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Rhythmic instrumental orchestration: Joining two theoretical perspectives in designing an online summer school

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Due to the pandemic situation in 2020 the ERME summer school (YESS10) was designed for an online format using a conference system. Our design choices were based on previous experiences with YESS and the use of the research pentagon as a tool to think about research. This paper elaborates theoretically and empirically the specification of the concept of instrumental orchestration of the pentagon use through its rhythmic implementation into the summer school. Research results indicate that this specification had two main effects: The students described their instrumentation of the pentagon as a structuring tool in various ways. The most relevant pentagon use for the students' experience of growing expertise was listening to and observing how the others used the pentagon.

Keywords: Design-based research, instrumental genesis, rhythm, online learning, summer school

Introduction and background

Due to the pandemic in spring 2020 the Young ERME Summer School (YESS) of the European Society for Research in Mathematics Education (ERME) switched to using a synchronic online conference system. Two out of seven thematic working groups (TWG7, TWG5) run in a virtual environment. As neither clear conceptions nor research were available for the design of the school with respect to distance learning of PhD-students via a conference system, the two experts and two brokers (previous PhD-students of YESS) decided to conduct a design-based research study involving the conference system Adobe Connect. Planning jointly these TWGs led the brokers to decide to act as assistances and to provide several Adobe tools to be shared in the TWGs. The leading experts made common design choices based on their experiences in the previous YESS-TWGs. As each student had to submit a short description of their research project, all the students were asked to read all the papers before the school and prepare a presentation of their project to be discussed during the school. Prior to the school, pairs of critical friends were built within both TWGs to make them engage deeper into the friend's paper and present their critical feedback in an explicit presentation. The main design choice concerned the research pentagon (Bikner-Ahsbahr, 2019) as a tool to think and reflect about research in terms of research aims, questions, objects, methods, and situations involving the situation of the project in the field and creating a specific situation for the research in the project (Figure 1, left). The design of how to use the pentagon took into account previous experiences with the pentagon as well as the fact that the students coming from different time zones, and simultaneously being involved in their families during the school, required a clear timetable so that

they would be able to manage their pandemic situation and attend YESS10. This resulted in a sequence of five situations of using the pentagon (Figure 1, middle). This sequence was repeated in all the ten sessions in the same order in both TWGs, however with some variations (Figure 1, middle & right).

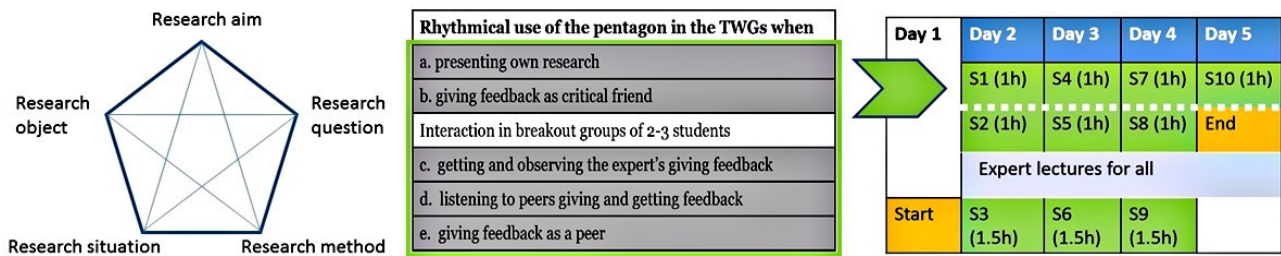


Figure 1: The research pentagon (left), sequence of pentagon use in a session (middle) and the sequence of sessions S1-S10 (right)

Based on these design choices, we ask: How did the students experience the rhythmic orchestration of the pentagon use and the pentagon use itself as contributing to their learning about research?

