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Beyond orchestration: Norm perspective in technology integration

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The aim of this study is to bring a socio-cultural dimension to "instrumental orchestration" framework. Our claim is that social and socio-mathematical norms endorsed by teachers are crucial for their pedagogies. A case study was designed to investigate how orchestration types and norms affect each other in technology-enhanced learning environments. Participants are five pre-service mathematics teachers. Data were collected through lesson plans, semi-structured interviews and observations. Analysis of data indicates that there is a two-way interaction between norms and orchestration types. In some cases, norms are determinants of orchestration types used by participants. In other cases, orchestration types challenge participants' endorsed norms.

Keywords: Socio-cultural approach, Social norm, Socio-mathematical norm, Instrumental orchestration.

INTRODUCTION

Recently, mathematics teaching in technology-enhanced environments has been widespread and mathematics teachers are faced with a large number of resources (Drijvers, 2012). Various official curriculum documents around the world emphasise the importance of using technology to support learning (NCTM, 1999, 2000; DfES, 2013a, 2013b). This requires certain knowledge and pedagogy. For example, International Society for Technology in Education describes technology standards and performance indicators for teachers. Teachers should be able to "plan and design effective learning environments and experiences supported by technology" (ISTE, 2000, p. 9).

Teachers play a key role in effective use of technology in the classroom and the way they integrate technology into teaching affects the way students learn mathematics (Ely, 1996, as cited in Besamusca & Drijvers, 2013). Therefore, mathematics teachers and teacher educators should be guided for the design of learning environments using technological tools and resources (Şay, Kozaklı, & Akkoç, 2013).

One of the theoretical frameworks to investigate the use of technological tools in the classroom is "instrumental orchestration" which is based on the framework of instrumental genesis (Trouche, 2004). Considering the literature on orchestration, it can be claimed that this theoretical framework focuses on classroom organisation but fall in short to explain psychological and sociological development of teachers. Teachers and pre-service teachers have different pedagogical approaches and go through different professional development phases. Therefore, an investigation of technology integration purely based on physical organisation of technology-enhanced learning environments and certain teacher behaviours is only one part of the whole picture. Teachers might have different norms and these affect the way they integrate technology into their lessons. However, there is little research in the literature on how teachers' activities in the classroom are shaped by their norms and very few of them investigated this in the context of technology. The aim of this study is to bring a socio-cultural dimension to instrumental orchestration. Socio-cultural theory aims to investigate human action and its relationship with cultural, institutional and historical situations. Therefore, it focuses on social interactions and the effects of culture on psychological development (Wertsch, del Rio, & Alvarez, 1995; Lerman, 2001). Technological tools can turn into effective instruments for learning mathematics via effective classroom interaction. Social and socio-mathematical norms, as one of the aspects of socio-cultural theory, might take a role in shaping student-teacher-tool interaction in the classroom. Furthermore, they are also shaped by this interaction. Therefore, one could elucidate how teachers use technological tools by embracing a norm-perspective within so-

cio-cultural approach. Our claim is that social and socio-mathematical norms (Višňovská, *Cortina*, & Cobb, 2007) endorsed by teachers are crucial for their pedagogies and their choices for different orchestration types. To support this argument, this study investigates the interaction between orchestration types used by pre-service mathematics teachers and social and socio- mathematical norms.

INSTRUMENTAL ORCHESTRATION

An instrumental orchestration is defined as the teacher's intentional and systematic organisation and use of the various artefacts available in a learning environment in a given mathematical task situation, in order to guide students' instrumental genesis (Trouche, 2004).

Drijvers (2012) distinguishes three elements within an instrumental orchestration: a didactic configuration, an exploitation mode and a didactical performance. "A didactical configuration is an arrangement of artefacts in the environment, or, in other words, a configuration of the teaching setting and the artefacts involved in it" (p. 266). An exploitation mode is defined as the teacher's decisions on the way she or he configures a task by providing certain roles for the artefacts to achieve his or her didactical intentions.

> A didactical performance involves the ad hoc decisions taken while teaching on how to actually perform in the chosen didactic configuration and exploitation mode: what question to pose now, how to do justice to (or to set aside) any particular student input, how to deal with an unexpected aspect of the mathematical task or the technological tool, or other emerging goals (Drijvers, p. 266).

