Review Article

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Shedding Light on the Convoluted Terrain of Differentiated Instruction (DI): Proposal of a DI Taxonomy for the Heterogeneous Classroom

https://doi.org/10.1515/edu-2019-0005
received February 15, 2019; accepted August 24, 2019.

Abstract: Student heterogeneity is not limited to performance, but encompasses cultural background, language competence, learning styles, and motivation. Thus, heterogeneity inherently changes the demands placed on teachers and requires them to practice differentiated instruction (DI). However, existing DI frameworks tend to describe single exemplary DI practices and widely lack an empirical view. Thus, these frameworks may provide little help to classroom teachers when it comes to the question of how or by which instructional arrangements they can address student heterogeneity in their everyday classroom teaching. In an attempt to bridge the gap between educational theory and everyday instructional practice, this theoretical paper focusing on differentiation within secondary school education proposes a comprehensive taxonomy of the DI practices known in the literature and practice. Outlines for future research on DI are discussed.

Keywords: heterogeneity; student diversity; differentiated instruction; differentiation practices.

Abbreviations

Differentiated instruction (DI)

1 Introduction

Our world today has become more and more diverse, and classrooms mirror this reality. While policy makers have been making efforts to deal with heterogeneity by organizing school systems into streams or tracks (Dupriez, Dumay, & Vause, 2008), teachers still report that the heterogeneity of the student population is substantial and continuously increasing (Dixon, Yssel, McConnell, & Hardin, 2014; Ehlers & Montgomery, 1999; Valiandes & Koutselini, 2009). Heterogeneity is by no means limited to performance and academic readiness. It also refers to aspects like cultural background, language competence, gender-based learning preferences, learning styles, motivation, as well as social, methodological, and self-regulatory competencies (Scharenberg, 2012; Smets, 2017; Valiandes, 2015; Voss, Kunter, & Baumert, 2011; Wenning, 2007). As student heterogeneity inherently changes the demands placed on teachers, teachers face a growing number of questions about how to effectively deal with the different learning requirements in order to ensure that every student experiences meaningful and successful learning. It is widely acknowledged that teachers must be able to diagnose and discriminate between a range of learning needs, abilities, learning styles, preferences, and motivations in order to effectively implement differentiated instruction (DI) and provide appropriate learning opportunities for all (Coffey, 2011; Hall, 2002; Tomlinson, 2001).

The ways in which teachers approach student heterogeneity are manifold, and many instructional practices have been discussed in the DI literature and are commonly applied in practice. However, established DI theoretical frameworks (Hall, 2002; Tomlinson, 2017; Reis, McCoach, Little, Muller, & Kantiskan, 2011) tend to describe single practices in an anecdotic manner, without providing an overview of the diverse strategies teachers may adopt to successfully handle student heterogeneity inside the classroom (Prast, Van de Weijer-Bergsma,

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Kroesbergen, & Van Luit, 2015). Consequently, teachers still face severe challenges to decide upon concrete instructional strategies for adequately addressing student heterogeneity (Suprayogi, Valcke, & Godwin, 2017).

Moreover, despite the vast amount of existing literature on DI (e.g., Carolan & Guinn, 2007; Chamberlin & Powers, 2010; Coffey, 2011; Coubergs, Struyven, Vanthournout, & Engels, 2017; Hall, 2002; Landrum & McDuffie, 2010; Lawrence-Brown, 2004; Levy, 2008; McTighe & Brown, 2005; Reis et al., 2011; Santangelo & Tomlinson, 2009; Schumm, & Vaughn, 1991; Smit & Humpert, 2012; Tomlinson, 2017; Valiandes, 2015; Wischer & Trautmann, 2012;), no theoretical conceptualization of DI has been agreed upon (Jennek, Gronostaj, & Vock, 2019; Prast et al., 2015; Roy, Guay, & Valois, 2013). Several authors (Koutselini, 2008; Wischer & Trautmann, 2012; Valiandes, 2015) see DI as a manifold construct or a "container" term that includes single practices such as learning centers, elements of scaffolding and support, small-group interaction, and tiered activities (e.g., Latz & Adams, 2011). In contrast, other authors (e.g., McTighe & Brown, 2005; Levy, 2008; Santangelo & Tomlinson, 2009; Coffey, 2011) still treat DI as a one-dimensional construct, while all large- and small-scale empirical studies employ one-dimensional DI scales (e.g., NEPS[1], 2016; PIRLS[2], 2016; PISA[3], 2006; Roy et al., 2013; TIMSS[4], 2015). This one-dimensional view hinders a theory-driven or evidence-based categorization of the wide variety of active practices teachers implement within a class to differentiate their instruction (Reis et al., 2011). Most importantly, it limits the possibility of testing the effectiveness of unique DI practices for addressing in-classroom student heterogeneity (Valiandes & Koutselini, 2009). To tackle this problem and attempting to provide a unifying DI conceptualization, in this article we define DI as an umbrella term encompassing any instructional practice that enables teachers to address student heterogeneity adequately and thereby support student learning.

