Proceedings

of the 45th conference of the international group for the psychology of mathematics education

July 18-23, 2022

EDITORS

Ceneida Fernández / Salvador Llinares
Ángel Gutiérrez / Núria Planas

VOLUME 2

Research Reports (A – H)

PME 45
Alicante · Spain · 2022

Universitat d'Alacant
Universidad de Alicante

Proceedings of the 45th Conference of the International Group for the Psychology of Mathematics Education

Alicante, Spain

July 18 – 23, 2022

Editors:

Ceneida Fernández

Salvador Llinares

Ángel Gutiérrez

Núria Planas

Volume 2

Research Reports

A – H

Psychology in Mathematics Education
(PME) Conference
18-23 July 2022
Alicante, Spain

Website:
https://web.ua.es/pme45

Cite as:

Fernández, C., Llinares, S., Gutiérrez, A., & Planas, N. (Eds.) (2022). *Proceedings of the 45th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 2). Alicante, Spain: PME.

Website: https://web.ua.es/pme45

Proceedings are also available on the IGPME website:
http://www.igpme.org

ISBN: 978-84-1302-176-8

Legal Deposit: A 289-2022

ISSN 0771-100X

Printed by Universidad de Alicante.

Logo designed by the Gabinete de Imagen y Comunicación Gráfica (Universidad de Alicante)

DIFFERENCES IN TEACHER TELLING ACCORDING TO STUDENTS' AGE

Markus Hähkiöniemi,[1] Antti Lehtinen,[1,2] Pasi Nieminen,[1] and Salla Pehkonen[1]

[1]University of Jyväskylä, [2]University of Jyväskylä,

Teacher telling can support but also hinder learning. In inquiry activities, telling that removes productive struggle may be problematic. In this study, different aged students experimented in a digital learning environment to build rules for a balance beam. We examined how the amount of teacher telling vary according to students' age and the sophistication level of the rule. We collected video data from 21 pre-service teachers when each of them guided eight, 10, and 12 year old students. We found that the amount of teacher telling generally was not related to students' age. However, when considering teacher guidance for more sophisticated rules, teacher telling was related to students' age. Thus, the focus of the guidance is an essential factor affecting telling and teachers may have pressure for guiding students towards a high-level product.

INTRODUCTION

There seems to be consensus that students need some support or *guidance* in inquiry activities (Lazonder & Harmsen, 2016). One essential dimension in guidance is the degree of students' *autonomy* (Vorholzer & von Aufschnaiter, 2019). On one hand, detailed instructions in performing something may remove student autonomy. On the other hand, sometimes non-specific guidance such as open or general questions do not offer enough help for students. Olsson and Granberg (2019) presented evidence that students are more able to perform an inquiry activity when having detailed instructions than those who received more open task. However, they also found that the learning results were more durable for those who were able to perform the open task.

One type of detailed guidance is *teacher telling*, in which the teacher provides full information or explanation to some issue leaving no autonomy for students in examining or working on this issue. Teaching mathematics solely through telling is against many recommendations (e.g., NCTM, 2000) and, particularly in inquiry activities, it hinders the underlying idea of students investigating mathematics. However, also completely avoiding telling is problematic. Smith (1996) suggests that avoiding telling may affect negatively on teachers sense of efficacy. Furthermore, Chazan and Ball (1999) point out several instances in which teachers may need to tell. Indeed, Baxter and Williams (2010) found that two teachers' teaching aligned with reform mathematics in many ways and the teachers at times strategically engaged in telling. Furthermore, Ding and Li (2014) suggest the need to flexibly use both direct guidance and facilitating guidance.