Drijvers and his colleagues (2010), Drijvers (2012) and Tabach (2013) distinguish ten types of instrumental orchestrations as seen in Table 1 (The last three orchestration types are not in the original table and were added from the literature). In this study, pre-service teachers' lessons will be analysed considering the orchestration types in this table.

The orchestration types	Didactical configuration	Exploitation mode
Technical-demo (Drijvers and his colleagues, 2010)	Whole-class setting, one central screen	The teacher explains the technical details for using the tool.
Explain-the-screen (Drijvers and his colleagues, 2010)	Whole-class setting, one central screen	The teacher's explanations go beyond techniques and involve mathematical content.
Link-the-screen board (Drijvers and his colleagues, 2010)	Whole-class setting, one central screen	The teacher connects representations on the screen to representations of the same mathematical objects that appear either in the book or on the board.
Sherpa-at-work (Drijvers and his colleagues, 2010)	Whole-class setting, one central screen	The technology is in the hands of a student, who brings it up to the whole class for discussion.
Not-use-tech (Tabach, 2011)	Whole-class setting, one central screen	The technology is available but the teacher chooses not to use it.
Discuss-the-screen (Drijvers and his colleagues, 2010)	Whole-class setting, one central screen	Whole class discussion guided by the teacher to enhance collective instrumental genesis.
Spot-and-show (Drijvers and his colleagues, 2010)	Whole-class setting, one central screen	The teacher brings up previous student work that he/she had stored and identified as relevant for further discussion.
Work-and-walk-by (Drijvers, 2012)	Students work individually or in pairs with computers	The teacher walks among the working students, monitors their progress and provides guidance as the need arises.
Discuss-the-tech-without-it (Tabach, 2013)	Every students have own laptops or laptops bring classroom with wheeled vehicles	The teacher uses mobile transport system if he/she needs computers in teaching
Monitor-and-guide (Tabach, 2011)	-----	The teacher uses a learning management system by giving guidance to students

Table 1: Orchestration types (Tabach, 2013, p. 3)

SOCIAL AND SOCIO-MATHEMATICAL NORMS

In mathematics education literature, it is widely recognised that social interaction promotes learning opportunities. Norms construct how students learn mathematics and how they become mathematically autonomous (Cobb & Bowers, 1999; Pang, 2000). Norms regulate the way teachers and students participate in learning and teaching activities within a classroom culture (Cobb & Yackel, 1996). While norm emerges from social interaction; belief, value, opinion and attitude are concerned with the individual.

Cobb and Yackel (1996) propose social and socio-mathematical norms to investigate how students' mathematical values and beliefs develop within the classroom culture from the psychological and socio-cultural perspectives. Cobb and his colleagues (2007) also investigated teachers' professional development through social and socio-mathematical norms (Visnovska, Cortina, & Cobb, 2007). Social norms apply to any subject matter area. Students' cooperation when solving problems or privileging a logical explanation over other correct answers are examples of social norms (Hershkowitz & Schwarz, 1999). Another example is the way teachers promote students' thinking and value different ideas. On the other hand, socio-mathematical norms are specific to mathematics and are concerned with the way mathematical beliefs and values develop in the classroom. For example, acceptability of a mathematical explanation or a justification is a socio-mathematical norm (Yackel & Cobb, 1996; McClain & Cobb, 2001).

METHODOLOGY

This study embraces the interpretive paradigm to investigate how orchestrations types and norms affect each other in technology-enhanced learning environments. A case study was designed to answer the research question. Participants are five pre-service mathematics teachers who were enrolled in a teacher preparation program in a state university in Istanbul, Turkey. It was a four-month program which will award its participants a certificate for teaching mathematics in high schools for students aged between 15 and 18. The program accepts graduates who have a BSc degree in mathematics. There were two kinds of courses in the program: education and mathematics education courses. The study was conducted during "Instructional Technologies and Material Development" and "Teaching Practice" courses. The former course focused on six software, namely Geogebra, Graphic Calculus, Derive, Geometry Sketchpad, Excel and Probability Explorer. Participants were involved in hands-on activities in front of a computer and prepared teaching materials. Participants also taught lessons in partnership schools during "Teaching Practice" course.

There were thirty-six participants in the program. They were all interviewed on their approach to the use of technology for teaching mathematics. Five participants were purposefully selected. Two of them (one male and one female) had positive attitudes and two of them (one male and one female) had negative attitudes towards the use of technology. One participant was selected because she had neutral attitude.