For the purpose of this paper, the common practice of addressing student heterogeneity by means of between-class grouping (i.e. tracking or streaming) will not be subsumed under our understanding of DI, as it is an organizational measure taken at the school level and not a decision of the teacher. Instead, we focus on DI practices that secondary school education teachers can actually implement in their individual classroom teaching.

The concept of "adaptive teaching" is an important issue in the field of teaching and learning research within educational psychology. Much like DI, it focusses on the optimization of learning process and its core objective is to identify practices that teachers use to teach all students (Corno, 2008, p. 162). While adaptive teaching and DI may differ in underlying theoretical assumptions, terminology, and instructional arrangements, both concepts are unequivocally dedicated to effectively address student heterogeneity and follow the same line of thought. Thus, in this paper, adaptive teaching is implicitly subordinated to a wider DI conceptualization.

The aim of this article is to present a theoretical and conceptual analysis, bringing together the literature on DI research and to introduce a taxonomy of DI practices for the heterogeneous classroom mainly focused on secondary school education[5]. Such taxonomy is intended to serve two ends: (a) scientific literature and pedagogical guidebooks provide teachers with a large number of approaches on how to address student heterogeneity in their everyday teaching. Yet, the mere quantity and diversity of the approaches and actions described therein might be overwhelming for practitioners (Reis et al., 2011), possibly resulting in them selecting single approaches on an arbitrary basis. A categorization may help teachers to reflect and decide upon individual DI practices (Altrichter, Trautmann, Wischer, Sommerauer, & Doppler, 2009). Additionally, (b) the multitude of practices presented under the umbrella term of DI is diverse in nature and, thus, implies that teachers adopt very different instructional strategies and behavior patterns when addressing student heterogeneity. Consequently, one cannot expect that all of these approaches produce identical effects on student learning, student motivation, and other important outcomes (Altrichter et al., 2009).

The article starts by exploring the current state of the literature, discussing the prevalent DI models and the related large- and small-scale research in order to ground the taxonomy of DI practices. Then, the article elaborates on six categories of DI practices, describing each one's relevant literature, research, and its practical considerations for effective implementation. Finally, the taxonomy is framed within the context of the discussed DI models concluding with a discussion of the taxonomy's

1 NEPS: National Education Panel Study. The NEPS is a nationally representative research database in Germany carried out by the Leibniz Institute for Educational Trajectories (LIfBi) at the University of Bamberg.

2 PIRLS: Progress in International Reading Literacy Study

3 PISA: Programme for International Student Assessment

4 TIMSS: Trends in International Mathematics and Science Study

5 The practice of DI is not limited to secondary education. However, as it is likely that specific DI practices are more efficient in specific age groups or educational stages, this paper focusses on DI practices in the secondary education classroom.

practical implications and delineates outlines for further research.

2 The present state of the literature on DI

2.1 A review of DI theoretical models

In order to deal with the increasing diversity inside classrooms, teachers have to move away from traditional "one-size-fits-all" educational methods to a DI approach (Darling-Hammond, 2006; Santangelo & Tomlinson, 2009). Within the international context, literature and research on DI have grown in the past years considering DI as a set of effective instructional practice (Chamberlin & Powers, 2010; Lawrence-Brown, 2004; Tomlinson, Brighton, Hertberg, Callahan, Moon, Brimijoin, & Reynolds, 2003) which ensures successful and meaningful learning for all. Given the increase in DI literature, a number of frameworks have been proposed which vary with regard to their structure, key elements, and preconditions for differentiation. The following section will provide a discussion on the most well-known DI models: I. Tomlinson (2017), II. Hall (2002), and III. Lawrence-Brown (2004).