Thus, the literature suggests that productivity of telling depends on the context including the students, the mathematical issue, the purpose of telling and the point in

2022. In C. Fernández, S. Llinares, A. Gutiérrez, & N. Planas (Eds.), *Proceedings of the 45th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 331-338). PME.

time. *Productive struggle* is a concept that may help to consider telling. According to Hiebert and Grouws (2007), in productive struggle, students expend effort to make sense of mathematics. Thus, we can consider whether telling increases or decreases productive struggle. In an inquiry activity, telling may increase productive struggle, for example, if the teacher tells the meaning of a mathematical concept and students ponder how to apply the concept. On the contrary, telling may decrease or even remove productive struggle, if the teacher tells the steps how to achieve a particular result.

Finally, Lobato et al. (2005) suggest considering the function of telling instead of the form of telling. The teacher may introduce information in the form of questions or in the form of declarative statements. For example, a series of questions can introduce an idea to students.

An underexamined issue in teacher guidance seem to be the relation between guidance and students' age. In their review of studies of inquiry-based learning in mathematics and science, Lazonder and Harmsen (2016) cautiously note that younger students may benefit from more specific guidance. They call for more studies in teacher guidance of different aged students, particularly when a same task is used with students of different age. Songer et al. (2013) found that while some kind of guidance was used similarly with younger and older students, more specific guidance (e.g., turning an open-ended question into a few multiple-choice options) was used with younger students. As there exists suggestions that more specific guidance might be suitable for younger students, it may be that teacher telling is used differently depending on students' age. In this study, we focus on this issue taking into account Lazonder and Harmsen's (2016) recommendation of using the same task with students of different age.

In this study, the same inquiry activity was used in grades 2 (8 year old), 4 (10 year old), and 6 (12 year old). In the activity, the students experimented in a digital learning environment to build rules that describes an equilibrium state for a balance beam. As several rules of different sophistication level are possible, the activity is suitable for the different grades and teachers may need to guide students differently. In this paper, we focus on teacher telling that decreases productive struggle by removing student autonomy in considering a particular rule as we hypothesize that this may happen more often with younger students and with more sophisticated rules. The following research questions guided the analysis:

- How does the amount of teacher telling vary according to students' age?
- How does the amount of teacher telling vary according to sophistication level of the rule with different aged students?

METHODS

Context

We developed a digital learning environment involving dynamic representations. In this environment, students work to construct a rule or several rules that can be used to find an equilibrium state for a balance beam. Using dynamic representations made with

GeoGebra, students can experiment with a balance beam where two birds with varying weights can be placed on different sides of the fulcrum at different distances from the fulcrum (Fig. 1). The environment contained a laboratory where students could explore rules in an open setting and tasks in which they were supposed to use their rules. Usually, students first build less sophisticated rules such as 'same weights and same distances' before more sophisticated rules such as 'the product of the weight and the distance on both sides are equal'.