Theoretical framework

Instrumental approach and instrumental orchestration

Considering the pentagon as a tool that participants need to appropriate in order to use it efficiently, *instrumental approach* (Vérillon & Rabardel, 1995; Rabardel, 2002) is one of two theoretical approaches in our research framework. The key idea is the distinction between an *artefact* – material or symbolic object available to a subject, and an *instrument* – a merging construct that consists of the artefact and the related mental schemes coming from the use of the artefact by the subject in a given context. The process of transformation of an artefact into an instrument, called *instrumental genesis*, consists of two interrelated processes: *instrumentation* leading to the constitution and the evolution of schemes of using the artefact in the subject, and *instrumentalisation* during which the subject adapts and personalizes the artefact according to her knowledge and beliefs. The development of schemes of use manifests itself in the subject's invariant organization of behavior in a given class of situations (Vergnaud, 1990). Trouche (2020) suggests seeing instrumentation both as “an action (by which someone acquires an instrument)” and as “the influence of this action on a subject's activity and knowledge” (p. 307). Thus, using an artefact yields both pragmatic and epistemic outcomes.

In the context of students' learning, students' instrumental geneses need to be accompanied by a teacher. Trouche (2004) introduced the notion of *instrumental orchestration* to describe how a teacher can plan and organize students' interactions with available artefacts in order to enhance individual and collective instrumental geneses. Referring to Trouche (2004), Drijvers et al. (2010, p. 214) define an instrumental orchestration as “the teacher's intentional and systematic organization and use of the various artefacts available in a [...] learning environment in a given [...] task situation, in order to guide students' instrumental geneses”. It consists of three elements:

1. A *didactical configuration*, which is “a configuration of the teaching setting and the artefacts involved in it” (Drijvers et al., 2010, p. 215);

2. An *exploitation mode*, which is “the way the teacher decides to exploit a didactical configuration for the benefit of his or her didactical intentions” and includes in particular the teacher’s decisions “on the possible roles of the artefacts to be played” (p. 215);
3. A *didactical performance*, which involves “the ad hoc decisions taken while teaching on how to actually perform in the chosen didactic configuration and exploitation mode” (p. 215).

Design approach to orchestrate the pentagon use

The pentagon was implemented in the design of the sessions as a tool to structure and reflect on research (Bikner-Ahsbals, 2019) individually and in interaction with others. Pairs of critical friends provided mutually more in-depth feedback in their presentation in addition to the spontaneous feedback coming from all the other peers. Whereas TWG7 introduced an article about the research pentagon before the school to be used for the preparation of the presentations, the expert of TWG5 introduced this tool in the first session. Besides this distinction, both experts used the tool permanently during the school as a reference object in their feedback and the discussion. We organized each of the 10 sessions in the TWGs by five situations of pentagon use (Figure 1, left) so that, in the course of these sessions, the students’ roles as presenter, critical friend, observer and listener, feedback provider and receiver of peer and expert feedback varied regularly in time and space of the virtual environment. This organization aimed at enhancing participants’ instrumental geneses to improve their research expertise.

The change from a face-to-face summer school to an online format required to theorize the meeting space. According to Lefebvre (1991), any space is established with respect to three dimensions: (1) A space is represented materially (also technologically), (2) it is representational in that it represents some idea (here: switching YESS to an online school), and (3) it is (re-)produced as a social space by the people involved. All the three dimension apply to YESS10. The digital conference system Adobe Connect used as a technological space linked to the individual material home computer spaces, constituted a representation of the virtual space. It provided tools for sharing and distributing information among the students, hence, for creating the social space of acting and interacting of the participants supported by these tools, e.g. the breakout rooms, chat, and note taking possibilities were included into the didactic configuration. This notion of space developed structured in time with a frequency of three sessions per day and breaks of different lengths (session–short break–session–lecture break–session–night break) repeated day after day.

