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Curriculum and Didaktik in 21st Century: Still Divergent or Converging?

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Abstract
An intensive dialogue between US, German and other European scholars on topics of didaktik and curriculum took place during 1990s. Here, we review this dialogue and extend it into current post-2000 conversations to examine how the two education traditions are being affected by global trends in education. We employ content analysis to examine publications that derived from previous curriculum-didaktik dialogue as well as recent education policy documents and education developments in U.S. and Germany, as two core curriculum and didaktik countries respectively. Then, we exemplify the initial state and the identified changes through two logical models, which compare and contrast didaktik and curriculum theory as two educational policy systems. The results point to two key educational changes, namely the introduction of common core educational standards, i.e. national educational standards in the U.S. and introduction of external assessments in Germany. While curriculum and didaktik still hold to their traditional conceptualizations of the field, we conclude that to some extent both traditions are moving towards one another as a result of global education trends such as international assessments and the coordination of teaching and learning around research-based learning trajectories and learning progressions, in math education and science education, respectively.

Keywords: Curriculum; didaktik; logic models; educational policy; comparative education.

Introduction

Intensification of global cross-national cooperation in almost any fields, including education, has been inviting for educational theorists and practitioners to look ‘over’ the borders of their nations for exchange and transfer of ideas for educational improvement. But for exchange and transfer to occur, some level of understanding is required to enable the flow of ideas in a two- or multi-way direction. In efforts to reach that level of understanding, European and US scholars initiated a more intensive dialogue to discuss and understand similarities and differences between German-based Didaktik and US-based curriculum theory traditions during the 1990s. The spark for that intensified dialogue, after some earlier exchanges between two traditions starting from 1960s, came from

the interest of US educational scholars to better understand what was this concept called 'Didaktik'? (Hopmann & Riquarts, 2000). Of course, the underlying objectives and intentions were much broader and the dialogue tried to address questions, such as: How did the two traditions compare and contrast? Could, and to what extent, one tradition inform the other? Is there something that they can learn from one another? etc. We have summarized the findings of the dialogue during 1990s in Table 1.

So what is *Didaktik* theory? German *Didaktik* theory is central to curriculum, teaching and learning in Continental Europe generally and German speaking world specifically, but is mostly unknown in the English-speaking world (Hopmann, 2007; Westbury et al., 2000). The German term *Didaktik* is well established in post-1990s English literature, and to avoid the use of more negatively loaded concept of didactics as teacher centered and controlled instruction (Kansanen, 2002), we use the original spelling Didaktik throughout the article. In its original conceptualization, "Didaktik is about how teaching can instigate learning, but learning as a content-based student activity not as swallowing a sermon or a monologue or otherwise one-sided distribution of knowledge by a teacher" (Hopmann, 2007, p. 113). The interpretation of Didaktik across Europe led to a variety of modes but Hopmann points out they shared three common aspects, "(a) the concept of Bildung, (b) the embedded differential of matter and meaning, and (c) a concept of the necessary autonomy of teaching" to address "problems of order, sequence, and choice within their respective frames of reference" (Hopmann, 2007, p. 115). We will return to Bildung later, as another key concept within Didaktik theory.

Curriculum, on the other hand, is a widely used theory amongst many countries, primarily in the English-speaking world, but we focus here more on its North American and more specifically US tradition. While there are numerous definitions and constructs on curriculum, varying largely from one period of time to the other, what we refer to as curriculum here, is the prevailing curriculum model that has been in place in the U.S. since early 1900s, when the so-called social efficiency model of curriculum promoted by Franklin Bobbit and largely perpetuated by US industrial forces of the time, won the American education battle against humanistic-based models of curriculum, who were mainly led and supported by John Dewey (Kliebard, 2004). According to Kliebard (2004), ideas outside the realm of education, such as those of Frederick Taylor, an engineer from scientific management, that gave birth to social efficiency as a social ideal and educational doctrine, and ideas of Edward Thorndike from psychology, who introduced educational or "intelligence" measurement into American education, led to social efficiency curriculum models within the U.S. education. Such models have shaped US education curriculum and educational thinking and practice to the present days with continued heavy focus on externally-mandated assessments and accountability models. Social efficiency models suggested that students would learn in schools only what they needed to know in order to perform as an adult member of social order, that is, "To go beyond what someone had to know in order to perform that role successfully was simply wasteful" (Kliebard, 2004, p. 77). More recently the criticism against so-called 'business-driven' educational policies in the U.S. have mounted to such heights

where it is argued that “the common school became first a factory, then a corporation, now a cram school, but always a business” (Pinar, 2012, p. 15). However, with advancement of the learning sciences in the last several decades, curriculum has seen a shift towards cognitive and constructive models of curriculum, but the driving assumptions about education have not been challenged.

Debates between Didaktik and curriculum have already been extensive during 20th century. During 1960s, there was an export of curriculum ideas from the U.S. curriculum to Germany (Gundem & Hopmann, 1998), during 1990s, there was a dialogue for the benefit of better understanding between traditions (Westbury, Hopmann, & Riquarts, 2000), while more recently there is renewed interest in cross-cultural comparisons and scholarly exchanges between the US curriculum and German Didaktik, especially in relation to learning progressions and teaching sequences research and to curriculum content issues (Duschl, Maeng & Sezen, 2011). This rekindled interest is an opportunity for both traditions to reflect upon their recent past and current developments and identify areas in which they could be strengthened if they are open to changes and willing to learn from one another.