I. Tomlinson's (2005a, 2005b, 2017) DI framework starts by focusing on the teacher's mindset and beliefs, as it can influence how he or she carries out DI. The construct of teacher beliefs (Pajares, 1992) and mindset (Dweck, 2007; 2010) refers to the implicit views that administrators, teachers, and students hold regarding teaching and learning. According to Fives and Buehl (2012), these views are related to: (a) specific teaching practices, (b) teaching practices which encompass direct-transmission or constructivist approaches (Staub & Stern, 2002), and (c) views concerning student diversity, learning, and ability.

In line with the concept of teachers holding transmissive vs. constructivist beliefs, Dweck (2007) distinguished between two types of implicit beliefs about ability and success: fixed and growth mindsets. Teachers with a fixed mindset tend to believe that students' talents and abilities are trait-like entities which determine their academic success. In contrast, teachers with a growth mindset believe that persistence and dedication lead to student success (Dweck, 2010). Beliefs or mindsets have been found to impact teaching approaches (Gutshall, 2013; Swann & Snyder, 1980) as they function like filters influencing whether teachers adopt a direct-transmission or constructivist teaching approach.

Taking up these considerations, Sousa and Tomlinson (2011) posited that effective teachers possess "growth" mindsets that enable them to create a positive learning environment where teachers can flexibly change their teaching to best suit their students' needs, address students' social-emotional as well as cognitive needs, and reinforce students' strengths and competences. Teachers with growth mindsets are committed to help each student reach their full potential (Dweck, 2010; Coubergs et al., 2017), and tend to follow a constructivist teaching approach enabling them to gear their in-class practices towards differentiation (Valiandes & Koutselini, 2009).

Tomlinson (2005a, 2005b) proposed that teachers differentiate with regard to content: (a) The subject matter that has to be taught; (b) the process, which outlines the tailored learning activities for students, and (c) product, the assessments in which students demonstrate how well they can apply their new knowledge. Content, process, and product can all be differentiated depending on the readiness, learning profile, and interest of students (Tomlinson, 2017). When teachers differentiate according to students' academic readiness, their goal is to provide every student with appropriately challenging learning experiences (Coffey, 2011). Additionally, teachers may differentiate according to students' learning profiles (Landrum & McDuffie, 2010), that is, based on students' favored approaches to learning. This would imply that teachers provide tasks that help students learn more effectively (Tomlinson, 2017). When differentiating according to students' interests, a desired teacher's objective is to promote students' engagement and motivation in order to bring them closer to topics and contents that they find meaningful. Teachers must possess a profound understanding of their students' characteristics (readiness, interest, and learning profile) in order to ensure the effective differentiation of curricular elements (content, process, or product). To this end, Tomlinson (2005a, 2005b, 2014) suggests specific instructional strategies to facilitate differentiation: learning centers, scaffolding and learning aids, learning contracts, small-group interaction, organizers, tiering activities based on varied levels of complexity, provision of alternative topics, and assignments that focus on real-world relevance.

II. Hall's DI model (2002), identifies pre-assessment as the starting point for differentiation. By assessing students before starting a unit, teachers are able to determine their background knowledge, skill, understanding, attitudes, interests, and learning styles (Coubergs et al., 2017; Roy et al., 2013; Valiandes & Koutselini, 2009). Hall (2002) strongly advised using assessment as a formative teaching

tool for gathering information about students' needs (Reis et al., 2011) rather than merely employing it to measure the outcome of instruction. Information collected within formative assessments (Black, 2015) may then be used to decide how to (a) differentiate based on students' learning pace, knowledge and understanding, and interest (Hall, 2002) and to (b) plan the content, process, and product (Tomlinson, 2001). Finally, teachers must clarify learning objectives and provide different pathways to achieve them (Hall, 2002). Learning objectives must be customized so that students are adequately challenged and encouraged to use their background knowledge. Hall (2002), in line with Tomlinson (2005a, 2005b, 2014), suggested a variety of strategies for differentiating instruction such as tiered assignments, compacting, and flexible grouping.

