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**CONVERGENCE OF TOOLS, THE STUDENT AND THE
TEACHER IN THE MATHEMATICS CLASSROOM:
INSTRUMENTAL GENESIS AND ORCHESTRATION**

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ABSTRACT

Researchers have been paying attention to the convergence of technologies for it can result in improving human behaviour, including student's learning and teacher's instruction. The present paper intends to describe the different types of convergence of technologies in the classroom in general and the mathematics classroom in particular, focusing on the convergence of two types of them: convergence of the learner with the technological tools and convergence of the teacher with those tools. This focus is concerned with two instrumental frameworks: the instrumental genesis and the instrumental orchestration. The paper discusses the foundations of these two theoretical frameworks, the components of the frameworks and their educational uses as tools for analysing learners' and teachers' convergences with technological tools. Researchers assert that the two frameworks have contributed to the understanding of convergence of the learner and the teacher with technological tools, pointing, at the

same time, at the need to extend these frameworks or combine them with other frameworks in order to understand the different aspects of this convergence.

Keywords: convergence of technologies; convergence with the learner; convergence with the teacher; instrumental genesis; instrumental orchestration

Introduction

Convergence of media in general (Jenkins, 2018) and convergence of technologies in particular is attracting the attention of researchers to improve human behavior (Roco & Bainbridge, 2002), including teacher's instruction and student's learning (Delich, Kelly & McIntosh, 2008). The present paper intends to describe the different types of convergence of technologies in the classroom, where many of the examples given will be from the mathematics classroom. Afterwards, we elaborate on the convergence of two types of them: convergence of the learner with the technological tool(s); through the instrumental genesis framework, and convergence of the teacher with this/these tool(s); through the instrumental orchestration framework. Specifically, it intends to study the origins of the theoretical frameworks on which the two convergences are based, their factors and potentialities, in addition to how they were utilized to understand classroom practices with technologies.

Types of technologies convergence in the classroom

Convergence of technologies refers to different types of convergence. One such convergence is the convergence of disciplines or interdisciplinarity. This type of convergence is encouraged by the National Science Foundation's report as learning sciences can benefit from their connection (Roco & Bainbridge, 2002). The need for interdisciplinarity stems from its potentiality to facilitate knowledge production and

processing (Schmidt, 2007).

The second type of convergence of technologies is the convergence of multiple technological tools into one tool, which could serve innovative educational practices. Delich, Kelly and McIntosh (2008) say that, as technologies become more sophisticated and as they begin to converge, educators will have more options for creating innovative practices in education. One such option is the utilization of the tool's mobility (Banks, 2008).

A third type of convergence of technologies is the convergence of the teacher with different tools for accomplishing specific objectives in the classroom, which enables the development of such objectives. Different theoretical frameworks were developed to study the previous type of convergence, where, in the present paper, we study the instrumental orchestration framework.

A fourth type of convergence of technologies emerges during the learning processes (Rabardel & Beguin, 2005). One such convergence framework is the instrumental genesis; a theoretical framework that suggest how learners appropriate technological tools for solving tasks (Rabardel & Beguin, 2005). The present paper utilises this framework to study the convergences of the learner with the technological tool(s).

Convergence of the learner and technological tool

Researchers became concerned with the convergence processes between the learner and the technological tool in order to understand scientific concepts. One theoretical framework that was suggested to explain this convergence is the instrumental genesis (Rabardel & Beguin, 2005) whose target was to explain how learners appropriate a technological tool to accomplish tasks. The theoretical basis for this framework was

originally developed by Verillon and Rabardel (1995) as a tool in cognitive ergonomics, where ergonomics seeks to establish the rules that direct the person's activity at work. Cognitive ergonomics is the design that draws on a joint cognitive system consisting of the user and the technological tool. Hollnagel (1997, p. 1177) says that in cognitive ergonomics, "the focus is on the reciprocal influence between work and mind" and "the purpose is not to try to understand the nature of human cognition but rather to describe how human cognition affects work and is affected by work". Talking about instrumental genesis, the goal was to describe how human cognition affects and is affected by working with technological tools. The instrumental genesis was utilized to understand the interaction of the subject and technology in various disciplines as mathematics, science and language (Pargman, Nouri & Milrad, 2018).

