Scaling Just Like Experts Do: Results of an Expert Interview Study

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Abstract: Scaling innovations such as adaptive educational technologies into practice is a complex endeavor. It requires both an increase in the number of users and a deep change on different school levels. The goal of this study is thus to investigate enabling conditions and limiting factors of scale and specifically how these factors relate to each other by applying a data-driven approach. That is, conducting interviews with experts in the field of scaling-up adaptive educational technologies. By conducting expert interviews, we had access to their accumulated expertise about scaling factors and the interplay between these factors. For our analysis, we applied Epistemic Network Analysis. The analysis positioned collaboration between stakeholders at the core of the network and revealed the strongest connection between collaboration and teacher characteristics such as teacher concerns, competencies and professional development. We discuss our findings in light of existing scale approaches and draw implications for future scale efforts.

Keywords: Scaling innovations, Epistemic Network Analysis, educational technologies

Introduction

Scaling up an educational innovation refers to both an increase in the number of users and a deep change on different levels of the envisioned practice environment (Clark & Dede, 2009). For example on the learning and teaching level, due to the innovation students and teachers will probably have to learn new roles. At the system level, to enable teachers to act in new roles professional learning is required. And further, to prepare the envisioned innovation for local adoptions a flexible approach is needed (Cohen & Mehta, 2017). Both professional learning and local adoption in turn need a lot of communication across different school levels and between educational practice, administration and research, but lack according to Burkhardt (2018) from exactly that communication. Therefore, scaling is considered to be a multidimensional, resource-intense and challenging endeavor (e.g., Cohen & Mehta, 2017).To address these issues, a number of scale approaches arose (often also termed as implementation or transfer process; e.g., Design-Based Implementation Research, DBIR, Fishman et al., 2013; Design-Based Research, DBR, Design-Based Research Collective, 2003 and many more). For example, DBR (Design-Based Research Collective, 2003) and DBIR (Fishman et al., 2013) deliver important impulses about scaling educational innovations such as to collaboratively and iteratively designing an innovation with practitioners and flexibly addressing local needs. Overall, these approaches represent valuable sources for conceptualizing scale but might lack empirical validation and a clear understanding about the interplay between different scale aspects. By making scale the object of inquiry and by applying a data-driven approach the present study aims to contribute to close this research gap. More precisely, we examine how different enabling conditions and limiting factors of scale relate to each other by conducting interviews with experts. The experts had profound experience in the field of scaling-up not just any innovation but a stellar example for a 21st century innovation. That is, adaptive educational technology (EdTech). This educational innovation allows for personalized and effective student learning (e.g., Pane et al., 2014) and requires a deep and wide change on different school levels. Thus, adaptive EdTech is seen as a suitable representative of a range of educational innovations and scale-related challenges.

Method

Sample and data collection: To examine how different scale aspects are connected, we recruited fifteen experts in the field of scaling-up adaptive EdTech. Experts were primarily researchers who had long-standing experience and profound expertise in a variety of EdTech development and scale projects. To get a broad variety of prior experiences both the experts' disciplinary background and role ranged from a) Computer Science, Learning Sciences, Science & Mathematics Education to Learning Assessment and from b) Principal Investigator, Co-Principal Investigator project manager, research associates to advisory board member. Interviews were conducted either personally or with a video conferencing tool and took between 41 to 96 minutes. The interviews were audiotaped with the experts' consent. *Interview Protocol:* For the interview protocol, we reviewed scale and EdTech related literature (see above and e.g., Puentedura, 2010) and identified categories of question. We then pilottested an initial protocol with an expert who was not included in later analyses and revised it accordingly.

The final protocol included 20 open-ended questions and covered the following broader themes: general experience with the scale process, collaboration with different stakeholders, technical implementation, use of EdTech in school, teacher competencies, mindsets, concerns with regard to EdTech, role of the curriculum. *Coding Scheme:* To code the transcribed interviews, we developed a coding scheme by combining a top-down and bottom-up approach: We again reviewed the scale and EdTech related literature and derived initial codes. For the bottom-up approach, we repeatedly reviewed the transcribed interviews and identified codes that were not yet touched by the aforementioned literature. Our final coding scheme covered six codes, namely *collaboration (C), teacher (T), resources (R), technology characteristics (TC), curriculum* (CU) and *else (E).* For example, the code C was aligned to an expert's answer if the expert referred to any form of collaboration either within the same group of stakeholders or across different stakeholders. The unit of analysis were the experts' answers to a single question. Because our goal was to analyze dependencies between different scale aspects, more than a single code was applied to an answer. To code, two raters were intensively trained. Interrater reliability was assessed with a subset of three interviews. Across all six codes interrater reliability was very satisfactory (C: $\kappa = 0.85$, T: $\kappa = 0.86$, R: $\kappa = 0.76$, TC: $\kappa = 0.74$, CU: $\kappa = 0.85$ and E: $\kappa = 0.67$). Disagreements were resolved by discussions. *Data Analysis:* To investigate how different scale aspects relate to each other, we conducted Epistemic Network Analysis (ENA; e.g., Shaffer, Collier & Ruis, 2016). That is a method for quantifying connections between codes and for visualizing these connections in a network. While the network nodes represent the frequency of the code, the connecting lines between nodes represent the co-occurrence of codes within temporal or local proximity.