In our analysis, we extend the prior work in the field in an innovative way by translating the outcomes of the Didaktik-curriculum dialogue into logic models. Logic Models are tools primarily developed and used by program managers and evaluators to describe programs in terms of their assumptions, inputs, activities, outputs and outcomes (McLaughlin & Jordan, 1999). In this article, we conceptualize Didaktik and curriculum as two broad programs of education policy systems representing German and US contexts and through the logic models did analyses of salient changes over the years. While we understand that Didaktik would strongly resist such a comparison model, we consider the models do provide a clear layout as to how Didaktik and curriculum compare and contrast across same logic model categories.

One purpose for our theoretical work is to revitalize the cross-national and cross-cultural educational dialogues and exchanges between Didaktik and curriculum theorists, educational practitioners, researchers, and policy makers. We feel that a more intensive and extensive educational exchange between nations’ scholars could lead to 1) a deeper and better understanding of pedagogical traditions and 2) better informed decision-makers and policy makers to help avoid challenges in policy development and program implementation. A second purpose is to show how the administration of international assessments such as Trends in International Math and Science Studies (TIMSS) and Programme for International Student Assessment (PISA) has pushed many countries, including the U.S. and Germany, to undertake reforms that improve their students’ achievement in those assessments. These global and national educational processes as well as the lessons learned in the past in Didaktik and curriculum traditions could save significant resources and time for nations engaged in further educational developments in the coming years (e.g., 21st Century Skills, Diagnostic Assessments, Scientific Practices) by avoiding development of policies that lead to one versus another outcome. An example here is Germany’s decision to introduce external assessments, which have not proved to increase student achievement over time in the U.S., therefore it would

save resources required for test development and administration, etc., if such a policy was never put in place.

Comparative education scholarship is divided over usability and validity of cross-national education research due to national cultural and historical differences. Indeed, scholars participating in Didaktik-Curriculum debate during 1990s noted that educational issues "[…] are always rooted in the particularities of national histories, of national habits, and of national aspirations" (Reid, 1998, p. 11-12). However, we contend that fruitful insights and understandings emerge when trying to disentangle global and cross-national educational developments and practices. While it is argued that educational policy discourse has largely been standardized globally (Schriewer, 2000), within-country educational differences in Germany and the U.S. still provide relevant potential research-based solutions for one another. An example is with issues related to curriculum coherence and alignment, as central elements for provision of high quality education and experiences for everyone participating in and contributing to education systems in respective countries. We begin the paper by providing discussions of the theoretical frameworks and methodology that informed our work. We then follow with presentations of results and discussion, and conclude with some insights as to where our thinking might lead to in the near future.

Theoretical Frameworks

We draw from three theoretical perspectives to conceptualize the discussion on Didaktik and curriculum traditions: logic models, Didaktik/Bildung, and curriculum theory, with an emphasis on teaching sequences and learning progressions. First, we employ logic models of inputs/outputs to put Didaktik and curriculum traditions in a comparative and contrasting perspective. Logic models are a way to highlight the key elements of a project or program from assumptions to inputs to outcomes so that those involved in design, implementation and evaluation use the same platform as a point of reference (McLaughlin & Jordan, 1999). We view Didaktik and curriculum traditions as two separate standalone programs of education; therefore, the logic models framework serves our purpose to examine both traditions through the same perspective and to facilitate our discussion here.

Second, we use Didaktik/Bildung theory to focus the discussion on German educational thinking. Klette (2007) described this tradition "as a relation between teachers and learners (the who), subject matter (the what) and instructional methods (the how)" (p. 147). Similarly, Didaktik "provides teachers with ways of considering the essential what, how and why questions around *their* teaching of *their* students in *their* classrooms" (Westbury, 2000, p. 17, emphasis in the original). Hopmann (2007) stated that Didaktik is a matter of order, sequence, choice; features that align well with contemporary thinking regarding US standards revision and attention to Learning Trajectories in mathematics education and Learning Progressions in science education. Within the frame of order, sequence, and choice, Hopmann stated "Didaktik became the main tool for creating space for local teaching by providing interpretative tools for dealing with state guidelines on a local basis" (p. 113).

As noted above, Bildung is a central concept in Didaktik tradition. German concept *Bildung* is a noun meaning something like "being educated, educatedness." It also carries the connotations of the word bilden "to form, to shape". Bildung, as understood by Humboldt (1792), means 'grasping as much world as possible' and as 'contributing to human kind' by development of one's own unique self. In Bildung, whatever is done or learned is done or learned to develop one's own individuality, to unfold the capabilities of the I (Hopmann, 2007). The notion of Bildung, as developed in the Didaktik perspective, sees Bildung as an individual outcome, not as a program for education. This is in opposition to US testing-driven education and international testing programs where the meaning of the subject matter content is fixed, and in most cases only one right solution is sought from everyone. Furthermore, competence-based curricula are problematic as it is not possible to match a certain competence with a certain content matter, and also gaining competence is but one of the many potential meanings which can be achieved by a given content matter (Hopmann, 2007). Bildung is seen as an ideal aspiring to be mastered by students with teacher's support and something to hold on to and work towards throughout a personal life journey. In other words, it means preparing students for lifelong learning beyond formal education, for the sake of transforming themselves as human beings, and to the extent possible, extend that transformation to what the person does (occupation) and society at large.