The instrumental genesis framework considers an instrument a two-fold entity, part artifactual and part psychological. The user appropriates the technological tool as a learning tool through acquiring a utilization scheme and applying it to the artifact. This appropriation can be considered as convergence of the user with the tool, which, from one side, happens, and, from the other side, results as the user transforms the tool into one that he/she utilizes for understanding scientific concepts. The user is engaged with the tool through two phases called instrumentalization and instrumentation. These two phases are based on the distinction between artefact and instrument. An artefact, whether it is a physical-object or not, is a product of human activity that incorporates both social and cultural experiences (Drijvers, Godino, Font, & Trouche, 2013). As such, it is used to achieve a specific task (ibid). An artifact becomes an instrument when a meaningful relationship develops between artefact and the user for solving tasks.

Describing the two phases of the user's work with a technological tool, Rabardel and Beguin (2005) say that instrumentalization is the "process in which the subject

enriches the artifact's properties" (p. 444), taking into consideration the properties of the artifact and assigning these properties a status relevant to the continuing action with this artifact. In the instrumentation process, subjects are engaged in giving a new meaning to the artifacts and in the adaptation of schemes to these artifacts in order to serve their goals (p. 446). Here, the two processes of instrumental genesis are processes of convergence between the learner and the technological tools, because they entail collaborative processes of the learner and the tool in order to achieve the learner's goals. Saying this, this convergence in the two processes differs. Lonchamp (2012, p. 211) emphasizes that the two processes are different in their orientation: "the instrumentation process is directed toward the subject, whereas the instrumentalization process is directed toward the artifact component of the instrument. In the instrumentation process, the subject develops, while in the instrumentalization process, the artifact evolves". Despite this difference, the two participants in the convergence develop, which serves the subject's problem solving or conceiving of scientific ideas.

Rabardel (2002, p. 5) describes the foundations of the framework, talking about two main perspectives of technologies: the technocentric vs the anthropocentric. The technocentric perspective considers humans as occupying a residual position in which "their real activity no longer has a specific status. It can thus only be considered in the same terms as a technical process". As its name implies, the first approach focuses on the technology that is fixed, while the learner attempts to utilize its potentialities. On the other hand, the anthropocentric approach considers humans as occupying a central position and determining the relations with techniques, machines and systems (ibid). The second perspective makes human activity the focus of analysis and thus allows to speak of things in terms of subjects. Thus, this perspective emphasizes the role of the

learner in appropriating the tool. Rabardel (2002, p. 5) warns against neglecting one of these perspectives, saying that neither of the two is sufficient in itself.

Beguín and Rabardel (2000, p. 175) target the two perspectives above from the design-issue point, describing this issue as a complementary foundation of the framework. Doing that, they argue that the instrumental genesis framework came to change the dominance of the technocentric approach over the design process; a dominance that makes human activity a minor aspect of learning.

It should be noted that the attempts of Rabardel et al. to encourage the convergence of the anthropocentric and technocentric approaches are not new, as “since the early days of environmental ethics there has been discussion and debate about whether values in nature are anthropocentric (human-centered) or ecocentric (nonhuman-centered)” (Kopnina, Washington, Taylor & Piccolo, 2018, p. 110). The contribution of Rabardel et al. is in attempting to settle this issue in favour of the anthropocentric approach or at least in favour of the equilibrium between the two approaches. In addition, the instrumental genesis framework led first to the recognition of the role of the interaction between the tool and learner and second to the recognition of the activity of the learner in appropriating the tool.

A second foundation of the instrumental genesis framework is activity theory. Beguín and Rabardel (2000, p. 175) relate the instrumental genesis framework to activity theory, saying that the aim of the framework was to “develop activity theory so as to construct methods that are effective in instrument design”. According to this foundation too, this framework came to place human activity at the heart of doing, which enables to speak of things in terms of the person who interacts with these things.

Other researchers related the instrumental genesis framework to the ideas of Vygotsky. For example, Drijvers and Trouche (2008, p. 366) say that Vygotsky

describes the tool as a new ‘intermediary element situated between the object and the psychic operation’ and directed at the object. They argue that these ideas of Vygotsky constitute a basis for the instrumental approach. This argument is emphasised later when they say (pp. 366-367) “An “instrumental act” for Vygotsky includes a problem that needs to be solved, the mental processes involved in solving, and the (psychological) tools that are used to carry out and to coordinate these processes”. In the previous description, Drijvers and Trouche describe the acts of the learners with the problem, through the mediation of tools, as coordination/convergence between the learner, the problem/content/text and the tool.