In the summer school, the collective nature of teaching and learning is essential and this depends on the possibility of creating joint attention on the research presented. In face-to-face situations, this is established by building a reference space through deictic expressions, shown e.g., by linguistic means, through a projector, by gestures, gaze, body posture, moving (Balantani & Lázaro, 2021; Stukenbrock, 2015). However, most of these deictic expressions could not be shared in our virtual space. So, we designed the pentagon use in a way that it could facilitate creating a reference space because all the students could refer to this diagram sharing its structure, such as the vertices and their relations, with their peers, and simultaneously talking about their own research.

An implicit key idea in this design was rhythm as a way to structure time. Rhythm emerged as a critical design element when analyzing the data.

Rhythm as a design element

Lefebvre (2004) stressed that space, time, and energy are interrelated by rhythm, the latter being bodily grounded and thus always active. Rhythm as a structure of time is created in the course of sessions by an “ordered variation of changes” (Dewey, 1934, p. 160). Figure 1 (right) shows the *linear* rhythm as a repetition of sessions (three per day) with pentagon use and breaks. Within each session, the order of five situations of pentagon use is *cyclically* repeated involving regular and spontaneous variations by providing all students the opportunity to act in their way in all the roles and addressing various research topics and foci. This rhythmic characteristic of the *didactical configuration* was enriched by a rhythmic *exploitation mode* in which the experts regularly referred to the pentagon explaining while pointing to vertices and connections in varying research projects, and hence, inviting the students to use the pentagon as a reference space, too. Thus, the group could create joint attention on the research presented and discussed. As the experts have used the pentagon in previous summer schools, they related their feedback (*didactical performance*) to students’ actual needs, highlighting blind spots, missing aspects, or a change of view, in using the pentagon as an organizing tool for research. So there is constructive interaction of various rhythms, so-called “eurhythmia” (Lefebvre, 2004, p. 16). Lefebvre emphasizes that rhythm allows measuring changes: “No rhythm without repetition in time and in space, without *reprises*, without returns, in short without measure [*measure*]” (p. 6). As the same situations of pentagon use are repeated the students had the opportunity to experience and compare these uses within eurhythmia, thus measure changes of own and others’ pentagon uses related to research and hence, measure their own development of expertise on research.

Methodology

We use *rhythm analysis* (Lefebvre, 2004) to answer the research question focusing on how the students experienced the rhythmic instrumental orchestration, which instrumentation processes they reflect and how the instrumental geneses of the pentagon may have contributed to their learning about research. As we could not observe these processes in time, we shaped this research similar to action research. We drew on our experience of conducting the TWGs, our design choices and note taking. An external expert interviewed 11 volunteers of the 20 participants about the efforts they invested into the school, their experience of the pentagon use and of our design to develop their learning about research. These interviews were video recorded and transcribed verbatim (names were replaced with pseudonyms). Thus, we did not observe the rhythmic processes directly, but rather approached them through the students’ individual experience of the (eu)rhythmic orchestration in their interviews. This experience begins with a first contact with the pentagon and ends with reflections on own research. Related to this frame, we conduct our analyses in three steps considering the five different roles (Figure 1, middle) in which each student acted and interacted. First, we identified quotes in the interviews that refer to these roles, and described how each student experienced his/her individual instrumental genesis of the pentagon distinguishing between instances of instrumentation and instrumentalisation within the orchestration (Figure 2, vertical analyses expressed as vertical arrows). For each role, we secondly compared these descriptions across all the interviews to situate the individual experience into the collective (Figure 2, horizontal analyses expressed by horizontal arrows). In the third step, we identified the students’ individual reflections addressing their individual

experience on learning about research in the interviews, interpreted them related to their instrumental genesis and through the lens of rhythmanalysis, and compared these across all the students.