Third, we draw from the more recent work in the curriculum theory, which is shifting its focus from being more behavioristic- to being more cognitivist- and constructivist- oriented. In particular, we focus on learning trajectories in mathematics education and learning progressions in science education placed within US educational research, and curriculum theory. Learning trajectories is a promising field of research in mathematics education that focuses on better curriculum, instruction and assessment alignment for the benefit of students' learning. More specifically, learning trajectories were defined as:

> descriptions of children's thinking and learning in a specific mathematical domain, and a related conjectured route through a set of instructional tasks designed to engender those mental processes or actions hypothesized to move children through a developmental progression of levels of thinking, created with the intent of supporting children's achievement of specific goals in that mathematical domain. (Clements & Sarama, 2004, p. 83)

Learning progressions research focuses on curriculum coherence and puts into practice an aligned system between curriculum-instruction-assessment that strives to elevate students' understandings and reasoning from simpler to integrated levels. "Learning progressions (LPs) are research-based descriptions of how students build their knowledge, and gain more expertise within and across a discipline over a broad span of time" (National Research Council, 2007, p. 8-5). We extend the discussion on most recent developments in the science, technology, engineering and math (STEM) education in the US as per the recent push towards science learning and teaching that relies on integration of science and engineering practices, crosscutting concepts and disciplinary core ideas. The concept of Bildung maps well to Learning Trajectories and Learning Progressions constructs regarding pathways of formative development and developmental

corridors incorporating a focus on using knowledge and participating productively in disciplinary talk.

Methodology

To develop our arguments, we employ a conceptual/theoretical mode of inquiry situated within comparative educational research. We explore, analyze, and synthesize theoretical perspectives that helped develop Didaktik and curriculum traditions historically up to the present day through the comparative lens. We apply interpretive methods based on hermeneutics, a qualitative-based approach that draws heavily from German philosophers of the Enlightenment period. We follow Gadamer's (1993) conceptualization of hermeneutics, who viewed hermeneutic work as based on polarity of familiarity and strangeness and the tensions in-between the two. We extend this notion of hermeneutics to the investigation of Didaktik and curriculum traditions by interpreting them both within their own territory, and also explore how both are merging with and extending to the territory of the other. For our interpretative/hermeneutic work, we use primary source texts covering issues of Didaktik and curriculum theory since 1990s. We place our findings in two separate logic models, one covering Didaktik-curriculum dialogue during 1990s and the other based on more recent developments in both traditions.

Table 1 summarizes Didaktik-curriculum dialogue during 1990s and vertically is organized into two columns representing Didaktik and Curriculum and row sections, namely, Assumptions, outlining assumptions about intended educational policies in two educational systems; Inputs, highlighting what goes into education system; Activities, covering what supposedly happens at classroom level; Outputs, presenting expected educational outputs from the schools; and Outcomes, summarizing short-term, mid-term and long-term aspirations emerging from the educational outcomes. Table 2 is in same format, but it highlights in **bold** the changes we identified as part of post-2000s national and global educational developments in Germany and the U.S; and in *bold* and *italic* (***italic***) changes we contend pose significant departures from Didaktik-curriculum theory in the past. Dashes (meaning ----) in tables indicate we have not been able to identify a corresponding concept in the counterpart tradition.

Results and Discussion

Here, we report the results of our analytical and synthetic work in two separate logic models. The first logic model is based on the work of US and European authors that organized Didaktik/Curriculum dialogue during 1990s. Comparing the two traditions, Westbury (2000) argued that under curriculum theory, the social and cultural world is an objective structure and the task of the curriculum is to present the structure to students, and help them determine what place they will occupy in it. Within curriculum tradition the teacher role is the one of an invisible agent of the system, "seen as "animated" and directed *by* the system and not as a source of animation *for* the system" (Westbury, 2000, p. 21). On the other hand, under Didaktik, the world that education should help create is presented as subjectified and the question is not how students learn or how to

lead students towards a body of knowledge, but the question is about the object of learning in terms of Bildung, what it should signify to the student, and how students themselves experience this significance (Westbury, 2000). Didaktik theory is a teacher- rather than system-centered system, where the role of the teacher is "forming" rather "instructing" his or her students and in so doing, celebrates the individuality of each teacher as an active and reflective curriculum and decision maker rather than seeing the teacher as implementing a workplace manual of best practices, that is, a curriculum or a curriculum package (Westbury, 2000). Under Didaktik, teachers enjoy autonomy because "[…] nothing is decided by the choice of the matter itself, but by how the teacher chooses to enact a given content for a given audience of students under given circumstances" (Hopmann, 2007, p. 117). Furthermore, Hopmann argued, Didaktik is the necessarily restrained effort to make certain substantive outcomes possible, while knowing that it can always turn out completely different from what was intended. Hopmann (2007) writes that: "The purpose of teaching and schooling is in this perspective… the use of knowledge as a transformative tool of unfolding the learner's individuality and sociability, in short: the Bildung of the learners by teaching" (p. 115). Teacher's role within the system, and teacher education philosophy were identified as potential areas for exchange during 1990s.