The data collection methods are observation and semi-structured interviews. Each participant taught a total of five lessons in a partnership school. At least two of these lessons were technology-based. Each participant taught at least two same classes of students. They were interviewed after their lessons. During the semi-structured interviews they were asked what kinds of norms they endorsed, how they used technology in their lessons and differences between their lessons with or without technology. Their lessons were video recorded. The first author of this paper observed lessons using an observation form. The aim of the observation form was to reveal social and socio-mathematical norms endorsed by pre-service teachers. Interviews and lesson videos were verbatim transcribed. Data from different sources such as interviews, observations and field notes were triangulated. Common themes emerged from verbal discussions among pre-service teachers and students, patterns in pre-service teachers' behaviours and statements about their endorsed norms during the interviews. For instance, the socio-mathematical norm "Answers which are logical are acceptable" was determined considering pre-service teachers' discussion with students and how they defined "an acceptable answer" during the interview.

FINDINGS

This section presents orchestration types and social and socio-mathematical norms used by participants. First we demonstrated how participants used orches-

Orchestration types	Pre-service teachers
Technical-demo	Nil, Orkun, Melek
Explain-the-screen	Mahir, Orkun, Melek
Discuss-the-screen	Melek
Sherpa-at-work	Orkun, Melek, Nil
Not-use-tech	Oya, Mahir, Nil, Orkun, Melek

Table 2: The orchestration types used by pre-service teachers

tration types and then how norms and orchestration types affected each other.

The analysis of the data indicated that participants mostly used *technical-demo, explain-the-screen, link-the-screen-board, discuss-the-screen, Sherpa-at-work and not-use-tech* orchestration types as seen in Table 2.

Explain-the-screen promoted the social norm "the authority is the teacher". For example, Mahir taught a lesson on parabolas using Geogebra software. He started his lesson by explaining how to draw a parabola and adding a slide which is defined as the determinant. He then moved the slide and explained what happened to the graph of parabola. At this stage he did not questioned the mathematical meanings behind what the software performed, but just explained how to use the software.

When participants used *link-the-screen*, they explained a concept or a mathematical idea on the board followed by an elaboration using the software. For example, Orkun taught a lesson on how to draw the graph of $y = \sin x$ using Geometry Sketchpad. He first plotted a few points and then drew the graph on the board. However students claimed that points should be joint using straight lines. He then moved to the software and constructed a unit circle. He defined a point A on the unit circle and a point B which defines the sine function. Using "trace" feature, he obtained the graph of $y = \sin x$. Up until now, the authority was the teacher. Therefore, it can be claimed that *link-the-screen* orchestration type promoted this social norm. Afterwards he asked students how to draw $y = \cos x$ and $y = \tan x$ themselves. His question is an indication of a social norm "Students are challenged with the questions of why and how". This social norm required using *discuss-the-screen* orchestration type.

Another participant who used *discuss-the-screen* discussed with their students the actions they performed using the software. For example, Melek used Geometry Sketchpad to explain how to draw trigonometric functions. She first drew the graph of $y = \sin x$ and then asked one of her students to draw $y = \cos x$. Later she discussed with her students how to draw $y = \tan x$ using the software and tried to reach a common ground ($\tan x = \sin x/\cos x$):

Melek:	Is there anyone who wants to draw the tangent line?
Student A:	This time, we will construct a point with x and y (on the unit circle)...
Student B:	Slope
Melek:	What else? What is slope? One of the definitions is opposite over adjacent. It's the ratio of opposite side over adjacent side or what is $\tan x$?
Student C:	$\sin x$ over $\cos x$
Melek:	Isn't it $\sin x$ over $\cos x$. That's the expression that everybody knows. Therefore, when we want to find the ratio of $\sin x$ over $\cos x$, that is when we think graphically (showing the point on the unit circle) if we vertically projected this point onto x-axis, we say opposite over adjacent to find the tanjant

When pre-service teachers were using *discuss-the-screen* they endorsed the socio-mathematical norm "Answers which are logical are acceptable". For example, Melek who used *discuss-the-screen* aimed at having her students discuss mathematical meanings behind what the software perform. When doing this, she considered different student answers and did not impose her answers or solutions. She encouraged her students discover their own solutions which were meaningful for them. As can be seen in this case, the orchestration type used by this pre-service teacher affected her endorsed norm. In other words, a norm has emerged which support *discuss-the-screen* orchestration type.