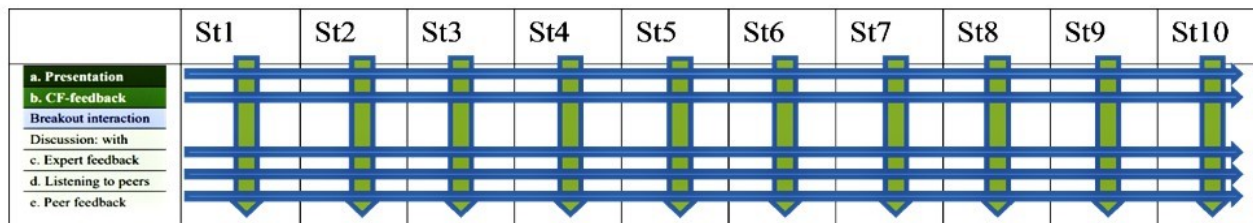


Figure 2: Rhythmanalysis (Stn: Student No. n)

Results

Based on our framework, we extracted quotes from the interview data, which express the students' experience in their reflections immediately after the summer school. Therefore, these results indicate what the students declare to have taken from the summer school rather than the learning processes themselves. The experiences of expertise are regarded as relevant outcomes for the PhD students who after the summer school may then continue their research with a refreshed expertise.

Step 1: The pentagon becoming an individual instrument

From the *case of Emma* we learned that some students' instrumental geneses started before YESS as Emma had read the paper and used the pentagon before the school already. The rhythmic organization of the situations in which she used the pentagon enhanced it. In the interview, she expresses a variety of instrumentation processes developed in different situations. She developed an *instrument for analyzing own research and checking its coherence* ("Also, just to see that you are making progress or making your project more coherent because I think it's very useful to talk about; if there's some parts of your research project that is not coherent.") and for *analyzing other's research projects* ("I used the pentagon when I read the papers, for instance when I read through my critical friend's paper and whether I found some indications of the research aim and the research object, research questions, the method and..."). She also developed instruments related to feedback, for example for *structuring feedback for a critical friend* ("when I did the presentation for my critical friend ... I could give feedback on that so what I thought was making a lot of sense") and for *structuring the feedback presentation* ("it can also be quite hard to understand where they [the peers] are exactly in the process and what they would need the feedback on to make them come further because. I think the research pentagon helped in that matter because I could use it to structure my presentation of my feedback"). We identified similar instrumentation processes in other interviews, too.

The *case of Nordy* made us aware that students in TWG5 came to know the pentagon use in the first session when the expert introduced it for the first time. As Nordy was the first presenter, he did not have time ("I need some more time to read the whole text and to incorporate it, to think about this research pentagon") for appropriating the pentagon although he perceived its potential ("I really think that it could be a great thing to organize your work [with the pentagon]"). Compared with the case of Emma, this shows the *lack of and need for instrumentation*. However, his instrumental genesis was about to start. Other students from TWG5 showed similar experiences.

Nordy's *beginning instrumentation process* was based on the expert's didactical performance, when listening to the expert's systematically and repeatedly referring to the pentagon. Nordy says: "as long as our research topic group was going on, then her [the expert's] feedback was more and more referred to it". He relates his individual to the collective instrumental genesis, when stressing "we should do our feedback depending on the research pentagon to our critical friend, I try to do that, I think we handled it quite good".

Through the *case of Kira* we learned that the first parts the students grasp are *vertices* of the pentagon as an instrumentalisation in the sense that students select the artefact features they are going to use. The links between the vertices are more complex to make sense of and need perhaps a specific orchestration (e.g. a 'technical demo' by the expert). For example, Kira used the pentagon as a feedback-structuring instrument identifying missing vertices in a peer's paper ("I could more clearly identify what was missing for me and what was also good"). Then she points to the need to fill the links between two vertices, the research question, and the methods ("filling the link to the research question would mean to ask myself, or for him to ask himself the question 'How can I measure this?' What method can I use? ..."). Kira also expresses another instance of instrumentalisation in the idea to take the pentagon home for her peers: "I will take the research pentagon into a small group discussion at the university." Thus, within one week, the instrumental genesis entailed instrumentation as well as instances of instrumentalisation for Kira as well as other students.