	DIDAKTIK	**CURRICULUM THEORY**
ASSUMPTIONS	- Education creates a world as subjectified - Hermeneutics - Humanistic / Romantic	- Education creates a world as objectified - Empiricism - Positivist / Formalist
INPUTS	-State-prescribed curricula (*Lehrplan*) ---- -Teachers as professionals/ curriculum makers - Teacher autonomy - Students - Subject matters/objects of learning in terms of Bildung/ content of teaching ----	- State-prescribed standards - District and/or school curricula - Teachers as system's agents ---- - Students - Subject matters/bodies of information -Accountability
ACTIVITIES	- Reflective practice of teaching - Teaching as licensed - Didaktik reflection - Observation - Peer-teacher evaluation / self-professionalism ---- ----	-Teaching as enactment/ instruction - Teaching as certified/in-serviced ---- - Student assessment/testing - Systemic teacher performance evaluation - Curriculum implementation - Curriculum evaluation
OUTPUTS	- Initiation of learning -Unfolding of individuality/creativity - Meaning-making - Reflection	- Learning outcomes/objectives - Test scores -Knowing/understanding/ applying ----

O U T C O M E S	**Short-term**	- Bildung - Self-determination - Co-determination - Solidarity	- Mastery of knowledge and skills/literacy ---- ---- ----
	Medium-term	- Increased student contribution to and transformation of disciplinary knowledge/society - Diversity	- Increased student productivity for and consumerism in the society - Conformity
	Long-term	- Increased commitment to Bildung	- Maintained competitive advantage over other nations

Table 1. First Logic Model of Didaktik and Curriculum as programmes of education policy systems based on 1990s' debate

The second logic model draws from post-2000s policy documents to examine how and to what extent the two traditions departed from their more historical and modern roots as exemplified during 1990s. Our analysis shows that significant developments in the U.S. and Germany have enabled both Didaktik and curriculum to seek new avenues for further developments. We found significant changes in both Didaktik and curriculum theory. However, the motivations for changes seem to have been not very wide apart but of varying degrees: in Germany, the so-called PISA shock seems to have pushed German educators to reconsider their educational policy orientations; in the U.S., PISA 'syndrome' also had an impact but the efforts to achieve curriculum coherence seem to have been a larger influence. Curriculum coherence is described as the alignment of the specified ideas, and the depth at which the ideas are studied, and the sequencing of the topics within each grade and across the grades (Fortus & Krajcik, 2012). Efforts towards coherence are most obvious in the field of STEM education, where there is an almost nation-wide state-led undertaking to put in place integrated science learning and teaching that is adequately aligned across curriculum, instruction and assessment.

	Didaktik	**Curriculum-Instruction-Assessment**
ASSUMPTIONS	- Education creates a world as subjectified - Hermeneutics - Humanistic / Romantic	- Education creates a world as objectified - Empiricism - Positivist / Formalist / **Cognitivist / Constructivist***
INPUTS	***- National Bildungs-standards (Competencies + Bildung)***** ***- School curricula based on federal state curricula (developed and enacted by within school subject matter teachers)*** - Teachers as professionals/ curriculum makers - Teacher autonomy - Students **(Students' conceptions as relevant aspects of classrooms)** - Subject matters/objects of learning in terms of Bildung/content of teaching ----	- ***National common core standards*** - ***District and/or school curricula based on national common core standards*** - Teachers as system's agents ---- - Students **- Subject matters/learning for deep understanding**

			- Accountability
ACTIVITIES		- Reflective practice of teaching - Teaching as licensed - Didaktik reflection - **Observation based on competencies defined in Bildungsstandards** -***External state assessments of Bildungsstandards after grade 10 and 12 (state assessment counts for approx. 30% of students' final grade)*** - Peer-teacher evaluation / self-professionalism **-School evaluation – consequences are recommendations** ---- ---- **-Teacher education exceeds subject orientation (psychology, educational sciences FachDidaktik), includes 7 years of education (3 years undergraduate+2 years master+2 years in-service training)** **- Mandated advanced training on the job**	- **Effective teaching** - Teaching as certified/in-serviced - ***Adaptive instruction*** ---- - **Assessments aligned to common core standards** - Systemic teacher performance evaluation **-School evaluation – consequences are high-stakes** - Curriculum implementation - Curriculum evaluation -Teacher education exceeds subject orientation (psychology, educational sciences, subject matter-oriented methods) ***-Professional development relevant to content to be taught***
OUTPUTS		- **Initiation of learning to help students achieve competencies** - Unfolding of individuality/creativity - Meaning-making - Reflection	- **Learning outcomes** - Test scores/**Student performances** **- Deeper understanding** ---- ----
OUTCOMES	**Short-term**	- Bildung - Self-determination - Co-determination - Solidarity ----	- Mastery of knowledge and skills**/deeper learning for deeper understanding** ---- ---- ---- **-STEM literacy**
	Medium-term	-Application of competencies for an active participation in society - Diversity	- Increased student productivity for and consumerism in the society - Conformity
	Long-term	- Increased commitment to Bildung	- Maintained competitive advantage over other nations

Table 2. Second Logic Model of Didaktik and Curriculum changes based on post-2000s developments

Notes: *****Words in **bold** indicate changes in Didaktik and curriculum as departures/extensions from their traditional roots noted in Table 1. ******Words in **bold** and *italic* (***italic***) indicate the most significant changes that constitute both departures from their traditional roots as well as shifts towards one another as a result of global educational trends.

For this paper, we focus on changes highlighted in **bold** and ***italic***, which we consider to represent significant departures from previous policy thinking in

Didaktik and curriculum traditions. Ironically, but maybe not coincidentally, through these major changes, we find Didaktik and curriculum moving towards one another's 'territories'. Included in these changes are the following:

1) in **Input** section, changes on national education standards and alignment of school curricula with national standards, and
2) in **Activities** sections, introduction of external assessment in Germany and adaptive instruction and professional development relevant to what will be taught in the U.S.