Results

Prior analyses

Across all 15 interviews we coded 534 answers with the codes C, T, R, TC, CU and E. Expressed in absolute frequencies the six codes occurred as follows*:* C occurred 349 times, T occurred 277 times, R occurred 162 times, TC occurred 145 times, E occurred 86 times and CU occurred 53 times. In line with Shaffer and colleagues (2016) our network had a strong goodness of fit as the co-registration correlations measured by both Pearson and Spearman across the first and second dimension of the network were extremely high $r > 0.9$ (1^{st} dimension: Pearson's $r = 0.94$ and Spearman's $r = 0.93$; 2^{nd} dimension: Pearson's $r = 0.98$ and Spearman $r = 0.97$).

Core of the network and connections between different scale aspects

As seen in Figure 1, the code C is at the core of the network. Across all interviews, we could distinguish between two different forms of collaboration: The first refers to interdisciplinary collaboration between (multidisciplinary) researchers and practitioners from all levels of the educational system and from all levels the school. Experts mentioned for example the following partners to be important during different stages of the scale process: *Policy makers, district leaders, super intendents, subject matter coaches and other professional developers, science coordinators, principles, senior administrative leaders, teachers, students, school boards, parents clubs and the broader school community*. Note that the italics (other than the italic codes) display paraphrased parts of experts' answers. The other form of collaboration that facilitates the wide use of an adaptive EdTech is collaboration amongst teachers. Experts spoke either of a *culture of collaboration* or *communities of practice*.

Given our six codes, the ENA revealed a network with 15 connections (see Figure 1). In the following, we concentrate on the three strongest connections. That is, connections clearly greater than 1.5 measured by the relative frequencies of codes' co-occurrence. These connections are between C-T with 2.53, C-R with 2.12, C-TC with 1.86. *C-T* forms the strongest connection. That is, a close collaboration between both is required to identify and address teacher mindsets, concerns, competencies and to provide for professional development and other forms of support. For example, expert B said the following about gaining teachers' trust and collaboration to facilitate a smooth scale process: "Yeah. I think we're talking indirectly about the questions you asked, but I think they all add up and add to the fact that if you have to work with teachers and be able to run studies in schools, that you have to be aware of all of these issues and try to address (...) because if you do that, I think you gain the teachers' trust and the confidence and they see the value in what you are doing and therefore are more welcoming." To understand the relationship between *C-T*, we further examined what kind of teacher mindsets, concerns, competencies and forms of professional support the experts mentioned. Depending on their specific form, these teacher characteristics either display enabling conditions or limiting factors. Across all interviews, experts described the following teacher mindsets to be important for enabling the scale-up process. Teachers would need to be *willing to adapt or adopt these technologies into their teaching processes, need to be willing to accept that change and be willing to spend some time and to continue learning.* In this context, it is also important to help teachers *see the need, perceive the (added) value and to perceive the technology as a solution to a given problem*. In addition, experts named a variety of teacher concerns that might display limiting factors. Teachers were concerned about *the volume of work* and *time* that is required to work with an adaptive EdTech. That is, *not delivering the demanded content in time*. Teachers were further concerned about the extent to which the technology *is aligned with curricular standards and the lesson plan and to which extent it prepares students for assessment* (e.g., state tests). *Student privacy* (e.g., sharing and storing of data) and *equity* (e.g., access to computers beyond school) were two other major concerns. In terms of teacher competencies, the expert named the following as enabling conditions. They ranged from *basic tech skills, working knowledge of the system, knowledge about how to use the tool (translate data, to be able to interpret those results), TPCK – technological, pedagogical, content knowledge, ability to run experiments in classrooms, competence to work with constraints and have a Plan B as well as classroom management, teaching experience and knowledge about their student thinking.* There was consent across all experts that *professional development in form of trainings or workshops* is a key in the scale-up process.

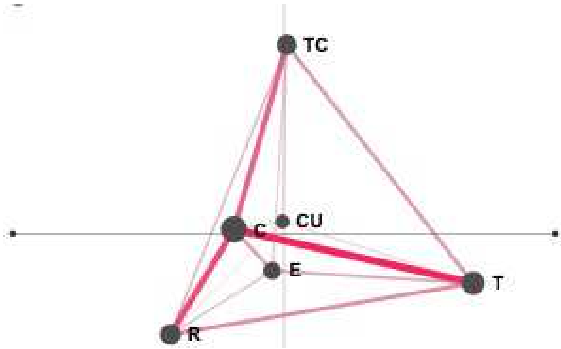

Figure 1. ENA across the codes collaboration (C), teacher (T), resources (R), technology characteristics (TC), curriculum (CU) and else (E).