The above argument indicates that the instrumental genesis framework has roots in the cultural historical approach, which points at the technological tool as mediating the activity of problem solving. Thus, the convergence of the learner and the tool has its antecedents in the design of the tool. This is supported by Bumbacher, Hossain, Riedel-Kruse and Blikstein (2018, p. 839) who say that the design of the tool’s interface was “conducive to the different forms of engagement in the inquiry activity, ... offering distinct affordances for learning”, which makes them conclude that “designers of technology for science inquiry need to be explicit about desired learning goals and forms of engagement”. This indicates that the design of technological tools and being aware of it could contribute to the convergence of the learner and the tool through the instrumental genesis.

Additional foundation for the instrumental genesis framework is the nature context. For Rabardel and Beguin (2005), the framework is grounded in nature and its manifestations. This grounding in nature has two aspects. The first aspect is related to the situation, as they emphasize that the aim of the framework is “to understand human activity in natural situations” (p. 429) such as work situations or everyday life

situations. Thus, the framework came to understand human activity in natural situations. The second aspect is related to the nature of tools, as they emphasize that their framework “aims to both account for the nature of instruments mobilized by users in their activity and the processes by which they continue design in usage” (ibid), where the two tool’s nature-aspects in the previous text refer to the two phases of instrumental genesis.

The instrumental genesis framework was used by researchers for different goals. One of these goals was to understand a tool’s affordances for a specific goal or activity, in addition to how the learner converges with the tool, or more accurately with the tool and the text (Sherman, 2013). Another goal was to study the mediation of tools for students’ cognitive processes when learning scientific concepts/relations.

Kieran and Drijvers (2006) used the instrumental genesis framework to study the interaction of machine techniques, paper-and-pencil techniques, and reflection. Their findings point at the main role of the instrumental processes through which the learners and the tools converge during problem solving. Through the instrumental processes, the mathematical theorizing of a student is said to be intertwined with the techniques with which they are used and that co-emerge within the given tasks (p. 242). On the other hand, the nature of the task and the limits of students’ existing learning affect the epistemic value of CAS techniques. The authors explain this effect by saying: “When students cannot explain, in terms of their current theoretical and technical knowledge that a CAS technique produces, reliance on additional CAS techniques may not suffice” (ibid, p. 258). Thus, the instrumental genesis framework supported the authors to conclude the conditions for the interaction of the subject and the tool to lead to convergence.

The instrumental genesis framework also enabled Guin and Trouche (1998) to describe when the convergence between the learner and the tool could include incidents of misunderstanding. This helped them to recommend that the convergence of the teacher with the learner needs to take into consideration the representation of the mathematical objects in the interface of the technological tool, which could mediate the student's misunderstandings of mathematical concepts (Tamborg, 2017).

Convergence of the different technological tools to assist the teacher's instruction

According to Trouche (2004), the orchestration framework has two elements: a didactic configuration and an exploitation mode. The didactic configuration is “the layout of the artifacts available in the environment, with one layout for each stage of the mathematical treatment” (p. 296), while an exploitation mode is related to the utilization of the didactic configuration (ibid). Drijvers et al. (2010) added a third element to the instrumental orchestration, which is the 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). Drijvers et al. (2010) emphasize that the instrumental orchestration entails the layout of the class as a technological environment, the exploitations that the teacher makes of this layout and the in-class decisions that utilize the layout of technology in the class, in addition to the potential exploitations of this layout.

Drijvers et al. (2010) utilized a combination of theory-driven and data-driven analysis to identify six orchestration types in which teachers are engaged while teaching mathematics. These types are described in in the first six lines of Table (1). Other researchers added other orchestration types. Drijvers (2012) introduced the orchestration type Work-and-walk-by (line 7 in Table 1) and Tabach (2013) introduced

the orchestration type Monitor-and-guide (line 8 in Table 1). Bozkurt and Ruthven (2018) introduced the orchestration type predict-and-test (line 9 in Table 1).