Arguably, what a few years back would have been thought unimaginable is now a reality in the recently reconceptualized notions of Didaktik and curriculum *practices*. We note *practices* because these two changes appear in **Input** and **Activities** sections, which to a large extent relate to practices taking place within the systems. Interestingly, we found that these practices are being implemented without reconsideration of the initial assumptions on which the whole education policy system is built on. Also, we did not find many significant changes in **Output** and **Outcomes** sections as per Logic Models categories, even though we agree that focus on achievement of competencies in Germany and student performance in the U.S. are considerable steps, but we see them as extension of two major changes indicated above and which we will elaborate more in depth in the following sections.

Changes in National Education Standards and School Curriculum Alignment

Since the mid-1990s, international student assessments such as TIMSS and PISA have acted as a thunderclap on educational politics – especially in German-speaking Europe. Results showing that 50% of the students failed central aims of core knowledge (Baumert et al., 2000) initiated an empirical turn in the Didaktik tradition. Initiated by the growing influence of psychometrics, the Didaktik tradition shifted from an input to an output model, from evaluating education based on the question "What have we taught today" to "What concepts and competencies have we learned today". Based on international, national and regional assessment studies, educational standards (*Bildungsstandards*) were developed describing the knowledge and competencies a student has to achieve after leaving school. With the shift from input to output model a second shift was initiated: the *Bildungsstandards* are formulated at the state level and transformed by the schools into school-curricula at a micro level (Köller, 2009). The German *Bildungsstandards* try to make a connection between the holistic tradition of *Bildung* and the Anglo-American tradition of formulating core knowledge and competencies. The comparison of "post-PISA Didaktik-perspective" and the modern curriculum perspective shows that Didaktik is on the way of finding a new identity in formulating standards as a sine qua non for achieving *Bildung*. In curriculum tradition, we found that changes in national common core standards in English, Math, and Sciences constitute a sea change in the US curriculum making, traditionally an undertaking of individual states and school districts. Nonetheless, we consider that the changes reshaping Didaktik and curriculum

are largely situated within their previously held assumptions, and based on their historical roots and development stages.

However, the path to what is called common core initiative in English and Math and Next Generation Science Standards has not been short and smooth. Numerous scholars had been addressing the issue of lacking curriculum coherence and alignment in the U.S. curriculum since late 1990s. For example, Schmidt, Houng and Cogan (2002), investigating US students' achievement in TIMSS study, claimed that "American students and teachers are greatly disadvantaged by our country's lack of a common, coherent curriculum and the texts, materials, and training that match it" (p. 1), while analogous concerns were voiced repeatedly by other researcher reports (Schmidt, Wang & McKnight, 2005; Schmidt, 2008; National Research Council [NRC], 2007; Fortus & Krajcik, 2012). Therefore, as the Carnegie Corporation of New York, & Institute for Advanced Study (2009) report suggested, an alignment across curriculum, instruction and assessment would be the response to upgrading education standards for all students and schools in all states with the hope to improve students' achievement within country and vis-à-vis international peers. Almost all U.S. member states have signed up for 'common core' standards and national assessments expected to be put in place starting from 2014-2015 school year. In turn, school districts are expected to follow-up and develop their curricula that are in line with the national standards adopted at both state and federal level.

Whether these steps will produce intended outcomes remains to be seen, but concomitant developments are major shifts from curriculum structure of the past. In particular, US developments are strikingly different from century-old beliefs and practices, where school curriculum is an inherently community-based affair to be decided individually by schools and districts. In Germany's case, developments are in line with past practices of national curriculum, but introduction of competencies or *Bildungstandards*, is to some extent in contradiction with the Didaktik principles since focusing on certain standards means dumping down curriculum. From Didaktik perspective, when teachers and students meet around specific content matter, the result is not a specific outcome, in the form of competencies, but the outcomes are multiple and go beyond any individual competence (Hopmann, 2007). However, German educators seem to have well-situated their competency-based education within Bildung, considering standards as another way of achieving the ideals of Bildung, as the case has been within Didaktik all along (Köller, 2009). The shift from didaktik-based models of education towards models more in line with curriculum and competency-based models seems to be a trend in other Continental European countries formerly dominated by Didaktik tradition (Pantić & Wubbels, 2012).

The work on learning trajectories and learning progressions in the US contributed to further accelerate decisions on having national educational standards, which in turn would evolve into some kind of a national curriculum, and then to curriculum alignment and coherence. As Fortus and Krajcik (2012) have noted, learning progressions are descriptions of successively more sophisticated ways of thinking about how learners develop key disciplinary concepts and practices within a grade level and across multiple grades. In turn, they further argue, learning progressions allow designers to bring coherence to

their curriculum materials, coherence that is crucial in supporting student learning by providing alignment between standards, instructional tasks, and assessments across grades and grade bands. We predict that with the start of implementation of the national standards and curriculum in the US, there will be a greater need for results from educational research in learning trajectories and learning progressions. Also, this need will result with more funding for this line of educational research as both policy makers and educators at schools, districts or state or federal levels will be interested to have empirically established learning trajectories in math and learning progressions in sciences. In turn, extended learning about learning trajectories and learning progressions will assist teachers in schools to implement the new curriculum, and policy-makers at decision making levels to bring intended curriculum goals up to scale across the nation.