The codes C and R form the second strongest connection within the network (C-R). That means, collaboration between researchers and practitioners and also a coordinated effort and high amount of communication amongst practitioners is required to identify and deal with (local) *resources.* In this context, expert B said: "Yeah, so increasingly, school districts have firewalls for what – and that prevents students and teachers in classrooms from accessing particular web sites or portals. And so oftentimes a district teachers or the science coordinator for the district will have to check with their IT department to make sure that they can actually get access to the portal. That's not the case for the majority of schools […]." Again to finer investigate the connection between collaboration and resources, across all interviews we identified what kind of resources the experts see as decisive for the scale process. For instance, they named *money, time, school infrastructure, availability and bandwidth of the school internet, availability of technical support (for maintenance of school computers) and the availability of technology and computers at students' homes* as important. The actual use of the adaptive EdTech depends on the extent to which the resources are available in school and also to which extent solutions customized to local needs can be provided (e.g., small group work around limited number of computers, print out/ plan B for very limited number of computers).

The third strongest connection is established by C-TC. For example, expert D explained how collaboration helps in dealing with specific TCs: "Which would prepare them for the kinds of things that they would do. Often, the first – if a technology is particularly complex, like a particular project or subject matter, then a researcher would work closely with the teacher, sometimes even teach the class. You know, sort of model the teaching approach, and then allow the teacher to sort of gradually, maybe in a subsequent period, right, or maybe on a day's delay they might, you know, do it with another class, following the example from the researcher." To gain a better understanding of the C-TC relation, we identified a range of TCs (i.e., the domain, its purpose of use, the way it adapts to students' performance and the extent to which it functions) to display important enabling conditions or limiting factors (or just neutral facts). In terms of the domain, experts named mostly STEM-related topics such as *science, earth science, environment science, math* but also *writing*. In terms of the adaptivity, they, for example described the underlying *algorithm of the technical component* of the EdTech. With regard to the purpose of use, experts named *science simulation, access to data and visualizations of data to teachers in science teaching, reading and writing, helping learners […] develop their spoken English skills, helping students learn a specific aspect of math, getting the students to construct a model of scientific process, visualizations of complex system, automated scoring*. Specifically, in terms of the purpose of the technology use collaboration plays a crucial role to manage practitioners' expectations, to co-design or to enable a shift in ownership.

Discussion

Scaling up educational innovations such as adaptive EdTechs is a complex endeavor. To address the complexity many scale approaches evolved but did not yet entirely unfold how different limiting factors and enabling conditions of scale are interwoven. Thus, we set out to investigate not only individual scale aspects but also how they relate to each other. In so doing, we applied a data-driven approach, conducted, transcribed and coded expert interviews and used ENA to account for dependencies between different scale aspects. Our ENA revealed one main finding: Collaboration is the most important enabling condition in scaling-up an educational innovation such as adaptive EdTech as seen by its central position in the network and by forming one part of the three strongest connections (C-T, C-R and C-TC). Collaboration here referred to both collaboration within the same group of persons (e.g., teachers) and collaboration between persons from different groups. For instance, collaboration between researchers and teachers is needed to understand teacher mindsets, concerns, competencies and professional development requirements (C-T) and to identify local resources (C-R), such as the availability of school computers or the availability of the IT-person at school. By identifying users' needs and local conditions in advance and throughout the innovation development process, the research team is able to consider a range of settings and to develop, iterate and redefine customized solutions (e.g., through modularizations) accordingly. Collaboration also played a crucial role with regard to technology characteristics (C-TC). That is, by enabling collaboration between researchers and practitioners technology characteristics can be re-defined. In this context, it is particularly important for the research team to transfer the (added) value of the technology for student learning or teacher work facilitation as highlighted in the Substitute-Augmentation-Modification-Redefinition Model (Puentedura, 2010). These findings are in line with key components of previous scale related literature (cf. DBR and DBIR) such as establishing a space for co-designing an innovation with practitioners or iteratively improving the innovation in diverse teams. With regard to the other form of collaboration (within the same group) experts highlighted the need for a culture of teacher collaboration. In such culture, teachers can identify different technology features and can discuss how the technology might fit into the broader lesson plan/ curriculum. Considering also the specific nature of the educational innovation at hand (i.e., adaptive EdTech) in the recent International Computer and Information Literacy Study (e.g., Eickelmann et al., 2019) teacher collaboration was an important enabling condition for using technologies in the classroom (not necessarily *adaptive* EdTechs).

In sum, we draw the following implications with regard to a smooth scale process: 1a) Collaborate early on in the development process, 2a) collaborate with a variety of stakeholders, 3a) through collaboration identify end users' needs and local resources and adapt to them and 4a) enable collaboration amongst teachers. To further integrate practitioners' perspective one of our next steps implies to conduct similar interviews with teachers and to identify the extent to which dependencies between different scale aspects differ across teachers and researchers.

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