Table 1

Orchestration types and their descriptions

line	Orchestration type	Description
1.	Technical-demo	The teacher demonstrates the tool techniques
2.	Explain-the-screen	The teacher engages in whole-class explanation, guided by what happens on the computer screen
3.	link-screen-board	The teacher stresses the relationship between what happens on the screen and in paper, book and blackboard
4.	Discuss-the-screen	A whole-class discussion occurs about what happens on the computer screen
5.	Spot-and-show	Student' reasoning is used by the teacher to engage the whole class in a discussion
6.	Sherpa-at-work	A student uses the technology to present his/her work, or to carry out actions the teacher requests
7.	Work-and-walk-by	The students work individually/ in pairs at their computers, while the teacher walks around the classroom to provide feedback
8.	Monitor-and-guide	The students work at their computers for the entire duration of the lesson, while the teacher circulates among them to provide assistance

9.	Predict-and-test	Students make predictions and the technology provides feedback, which validates/invalidates the prediction
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The previous orchestration types are the means by which the teacher converges with the tool(s), and, in fact, with the text and the student. Four actors participate in the convergence situation: the teacher, the tool, the student and the texts. In the technical-demo orchestration, the teacher attempts to help the student and the tool converge, especially in the first phase of the genesis. In the explain-the-screen orchestration, the teacher and the tool attempt to help the learner and the text converge. In the predict-and-test orchestration, the learner converges with the tool in order to converge with the text. Thus, the orchestration types differ in who converges with whom and in who assists this convergence.

Little research has studied the foundations of the instrumental orchestration framework. Drijvers, Doorman, Boon and van Gisbergen (2009) referred to the foundations of the framework of the teacher’s convergence with the tool by acknowledging first the role of the instrumental genesis framework: “Many studies focus on students’ instrumental genesis and its possible benefits for learning” (p. 1349). Side by side with this acknowledgement, they pointed at the need for the instrumental orchestration framework: “However, it was acknowledged that students’ instrumental geneses need to be guided by the teacher ... through the orchestration of mathematical situations” (ibid). Hence, Drijvers et al. (2010) consider the instrumental genesis a framework for analysing the convergence of the learner with the tool, which points at the need for an instrumental framework for analysing the convergence of the teacher with the technological tool. Drijvers et al. (2010) emphasize that Trouche’s (2004) metaphor of instrumental orchestration fits the teacher’s fine-tuning of the students’

individual instruments to enhance both individual and collective geneses. This conclusion led them to the definition of the instrumental orchestration as “the teacher’s intentional and systematic organization and use of the various artefacts ... in order to guide students instrumental genesis” (p. 214-215). This ‘systematic organization and use of the various artefacts’ implies the need to consider how the teacher addresses the convergence of tools for her/his teaching goals.

In addition, the previous description in Drijvers et al. (2010) indicates that the orchestration framework came to understand how the teacher contributes to the convergence of the student with the tool, as well as with the text. Saying this, neither Trouche (2004) nor Drijvers et al. (2010) elaborate on the origins of the teachers’ instrumental framework. Trough (2004) focuses on the movement from a ‘techno-centered’ point of view ... to an ‘anthropocentric’ one (p. 295) to describe the instrumental genesis approach, which is the basis for the orchestration one. It seems that this absence of discussing the origins of the instrumental orchestration framework is due to its relationship with the first-suggested framework; i.e. the instrumental genesis framework. This relationship is emphasized in the text of Drijvers et al. (2010) above as well as by Trouche and Drijvers (2014) who say: “there is an interesting parallel between students engaging in instrumental genesis and teachers engaging in process of developing a repertoire of instrumental orchestration; a process of orchestrational genesis” (p. 10). Thus, the developers of the instrumental orchestration considered the orchestration as a developing practice inasmuch as the instrumental genesis.

Another foundation for the instrumental orchestration framework is the metaphor of orchestration; i.e. music orchestration. Drijvers et al., (2010) elaborate on this origin, saying that the metaphor of orchestration and the didactical performance

can be associated with a musical performance, where “the actual interplay between conductor and musicians reveals the feasibility of the intentions and the success of their realization” (p. 215). This metaphor is subject to controversy, as the similarity between the didactical configuration of the classroom and the musical configuration of the orchestra is disputed. This dispute follows from the highly skilled musicians in the orchestra, which is not the same as the expertise of the classroom students. This makes Drijvers et al. (2010) suggest to talk about the music configuration as a jazz band that consists of both novice and advanced musicians, and to talk about the teacher as being the band leader who is open “for improvisation and interpretation by the students, and for doing justice to input at different levels” (ibid). The previously- described attempts to adopt a metaphor for the teacher’s orchestration/convergence with technological tools in the classroom points at the complexity of the work of the teacher with the technological tools (Lagrange, Artigue, Laborde, & Trouche, 2003). Moreover, it indicates the desire of the developers to base their framework in naturalistic ground. This attempt is similar to the focus of Rabardel and Beguin (2005) on the naturalistic elements of their instrumental genesis framework.