The most recent emphasis on acceleration of STEM education reform in the US demonstrates a unique and ambitious agenda to redesign the science teaching and learning across the nation. To this end, a number of influential National Research Council (NRC) reports have drawn a new roadmap for U.S. science education. Among them, *Taking Science to School: Learning and teaching science in grades K-8* (NRC, 2007)*, A Framework for K-12 Science Education: Practices, Crosscutting Concepts and Core Ideas* (NRC, 2012a), *Education for Life and Work* (NRC, 2012b) and *Developing Assessments for the Next Generation Science Standards* (NRC, 2014) represent the stepping stones for the changes that are already initiated and those yet to come in US science education. A key recommendation that spans across all these reports is that science learning be organized into longer learning sequences, i.e. learning progressions that span vertically across grades and horizontally within a given school year. Another key recommendation that emerges from the reports maintains the need for fewer focused disciplinary core ideas that provide for deeper learning, as well as integration of science and engineering practices and crosscutting concepts to facilitate learning of core knowledge and practices that are crucial for mastery of scientific knowledge and reasoning. These developments are taking science education into a new space in efforts to overcome the past labeling of the US curriculum as a "mile wide and an inch deep." In the new agenda, a renewed definition of science is reconfirmed: "Science is not just a body of knowledge that reflects current understanding of the world; it is also a set of practices used to establish, extend, and refine that knowledge. Both elements - knowledge and practice - are essential." (NRC, 2012a, p. 26). To some extent, the redefined science for the US context sounds quite similar to the positions within Didaktik system that view the role of education beyond immediate knowledge mastery – such that entails a more transformative role for the students involved, the professional communities they engage with, and societies they contribute to. To make this possible in the US, the *Education for Life and Work* report (NRC, 2012b) recommends incorporation of "21st century competencies", such as problem solving, critical thinking and collaboration into teaching and learning activities for deeper learning purposes. The orientations laid out for the future of science education in the US start to sound a lot more as ideals aspired to be reached through Bildung in Didaktik tradition.

More specifically, the K-12 Science Education Framework sits on three dimensions, including scientific and engineering practices, crosscutting concepts, which have applicability across science disciplines, and core disciplinary ideas. In more detail, the scientific and engineering practices for science classrooms include: 1. Asking questions (for science) and defining problems (for engineering); 2. Developing and using models; 3. Planning and carrying out investigations; 4. Analyzing and interpreting data; 5. Using mathematics and computational thinking; 6. Constructing explanations (for science) and designing solutions (for engineering); 7. Engaging in argument from evidence; and 8. Obtaining, evaluating, and communicating information. In turn, there are seven crosscutting concepts, including patterns; cause and effect: mechanism and explanation; scale, proportion and quantity; systems and system models; energy and matter: flows, cycles and conservation; structure and function; and stability and change. The third dimension on disciplinary core ideas lists 13 core ideas distributed across physical sciences (four), life sciences (four), earth and space sciences (three) and engineering, technology and the applications of sciences (two) (NRC, 2012a). In the report words:

> Understanding the core ideas and engaging in the scientific and engineering practices helps to prepare students for broader understanding, and deeper levels of scientific and engineering investigation, later on – in high school, college, and beyond. One rationale for organizing content around core ideas comes from studies comparing experts and novices in any field. Experts understand the core principles and theoretical constructs of their field, and they use them to make sense of new information or tackle novel problems. Novices, in contrast, tend to hold disconnected and even contradictory bits of knowledge as isolated facts and struggle to find a way to organize and integrate them [24]. The assumption, then, is that helping students learn the core ideas through engaging in scientific and engineering practices will enable them to become less like novices and more like experts (NRC, 2012a, p. 25).

The Framework sets high expectations for the US students, and the ideals for developing a highly scientifically competent citizenry for both professional and other less formal contexts are largely commendable. These ideals pose a giant leap away from the past curriculum thinking and begin to even surpass ideals in Didaktik tradition as part of Bildung. One key challenge that needs to be resolved is whether US teachers will have the professional autonomy to adapt these high ideals into classroom realities of their districts and student populations. While teacher autonomy under Didaktik is still maintained, and teachers are less threatened by externally-mandated accountability models, if at all, the accountability systems in the US will still be in place and thus US teachers will have to walk again the fine line between supporting deeper learning for students and meeting accountability requirements imposed through externally-administered assessments.

To this effect, a latest NRC report on developing assessments for the NGSS (NRC, 2014) recognizes the challenges that might be encountered in implementation of the three-dimensional approach to STEM education, namely, practices, crosscutting concepts and core ideas, and emphasizes the need for adequate classroom assessments and monitoring assessments. The report recommends the use of both formative and summative classroom assessments, i.e. formative for the needs of instructional improvement and summative for the

needs of student grading. The monitoring assessments are recommended to track student learning and mastery of scientific practices, concepts and core ideas across different settings and time periods. The latter focus on monitoring assessments demonstrates continuation of past curriculum theory thinking is in line with the curriculum theory assumption that holds objectivist and positivist view of the world in which learning can be tracked and measured – a notion that Didaktik tradition in Germany has also started to lend itself into.

Returning to scientific and engineering practices one more time, here we offer a more extensive elaboration of the third scientific and engineering practice, i.e. Planning and Carrying Out Investigations as per *The Framework* provisions (NRC, 2012a). Planning and carrying out investigations is a science practice for making sense of and explaining the natural world. The outcomes of investigations help in the discovery of patterns and the development of cause and effect mechanisms that are used to explain and understand natural phenomena and engineering designs. For scientists and engineers, planning and carryout investigations has many steps, involving numerous decisions, and frequently requires repeated attempts. It takes time to sort things out in the natural world, to ask the right questions, and to make the appropriate measurements and observations. The *Framework* points out, however, that such sense-making enactments are missing in the current US K-12 science programs. One goal of the *Framework* is to make learners' experiences with science a bit of a struggle in order to develop images that science is a way of knowing that strives to make sense of the world. At its core, planning and carrying out investigations is a set of sense-making practices.