Pre-service teachers chose not to use technology (not-use-tech orchestration type) at least once out of five lessons they each taught. Before participants had teaching experiences with using technology in the classroom, they had the socio-mathematical norm which gives the teacher the mathematical authority and believed that technological tools were not necessary for teaching mathematics:

> Oya: I'm quite conservative. I believe that mathematics should be taught using the blackboard. I think that maths would be better understood this way

Oya was a unique case who's social or socio-mathematical norms did not change after she started using technological tools in her lessons. On the other hand, Orkun who has negative attitudes towards using technology in a mathematics lesson changed his endorsed norms and this situation is illustrated with the following excerpt:

> Orkun: In my first lesson (which he did not use any technological tool) I wished that student would not ask me any questions. Because I was teaching inverse trigonometric functions and the questions I prepared were very difficult ones... students in this school were very clever and I was worrying about receiving different questions. And there was no help from technology. I had to teach on the blackboard. But on the next lessons when I used technology, I wasn't afraid of their questions. When I'm stuck on the board I knew that I could switch to technology

As can be seen from the excerpt above, he sees technological resources as a helpful tool which gives him confidence. This confidence changed his norms and pedagogy.

Another orchestration type observed in this study is *Sherpa-at-work*. Participants in this study used this orchestration type in a different way when compared to the related literature. In the literature, when using Sherpa-at-work students work in front of a computer individually or in pairs and "the technology is in the hands of a student, who brings it up to the whole class for discussion" (Tabach, 2013, p. 3). However, there was a lack of technological resources in partnership schools and students did not get the chance to use their own computers during the lessons. Participants had their own computers which were projected on to a screen. This situation prevented active participation of students. Orkun, Melek and Nil tried to resolve this problem by having students use the teacher's computer. This corresponds to *Sherpa-at-work* orchestration type which emerges as a result of "students who answers correctly go to the blackboard" social norm.

DISCUSSION

This study investigated how orchestration types and norms affect each other in technology-enhanced learning environments. The findings indicated that pre-service mathematics teachers used some of the orchestration types frequently such as *link-the-screen-board* and *not-use-tech*. On the other hand, some of the orchestration types such as *spot-and-show*, *work-and-walk-by*, *discuss-the-tech-without-it* and *monitor-and-guide* were not used because of lack of technological resources in the partnership school. All classrooms in this school have smart boards but students did not have their own computers or tablets. Therefore, some of the orchestration types were not observed.

Drijvers and his colleagues (2010) claimed that teachers make pedagogical choices based on their views about how to teach mathematics. This study has similar findings by illustrating how orchestration types and norms support each other. Social and socio-mathematical norms endorsed by participants affected their choices of technological tools for teaching mathematics and as a result orchestration types they used.

Our claim was that there was a two-way interaction between orchestration types and social and socio-mathematical norms. This study attempted to justify this claim. As a matter of fact, Drijvers (2012) described *technical-demo*, *explain-the-screen* and *link-the-screen-board* orchestration types as teacher-centred and *Sherpa-at-work*, *spot-and-show* and *discuss-the-screen* orchestration types as student-centred. Therefore, participants who used teacher-centred orchestration types endorsed socio-mathematical norms accept the

teacher as the mathematical authority. On the other hand, participants who used student-centred orchestration types endorsed social norms which puts students into the centre.

Findings of this study also revealed that instrumental orchestration framework fall in short in explaining the socio-cultural aspect of technology integration. In terms of teacher-student-tool interaction, technological tools provide a language which supports communication between students and teachers (Noss & Hoyles, 1996). Examining the micro-culture of the classroom provided by this kind of language and social and socio-mathematical norms required by that culture expanded our understanding of orchestration framework. Integrating instrumental orchestration framework into norm perspective provided an insight on the question of why and how particular orchestration types are used.

This study suggests some implications for researchers and teacher educators. First of all, as mentioned above, there is not satisfying research which explicitly investigates norms in the context of technology integration. In this study, this was investigated in the context of a short-term teacher preparation program in Turkey. There is a need for further studies. Second, teacher education programs which aim successful technology integration should develop an awareness of social and socio-mathematical norms and monitor pre-service teachers' development with regard to their endorsed norms.

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