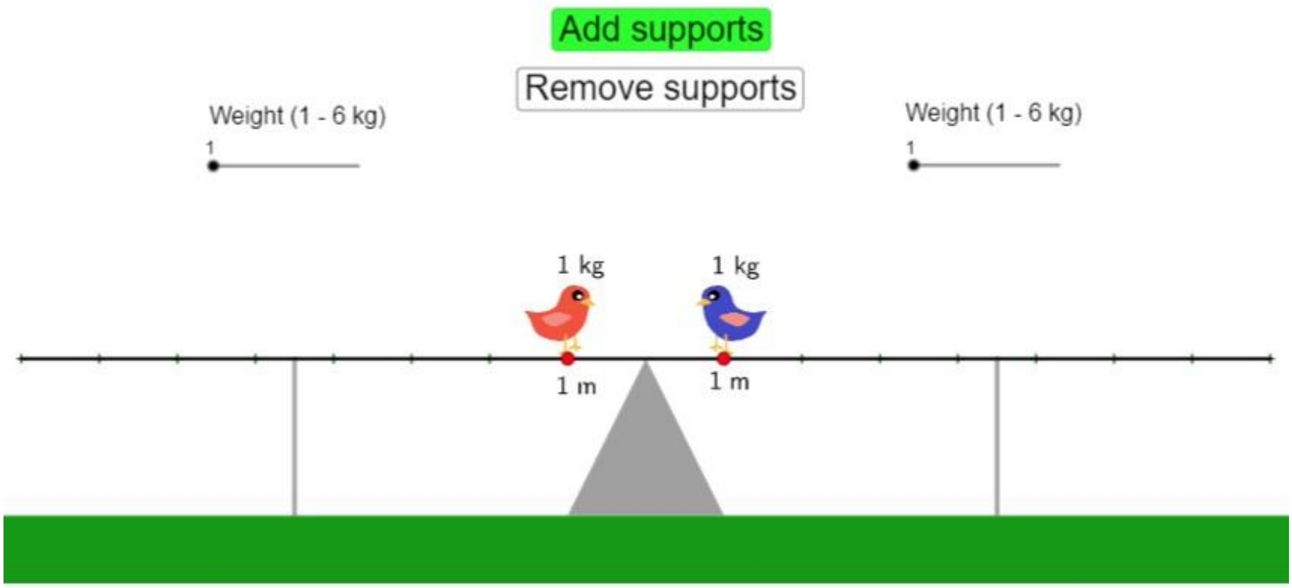

Fig. 1: The dynamic representation for exploring the rule for balance

The students worked in groups of three students for 40 minutes. Each group had one pre-service primary school teacher guiding their work. Each pre-service teacher guided one second grade, one fourth grade and one sixth grade group at different times. The pre-service teachers participated in a course in which they were prepared to guide students. For example, they used the same environment as students and discussed various kinds of rules for balance that are possible to build. Discussion also included pedagogical ideas, such as building on students' thinking even though the students would not be heading towards the most sophisticated rule.

Data collection

Altogether 21 pre-service teachers (hereafter shortly teachers) participated the study. Thus, data was collected from 21 second grade, 21 fourth grade, and 21 sixth grade groups that had three students in each group.

The screen of each student group's laptop was recorded using screen capture software. The software also captured audio from the laptop microphone and video from the laptop webcam in sync with screen capture. In addition, a small action video camera recorded the group from the side to enable the recognition of gestures and the person who is talking. All these data sources from each group were synchronized in one video file.

Data analysis

Data was transcribed, and the data analysis used transcript and video in parallel. First, we identified episodes in which students either tried to balance the beam or reflected on the result of trying to balance the beam. For each episode we coded whether the rule was expressed (partially or completely) or not. We further coded the sophistication level of the expressed rule as presented in Table 1.

	Description	Examples
Proportional rule	The rule consists of a correct relation between the proportion of masses and proportion of distances expressed in any form with or without symbols or variables.	Weight times distance equals on both sides. The weight is halved, and the distance is doubled. 9 kg / 3 kg = 3 and 6 m / 2 m = 3
Other rule	The rule consists of correct qualitative properties or the rule consists of non-generalizable relations between the variables.	The heavier bird is closer, and the lighter bird is further away from the fulcrum. If the weight is doubled, the distance between the birds is increased by one.

Table 1: Codes for the sophistication level of the rules for balance

Then, we selected episodes in which a rule was expressed and the teacher guided the students in building or using the rule. Thus, we omitted other kinds of guidance that could relate to, for example, use of the environment. If an episode contained teacher guidance related to a rule, we coded whether the guidance included telling that removes student autonomy related to building or using the rule (Table 2).

The reliability was tested with two coders. In all the dimensions (episodes, expression of rule, rule type, autonomy level), Cohen's kappa coefficient was above 0.80, which indicate that the reliability is very good.

	Description	Examples
Telling	The teacher guidance leaves no choices for the students in building or using the rule. The teacher lays out the essential components of the rule.	Instead of adding, you can divide these two and these two. Series of questions: What could you do to these numbers? Could you multiply them? Then, what about these numbers?

Guiding without telling	The teacher guides building or using of the rule but leaves some choices for the students. The students produce at least some essential component of the rule.	Revoicing a rule that the students expressed. Why did it stay in balance? Does the same rule work here?