Thus, the *Framework* suggests that over a three year grade band (e.g., K-2 3-5, 6-8, 9-12), students' engagements with the planning and carrying out of investigations, teachers should increasingly lead them to broaden and deepen the complexity of investigations; both in terms of the questions and problems being posed as well as the measures and methods being employed. The *Framework's* intent is to avoid students only doing investigations that present science knowledge and inquiry in ways that lead students to see scientific knowledge as non-problematic. Non-problematic in the sense that science is seen as an easy straightforward path to answers and explanations where there is no struggle. Ask a question, you always get the answer. Make measurements, you always selected the right tool and procedure. Make observations, you always obtain the correct information knowing when and where to look. Such investigations-without-struggles leads to students leaving school with naïve notions that the results from investigations and scientific knowledge as non-problematic. Thus, planning and carrying out investigations should instead reveal how obtaining, building and refining scientific knowledge through scientific inquiries involves working through a variety of complex problematic processes.

So how can investigations be planned and carried out within the classroom settings? Planning investigations begins with designing experimental or observational inquiries that align to the question(s) being asked or the hypothesis being put forth. One begins this process by considering the relevant properties, attributes and variables and then determining how they may be observed, measured, and isolated or controlled. Isolating and controlling

variables are important for determining patterns, establishing cause and effect relationships and building mechanisms to explain or describe events and systems. In laboratory or design experiments, students need to decide:

i. Which variable(s) will be treated as results, the outcomes of the experiment that are allowed to be different and vary, and
ii. Which variable(s) are to be treated as the inputs and thus must be held constant, that is controlled.

In field observations, planning investigations begins with finding out what can and can't be controlled and then deciding when to do measurements or how to collect different samples of data under different conditions. The range of choices, the complexities with obtaining and setting up materials, and the wide variety of sources of error are what makes scientific knowledge problematic – it is complex work and thinking that can frequently be inaccurate or misdirected.

Let's consider then about some of the problems of measurement and measuring. Important decisions about measure are part of planning and carrying out investigations. What measurements should be taken? What level of accuracy do you want? What instruments or tools should be used to make such measurements? Precision is very important, the goal is to measure and record as accurately as possible so as to try and eliminate as many sources of error as possible. Then there are the precision issues when doing field studies such as conducting observation, conducting counts, gathering samples, and generating representations and drawings. Once again, we see how obtaining, building and refining scientific knowledge becomes problematic. As noted earlier, *Framework's* goal is to avoid students developing 'Knowledge Unproblematic' views of science knowledge and scientific inquiry. Planning and carrying out investigations are important experiences that help students acquire conceptual knowledge, procedural knowledge and epistemic knowledge and develop a 'Knowledge Problematic' view of scientific inquiry. Again, considering scientific practices from the Didaktik-Curriculum dichotomy, it becomes obvious that teacher's role is central in engaging students in investigations with open ended solutions – in those where the goal is not only to reach to an answer that will be relevant in an upcoming standardized tests. In other words, diminishing teacher autonomy and professionalism through accountability models in the US, and anywhere where those models are in place, minimizes the opportunities for teachers to allow both themselves and students to engage in investigations that face errors and failures and experience 'problematic' nature of scientific knowledge, thus avoiding the trap of 'knowledge non-problematic.'

Introduction of External Assessment in Germany and Adaptive Instruction and Professional Development Relevant to be Taught in the U.S

External assessments in K-12 education have been around for a long period of time, but that was not the case in Germany until the beginning of 21st century. Didaktik literature does not elaborate much on external assessment, if at all. The primary reason for the lack of external assessments in Didaktik tradition in the past is the notion of teacher's autonomy and uniqueness of meetings between teachers and students around content matter. Didaktik theory suggests

that student assessment is a sole discretion of individual teachers when individual students try to come to terms and understand some specific content (curriculum) (Hopmann, 2007). Considering how long these Didaktik principles have been held amidst educator communities in Germany, external assessment is indeed a major revolution in Germany, and the one that is already facing some resistance and opposition whether it fits with German Didaktik-based educational model. Hopmann (2007) considered that if "[…] many politicians and researchers argue that national testing combined with reducing the state curriculum to competency expectations would enhance the autonomy of schools and teachers, this is – plainly speaking – educational rubbish, at least from a Didaktik perspective" (p. 120). According to him, this approach would reduce teacher autonomy, as the expectation would be to match specific matter with competence, and autonomy of situated meeting the learner with matter would get lost, under Bildung perspective. Didaktik literature shows that some curriculum principles were tried in Germany during 1960s, but resulted with a short-lived exchange and return of Didaktik to its traditional roots. However, we argue that the friction and tension between German policy makers who insist on external assessment and education community who insists on Didaktik principles will continue for some time, and while the administration of external assessments will persist, Didaktik will not give up its principles either.