In order to look for orchestration types in which teachers were engaged with while teaching with technology, Drijvers et al. (2010), as mentioned above, utilized theory-driven and data-driven analysis. The data-driven reasoning was referred to by the authors through expressions as “to interpret the information from teachers” (p. 216). Moreover, the two types of reasoning were referred to by the authors in the description of the origins of orchestration types: “The resulting orchestrations are the outcome of both the design by the researchers and the choices of the teachers themselves” (p. 218), where the design of the authors was affected by the “Realistic Mathematics Education principles” (p. 216). Moreover, the two types of reasoning were also referred to by the

authors in the following description: “The analysis was carried out in a bottom-up manner, though partly driven by theory” (p. 218). The authors did not elaborate more on the ‘partly driven by theory’. It could be argued that Drijvers et al. (2010), by adopting the instrumental orchestration framework suggested by Trouche, depended primarily on the theory, but to develop it, they depended primarily on the field.

Drijvers et al. (2009) argue that instrumental orchestration framework can be fruitful for analysing teachers’ practices when teaching mathematics with technological tools. The authors describe their experiences in utilizing the framework for analysing teachers’ use of tools in the classroom, pointing at two benefits of this analysis (p. 1357): better understanding of teachers’ practices and enhancing their professional development by developing a repertoire of instrumental orchestrations.

One study that utilized the instrumental orchestration framework to study teacher’s practices with technology is that of Bozkurt and Ruthven (2015) who analysed, based on orchestration types, how expert and novice teachers in technology use technological tools in the classroom. They found that both teachers used different types of orchestration, including ‘Predict-and-test’. They argued that this format makes the interaction become “between the teacher, class and computer” (p. 2324). Thus, the ‘Predict-and-test’ orchestration could be described as involving processes in which the four participants of the educational situation converge: the tool, the student, the teacher and the content/text, where this convergence is student-oriented. The instrumental orchestration framework enabled Bozkurt and Ruthven (2015) to differentiate between the practices of technology integration of the novice and the expert technology-user teachers. They reported that the convergence between the teacher and the tools differed, where the novice teacher’s orchestration types were “influenced by non-technology patterns, and not fully instrumented by the technology” (p. 2323).

Researchers also used the three elements of the instrumental orchestration (didactical configuration, exploitation mode and didactical performance) to analyse and assess teachers' convergence with technology in the classroom. The instrumental orchestration framework was utilized by Drijvers, Doorman, Boon and van Gisbergen (2009) to describe when a didactical configuration can enhance classroom discussion and student involvement. Specifically, the didactical performance component was utilized by the authors to describe when the convergence can assist the exploitation mode, as through minor comments, reformulating students' answers, and encouraging students to express their thinking. Thus, utilization of the three orchestration elements enabled to assess the teachers' mediation of classroom activity and the interaction between the teacher and the students, as well as between the students themselves. Trouche and Drijvers (2014) argue that the didactical configuration enables or restrains the exploitation of the interaction between students who use the technological tools. Thus, through the analysis of the potentialities of the didactical configuration, teachers can better help the student converge with the text by converging with the tool. This points at the instrumental orchestration as motivating teachers' professional development in technology use in the classroom.

Conclusions: The future of the instrumental frameworks

The instrumental frameworks, which are based on the conjugation of the technocentric and the anthropocentric perspectives, enrich our understanding of the educational production system from both human activity and technological perspectives. This is in line with Wittgenstein's argument that academics should study the actual production of scientific knowledge (Peters, 2019). In addition, the different foundations of the

instrumental frameworks gave the tool(s) a mediational role that develops during the subject's activity; what contributed to the recognition of the activity of the subject; whether a learner or a teacher, as appropriating the tool(s). This acknowledgement of the subject's appropriation acknowledges the relative openness of tools' design as well as the power of the subject in appropriating this design for varied educational goals.

