom and this one in this direction…* - ***(…)***
	PSTs expose mechanistic explanations of observed phenomena w ithout taking into account PS' ideas taking a transmissive approach. There's no classroom dialogue, just teacher exposes.	
	PS express explanations for a phenomena using analogies, making a parallel w ith other phenomena.	
	Classroom management conversations.	
	Epistemic conversations (aimed to distinguish betw een conclusions and explanations, explain w hat are variables, etc.)	
	Conversations betw een PSTs and PS aimed to identify key ideas.	

In order to visualize the structure and evolution of these classroom interactions through the inquiry teaching sequence, graphic representations were created. Using the above colour codes, episodes of whole group talk with the same pattern were identified and delimitated.



Case A: inquiry classes with a responisve dynamic **Case B: inquiry classes with a non-responsive dynamic**

In case A inquiries with a responsive dynamic, classroom interactions that led to mechanistic reasoning increase over time. PSTs seem to have sound epistemic knowledge clearly distinguishing between moments that seek to establish conclusions after experimentation (green patterns) and those aiming to explain phenomenon (yellow-orange). Therefore, PS' mechanistic reasoning (orange-yellow) usually appears after a "why does it happen" PSTs demand, while green patterns appear after a "what does it happen" demand. In such inquires, blue patterns aim, precisely to help PS make this distinction. Furthermore, PSTs seem to see PS' ideas as to be observed-interpreted in order to build on them. Thus, after initial PS' simple explanations, PSTs discursive actions seek that PS recognize entities, properties, activities… that they had not initially contemplated [2,9]. Discursive actions to share ideas are also common through the whole sequence. Consequently, a slight sophistication of PS' explanations and the participation of many more PS on final sessions is also observed.

PSTs in case B inquiries use "what happens?" questions to either ask for a conclusion or an explanation. Furthermore, when they ask "why does it happen" and PS answer establishing observable relationships between variables they accept the answer, cutting opportunities for mechanistic explanations to emerge (abundance of green pattern). Yellow patterns appear at a lower frequency and are of shorter duration. PSTs seem to consider students' ideas as indicator of students' learning. Therefore, any children's initial explanation that does not suit canonical explanations is cut off. Difficulties to identify step stones in PS reasoning and to use discursive actions to enhance it are constant. PSTs just emphasize when ideas are correct and rejects/dismiss errors. Finally, they explain phenomena to students (large presence of brown patterns).

5. Conclusions

This study illustrates basic patterns of classroom interaction that enlarge, sustain or, on the contrary, close down opportunities for PS mechanistic reasoning in relation to PSTs “in the moment” responsiveness. Results from this small-scale study are illustrative of some of the phenomena highlighted in other, similar studies in mainstream education [7,8]. Further research should be performed in order to deep on causes to explain difficulties to promote this PSTs “in the moment” responsiveness that enhances mechanistic reasoning to occur.

6. References

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