The changes with regard to adaptive instruction and professional education relevant to curriculum to be taught on the U.S. education spectrum have a better chance to succeed for three reasons: first, that they seem to be better aligned with the overall national agenda for curriculum alignment; second, adaptive instruction requires some teacher autonomy in adjusting national curriculum standards for the needs of individual and specific students, schools and districts in the U.S.; and third, because teachers will need to have higher academic levels to be able to teach a more demanding curriculum and they will need professional development tailored to specific curriculum content areas they will be teaching in schools. Indeed, research reviews have pointed to 'adaptive instruction' as a single most effective way to bring about intended changes at classroom settings (Corcoran & Silander, 2009). 'Adaptive instruction' is a vaguely defined term but it is suggested to make use of a variety of instructional approaches that are customized to individual students or groups of students and classrooms, such as group learning, project based learning, and dialogic teaching to name a few. Corcoran and Silander (2009) further argue that their conceptualization of adaptive instruction as well as formative assessment practices that pertain to providing immediate feedback to students for the sole purpose of advancing student learning and not evaluating them could potentially lead to ever increasing higher academic levels students are expected to achieve. However, they caution that "It is important to recognize that what is being "adapted" in adaptive instruction is not the learning goals for students, but rather the instructional strategies and supports offered to help students reach the goals" (Corcoran & Silander, 2009, p. 175). In addition, they noted that, "Adaptive instruction could incorporate the effective instructional approaches we have been reviewing, but add the power of real-time feedback and continuous improvement, for the

student, for the teacher, and for the profession" (Corcoran & Silander, 2009, p. 174).

It is eye-opening to see how well adaptive instruction argumentation fit within Didaktik and Bildung principles in general and to the Wolfgang Klafki's Didaktik analysis in particular. For example, Didaktik requires teachers to undertake a Didaktik analysis prior to teaching any content to students, asking for content of instruction to be analyzed at three levels:

> Relating it to subject matter as a structure of knowledge; Relating it to subject matter as in use in everyday life, and; Relating it to subject matter as in use in the frame of schooling and relations to other school subjects and its placement in the curriculum as a whole. (Westbury, Hopmann & Riquarts, 2000, p. 198).

From this perspective, it is ironic to observe how both Didaktik and curriculum traditions are moving towards each other 'territories' in areas they are being asked to change. We argue that it is tragic to some extent to see how Germany is trying to emphasize external assessments despite an ever growing body of decades of research against external and standardized testing in the U.S. By the same token, we contend the shift towards more teacher autonomy, adaptive instruction and formative assessment in the U.S. as an advocacy towards Didaktik-based thinking and practices, which Germany policy-makers are trying to do away with, but resistance of Didaktik scholars is promising in that it might lead to preservation of these values for the benefit of developing each students' individuality to their fullest potential.

Conclusions

In the globalized world of the 21st century, intensified by massive technological developments, education systems in the U.S and Germany, and indeed everywhere, are under double pressures: first, how to build a respectable and valid education system at home, i.e. within country, that matches the needs of students and expectations of the society, and second, how to increase achievement in international assessments to prove that they too have a 'world class' education irrespective of how 'world class' education is defined. Didaktik and curriculum are being shaped by these pressures, and the changes introduced in both camps hold significant implications for further work in educational arena.

Didaktik/curriculum changes we identified here have implications for educational research, policy making and educational practice for both countries. With regard to educational research, the example of the Didaktik-based model of educational reconstruction (MER) research program can be considered. The MER (Duit, Gropengießer & Kattman, 2005), coordinates three domains of research – 1) Investigations into students' perspectives; 2) Clarification and analysis of subject matter content; 3) Design of learning environments. The MER offers a well-conceived framework for educational research as well as a context for conducting theoretical, basic, and applied research. The corner stone of this research program is the 'Teaching Experiment', an interview-type method that seeks to understand how individuals coordinate core conceptual understandings in domain-specific contexts (e.g., evolution, ecology, adaptation, cellular functions, among others). This research can be a useful complementary to the research on learning trajectories and learning progressions in the U.S., as US

scholars and researchers undertake more extended initiatives to bring curriculum coherence and alignment at classroom level as a tool for teachers to prepare students to engage in deeper meaning making for the goal of transforming their lives, their professions and their communities and society at large. Indeed, the learning trajectories and learning progressions research in the U.S. is already stimulating rich debates as how to achieve more coherence and better alignment and rigor in curriculum-instruction-assessment triangle.

With regard to policy-making, the two traditions seem to be moving towards a similar educational trend and further developments will be critical to see whether the trend will continue or whether traditions will withdraw to their own roots again. As argued in this paper, the changes observed in the U.S. policy system seem to be better aligned between policy makers and education/academic community, therefore, we predict a better chance of success in these policy efforts which are built around the concept of curriculum alignment. In Germany, the situation is more difficult to predict as it seems there is more resistance from academic community to the policies introduced by the policy makers. However, we note that while external assessment will continue to be administered in German education system, Didaktik-oriented teaching force and academic community will do its best to align those assessments with Didaktik and Bildung principles, or discontinue them completely.

Educational practice is another field where we might expect new developments. Will US 'common core' initiatives bring about intended results? How will US policy-makers adapt their policies in the light of eventual potential implementation challenges in schools? To what extent will German policy makers push for external assessments to be used for accountability purposes in a country where teachers' professionalism and autonomy have been central to education for centuries? All these questions invite for further attention to be paid to these developments, but as the trend identified here shows, Didaktik and curriculum are likely to evolve into more converging than diverging education spectrums.

Significant changes in both systems – in Germany's case, the shift towards competency-based educational standards, introduction of external standardized assessment, and modifications in teacher education programs, and in the U.S. case, the shift towards national common core standards, alignment of assessments to standards, and increased focus on teacher professional development relevant to content to be taught – show that the past few years of national and global forces and trends have reshaped and restructured them in ways unimaginable a few decades back. The effects of this reshaping process is already felt in both Germany and the U.S. in terms of new policy and research initiatives being designed and supported (for example, Bildungsstandards in Germany and Common Core Initiative and Next Generation of Science Standards in the U.S.). Next, the challenge will be how these initiated changes will be implemented at the classroom level by teachers and learners as key beneficiaries and contributors to the educational transformation hoped for, and arguably needed, in the 21st century.

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