Our vertical analyses show that the individual processes of instrumental genesis led to various instruments where the vertices are the primary foci while the links between them are more difficult to understand. Instances of instrumentalisation appeared already as the students decided which vertices they take up. Thus, the pentagon provides instrumentation and instrumentalisation possibilities from the beginning.

Step 2: Rhythm and listening as essential parts for contributing to learning

Kira connected the individual and the common use of the pentagon when she pointed to it as a diagram expressing a common reference space and resource in the didactical configuration of the virtual space ("what appeared were the edges and also a definition of what can be found, what can be identified as a research aim ... the research pentagon in the middle on the whiteboard and then it was easy to just point somewhere"). The configuration of the virtual space where the pentagon was used as a diagram in screen sharing allowed sharing different research projects in the group ("This [the vertices] is very very different concerning what kind of research your project is about."). The repeated use of the pentagon emerged as a rhythmic exploitation mode. It helped the students to develop their expertise by listening to and observing others as well as practicing themselves to use the pentagon repeatedly. For example, Peter points to listening to and observing its repeated use by others ("I had the ability to see the pentagon in *action for ten times*"). Dan highlights practicing its repeated use themselves ("doing it like *a few times to other colleagues*, each one in a different subject area, and *hearing the other teammates*, how they raise questions, was really really valuable. I mean, I learnt from it a lot."). Therefore, the rhythmic configuration and exploitation mode seem to have the potential to support developing expertise on research. Mirka is a bit more precise as she expressed *how* the repeated use of the pentagon supports growing in expertise. It can happen during one session in the *rhythm of*

different situations (“I think there were some students who couldn’t find... who couldn’t use it in a specific way, but during the discussions of their feedback, they realized that they have to be more specific. [...]”), as well as through the repetition of the *same situational use* in the course of the school *during the cyclic rhythm* (“once you see how other students used it, I think it’s a very nice way to use it [the pentagon] your own way, personally, everyone used it; they didn’t use it the same way.”)

Step 3: Summarizing students’ reflections on learning about research

The students highlighted the relevant role of rhythm, linear as well as cyclic, for the different uses of the pentagon and their learning about research. The most important use, as shown in our *horizontal analysis*, is observing and listening to how others use the pentagon, hence, they benefit from the rhythm in the didactical performance of the experts as well as from observing and listening to the processes of instrumental genesis of peers to learn how to improve their own research. Lefebvre elaborates on rhythm related to measure change with respect to a reference and hence, enables to explain the phenomenon of experience of change in learning. For example, a student may identify that the research object is still a blind spot in the own research project. Through repeatedly listening to others talking about their research objects, he or she can compare and thus measure the change of view on the own object and the experience of learning on own research. For example, Surgeryfish reflects: “what I see from others and fit into my work. ... A kind of learning, becoming aware.”

Discussion on the theoretical specification of instrumental orchestration

The YESS10-study is deeply rooted in the common experience of an ontological change in the pandemic situation. This change raised the necessity to enable the participants of YESS10 to align their home situations with the summer school in space and time via a conference system. As this study shows, we have achieved this by a rhythmic synchronizing (cf. Akkerman et al., 2021) of the students’ instrumental geneses of the research pentagon in our virtual space and time with the goal to advance the students’ projects and by that improve their expertise on research. As a result, a *rhythmic instrumental orchestration* emerged as a specification of instrumental orchestration, theorized with the help of rhythmanalysis of the implemented rhythmic structure. This rhythmic instrumental orchestration involves a didactical configuration that provides a rhythmic organization of the various situations and kinds of tool use. Within this configuration, a rhythmic exploitation mode emerged, which involves the expert as well as the students allowing them to use the tool in various ways as well as listening to and observing how their peers use the tool. Within this mode, the expert synchronizes her didactical performance on the tool with the students’ needs. In sum, the design choices in the rhythmic orchestration led to eurhythmia, which allowed the students to develop their expertise in a communal way by learning from their peers, particularly through listening.

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