Table 2: Codes for teacher telling that removes student autonomy

RESULTS

Table 3 gives the frequencies and percentages of the episodes in which the teacher guided with telling or without telling and the guidance was related to any kind of rule. Table 3 also includes episodes in which the rule was not eventually expressed. A chi-square test of independence showed no statistically significant relation between students' grade and the amount of teacher telling, $X^2(2, N = 752) = 2.449$, p = 0.294. In all the grades, less than 1/5 of the episodes contained telling. In addition, the number of episodes in which teachers guided the students was about the same across the grades, which indicates equal amount of guidance in all the grades.

	Telling		Guiding without telling	
	f	%	f	%
2nd grade	35	16	181	84
4th grade	30	13	202	87
6th grade	35	12	269	89

Table 3: Episodes of teacher telling or guiding without telling related to any rule

To examine if the sophistication level of the rule affected telling, we examined separately episodes in which proportional rules were expressed and episodes in which other rules were expressed. Table 4 gives the frequencies and percentages of the episodes in which the teacher guided with telling or without telling students related to proportional rules. A chi-square test of independence showed statistically significant relation between students' grade and teacher telling, $X^2(2, N = 140) = 8.138$, p = 0.017. In case of proportional rules, telling existed more often in second grade. Half of the episodes in second grade contained telling. In addition, the total amount of episodes differed across the grades, which indicate that younger students less often considered proportional rules.

	Telling		Guiding without telling	
	f	%	f	%
2nd grade	7	50	7	50
4th grade	5	17	25	83
6th grade	17	18	79	82

Table 4: Episodes of teacher telling or guiding without telling related to proportional rules

Table 5 gives the frequencies and percentages of the episodes in which the teacher guided with telling or without telling students related to other rules. A chi-square test of independence showed no statistically significant relation between students' grade and teacher telling, $X^2(2, N = 387) = 2.797$, p = 0.247.

	Telling		Guiding without telling	
	f	%	f	%
2nd grade	27	21	104	79
4th grade	23	16	123	84
6th grade	14	13	96	87

Table 5: Episodes of teacher telling or guiding without telling related to other rules

Based on tables 4 and 5, teacher telling with 2nd grade students was more common in proportional rules than in other rules.

For example, in the following excerpt a teacher tells second grade students the proportional rule in one case when the students have balanced the beam with 12 kg in 1 m distance on the left side and 6 kg in 2 m distance on the right side.

Teacher:	Good, yes. Why did it stay in balance? Let's write this down. Juliana, would you write this?
Juliana:	Yes.
Teacher:	So, why do you think that it stayed in balance?
Alex:	Well, because the other was six, and then because 6 + 6 is 12 (inaudible) it was like half.
Teacher:	Really good observation.
Alex:	And 2 meters.
Teacher:	So 6 + 6 is 12 and 1 + 1 is 2. [Points the screen.] Thus, this is two times the weight of this one and this is two times the distance of this one. Isn't it? Really good. You solved it.

The student noticed the proportion of weights being 1/2 but did not yet connect this to distances. Directly after this, the teacher introduced the proportional rule that included both variables and thus, removed the opportunity for productive struggle related to this rule. After this, the group continued balancing the beam without mentioning the proportional rule.

DISCUSSION

In this study, we examined how the amount of teacher telling varies when the same teachers use the same inquiry activity in different grades. We found that the amount of teacher telling generally was not related to students' age. However, when considering teacher guidance for more sophisticated proportional rules, teacher telling was related to students' age. Thus, it is important to consider the focus of telling when examining telling. As Lazonder and Harmsen (2016) pondered, researchers may accommodate the inquiry tasks to the capabilities of the age group, which hinders the possibilities of noticing age-related differences in guidance. In this study, the task was the same across the grades, which allowed noticing that age-related differences existed when the teachers focused on more advanced issues.