Researchers say that the instrumental approaches need to be extended or integrated with other approaches in order to study all the aspects of the studied interaction or convergence. Drijvers et al. (2009) say that "the instrumental orchestration approach is promising, but needs elaboration and integration with other perspectives. For the moment, its descriptive power seems to be more important than its explanatory power" (p. 1357). Hegedus and Moreno-Armella (2010) offer a different perspective on instrumental genesis, suggesting that the relationship between instrumentation to instrumentalization needs to include not only the subject and the tool, but extends to the environment that the user interacts with. Thus, the discussed frameworks are not fully utilized yet, where extending them or combining them with other theoretical framework could increase their analysis power (Drijvers et al., 2009). Interestingly, Trouche and Drijvers who were behind the development of the instrumental orchestration framework call for new frameworks to study learning and teaching with the new technologies as the MOOC (Trouche & Drijvers, 2014, p. 15). The previous argument indicates that the instrumental frameworks are dynamic frameworks that could be extended in order to meet the new technologies, especially in relation to the convergence of these tools.

Another issue of the future of the frameworks concerns the number of mediators. The instrumental genesis was suggested to take care of the individual learner's processes while interacting with technology (Vandebrouck, 2018), while the later

instrumental orchestration was suggested to take care of various elements: the teacher, the learner, the tools and the text (Drijvers & Trouche, 2008). This theoretical development towards modelling the interaction between various elements needs to be part of a future instrumental genesis framework. The buds of this development are present in the previously mentioned description of an 'instrumental act' by Drijvers and Trouche; a description that includes three elements including the text. One potential development of the instrumental genesis framework is to take care of various mediators that impact the learning process. This potential development is in line with the call of Kaptelinin and Nardi (2012, p. 967) to view technology affordances as "a three-way interaction between the person, mediational means, and environment"; i.e. mediational means could be various not restricted to just one.

The potential development through taking care of various mediators can enable taking care of affective mediators, especially emotions that play an important role in how learners work with technological tools (Lee, 2001). As Lee (2001) argues for cognitive ergonomics in general, it is challenging to develop instrumental frameworks by taking into consideration not only cognitive mediators but also affective ones. This could be a promising development for the two instrumental frameworks.

The two instrumental frameworks can be developed together through combining between the two of them. This combination would help understand how the instrumentalization and instrumentation processes, in the instrumental genesis, occur in each of the instrumental orchestration modes: didactical configuration, exploitation mode and didactical performance. It would also help understand how each activity format in the instrumental orchestration helps mediate each of the instrumental genesis processes: the instrumentalization and instrumentation.

Sharples, Taylor and Vavoula (2007) discuss convergence in mobile learning, emphasizing that one type of convergence occurs between the new personal and mobile technologies and the new conceptions of learning. One such convergence is between personalised learning with personal technology, while another is between situated learning and mobile technology. This discussion of Sharples, Taylor and Vavoula (2007) leads to the option of extending the instrumental genesis and instrumental orchestration by contextualizing them to the different technological cognitive tools. This option would develop the theoretical frameworks to become more specific but still generic. Spreadsheets and applets differ in two aspects: the technical operations entailed in their manipulation and the scientific objects that they work with. First, the spreadsheets technical operations are related mainly to cell reference, while the applets technical operations are related mainly to writing the algebraic symbol of the object. Second, the spreadsheets work mainly with numeric object, while applets can work with different types of objects, especially graphs. It is interesting to investigate the difference between the learner's appropriation of the two technological tools as this appropriation could vary due to the difference of the tools regarding the technical processes of their manipulation in addition to the scientific objects that they work with. This direction of development is needed since it would shed light on the convergence of the parallel tracks of educational and technological development (Turner & Gassaway, 2019). In addition, there is little interest in the specificities of the processes of each type of instrumental convergence. Follmer et al. (2013, p. 417) suggested utilizing 'shape displays' in three different ways that clarify the mediation of interaction: "to facilitate by providing dynamic physical affordances through shape change, to restrict by guiding users with dynamic physical constraints, and to manipulate by actuating physical

objects”. It is interesting to develop a framework that models each phase of instrumental genesis for each way of mediated interaction.

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