The finding that telling is used more often with second grade students when focusing on the proportional rule, may be an indication of the teachers' pressure to reach the high-level rule. The teachers were introduced to various kinds of rules and were instructed to build on students' thinking even though the students would not be heading towards the most sophisticated rule. Nevertheless, the teachers were aware of the proportional rule and may have felted the need to guide students towards that. When the students have major difficulties, it is challenging to help students but still leave space for productive struggle. If only avoiding telling, the teacher may do nothing to assist the students (Chazan & Ball, 1999) or just asks general questions that do not help students (Hähkiöniemi & Francisco, 2019). However, in case of open problems, that have multiple correct solutions, there is also an option of focusing on less advanced solutions. Similarly, Hähkiöniemi et al. (2013) reported that in an open problem, a teacher directed students to consider an easier subproblem to support student reasoning. In the context of the activity used in this study, teachers could focus on less sophisticated rules if the proportional rule is too challenging for the students. This would still allow the students to engage in the inquiry activity in meaningful way and have productive struggle in building lower-level rules.

Finally, we emphasize that telling can also support inquiry, for example, by reminding students of previous knowledge or by introducing standard notation for students' ideas. We only question the productivity of telling that removes productive struggle from students inquiry. Afterall, the inquiry process is more important than the outcome of the inquiry.

Acknowledgment

This work was funded by the Academy of Finland (project number 318010).

References

Baxter, J. A., & Williams, S. (2010). Social and analytic scaffolding in middle school mathematics: Managing the dilemma of telling. *Journal of Mathematics Teacher Education, 13*(1), 7–26.

Chazan, D., & Ball, D. (1999). Beyond being told not to tell. *For the Learning of Mathematics, 19*(2), 2–10.

Ding, M., & Li, X. (2014). Facilitating and direct guidance in student-centered classrooms: addressing “lines or pieces” difficulty. *Mathematics Education Research Journal, 26*(2), 353–376.

Hiebert, J., & Grouws, D. A. (2007). The effects of classroom mathematics teaching on students’ learning. In J. Frank, & K. Lester (Eds.), *Second handbook of research on mathematics teaching and learning* (pp. 371–404). Charlotte: Information Age Publishing.

Hähkiöniemi, M., & Francisco, J. (2019). Teacher Guidance in Mathematical Problem-Solving Lessons: Insights from Two Professional Development Programs. In P. Felmer, P. Liljedahl, & B. Koichu (Eds.), *Problem Solving in Mathematics Instruction and Teacher Professional Development* (pp. 279–296). Springer.

Hähkiöniemi, M., Leppäaho, H., & Francisco, J. (2013). Teacher-assisted open problem solving. *Nordic Studies in Mathematics Education*, *18*(2), 47–69.

Lazonder, A. W., & Harmsen, R. (2016). Meta-analysis of inquiry-based learning: Effects of guidance. *Review of Educational Research, 86*(3), 681–718.

Lobato, J., Clarke, D., & Ellis, A. (2005). Initiating and eliciting in teaching: A reformulation of telling. *Journal for Research in Mathematics Education, 36*, 101–136.

National Council of Teachers of Mathematics (NCTM). (2000). *Principles and standards for school mathematics*. Reston, VA: NCTM.

Olsson, J., & Granberg, C. (2019). Dynamic software, task solving with or without guidelines, and learning outcomes. *Technology, Knowledge and Learning*, *24*(3), 419–436.

Smith, J. (1996). Efficacy and teaching mathematics by telling: A challenge for reform. *Journal for Research in Mathematics Education, 27*(4), 387–402.

Songer, N. B., Shah, A. M., & Fick, S. (2013). Characterizing teachers' verbal scaffolds to guide elementary students' creation of scientific explanations. *School Science and Mathematics*, *113*(7), 321–332.

Vorholzer, A., & von Aufschnaiter, C. (2019). Guidance in inquiry-based instruction–an attempt to disentangle a manifold construct. International *Journal of Science Education*, *41*(11), 1562–1577.