III. Lawrence-Brown's (2004) model focuses on two goals: (a) in line with the principle of mastery learning (e.g. Bloom, 1968), it recommends maximizing students' probability of achieving grade-level curriculum standards, and (b) it suggests adapting curricula for weaker learners. According to Lawrence-Brown (2004), DI serves a number of goals for distinct student subgroups: First, in order to achieve grade-level or minimum standards, additional support should be provided to struggling students. Average-ability students may, for example, be provided with manipulatives (e.g., for mathematics, the use of number system cubes to model or represent a problem concretely), visual aids, charts, outlines, and picture cues to effectively practice skills and concepts. Meanwhile, low-achieving students can work on a prioritized curriculum enabling them to participate in the general curriculum, while specifically addressing their individual needs. Secondly, DI should focus on both high- and low-achieving students because these groups require specific curriculum adaptations. High-achieving students should work on an enriched curriculum including extra challenges such as establishing cooperative heterogeneous groups with individualized roles (Lawrence-Brown, 2004).

The three outlined DI models argue that teachers need to have a profound understanding of their students' profile in order to plan differentiation. That is, teachers need to be able to diagnose individual students' learning needs, prior knowledge, interests, readiness level, learning styles, and preferences (Hall, 2002; Lawrence-Brown, 2004; Tomlinson, 2017). Furthermore, they share a set of differentiation principles (e.g., formative assessment), which enable teachers to respond to student needs while creating positive environments.

While the three models agree on a set of DI preconditions and principles, their main difference is set on the rationale on how to plan and implement DI. For instance, the models by Tomlinson (2017) and Hall (2002) propose adapting content, process, and product to the previously assessed student needs. Once these three elements are determined, Tomlinson (2017) and Hall (2002) suggest various instructional strategies to be implemented as DI practices. Lawrence-Brown's (2004) model, in contrast, viewed adapting the curriculum with the goal of maximizing attainment as the core element to plan and implement DI: the DI practices to be selected should be in accordance to the standard level set for distinct student subgroups.

2.2 Empirical research on DI

Research into teachers' use of DI has taken both a large-scale and small-scale perspective. The PIRLS (2016), PISA (e.g., 2006), TIMSS (e.g., 2015), and NEPS (2016) programs have all generated large-scale data on the frequency of teachers' use of DI. However, only a limited number of practices have been considered: NEPS (2016), PIRLS (2016), and TIMSS (2015) only assess two main DI practices: tiered assignments and within-class grouping. PISA (2006) includes a mastery-learning related item on whether teachers only begin to teach a new topic after assuring that all students have understood the current content, while both PIRLS (2016) and TIMSS (2015) contain items on whether teachers draw on students' interests as an impetus for differentiation.

Small-scale studies on DI mostly focus on two lines of research: (a) instrument construction and validation (exploring teachers' use of DI) and (b) examining teachers' use of DI and its effects on student achievement. In the first line of research, Roy et al. (2013) developed the Differentiated Instruction Scale which contains two scales that assess the frequency of instructional adaptations and academic progress monitoring. Data collected with this scale reveal that teachers favor instructional adaptations that do not require much preparation or adaptation. More recently, Coubergs et al. (2017) introduced the Differentiated Instruction Questionnaire (DI-Quest) which covers five DI aspects: (a) teachers' mindset, (b) teachers' ethical compass, (c) flexible grouping and peer learning, (d) assessment for learning, and (e) use of DI (based on interest, readiness, and learning profile).

Regarding the second field of research, Smit and Humpert (2012) reported that teachers mostly differentiate by implementing tiering activities, adapting the time for completion of tasks, or by using flexible grouping. Furthermore, two groups of teachers were identified: (a) teachers who hold a limited view on DI and only use

reactive strategies (i.e., additional exercises) and (b) more progressive teachers with a wider view of education who implement cooperative learning, formative assessment, and project work. Overall, Smit and Humpert (2012) reported that teachers did not show a great variance in their DI practices. This may indicate that teachers lack DI knowledge and practical experience, or that they might find certain differentiated practices to be desirable but not actually practicable in the classroom (Tomlinson et al., 2003). In this line, Schumm and Vaughn (1991) found that teachers considered DI practices that do not require them to make any curricular adaptations to be more desirable. In contrast, practices involving thoughtful adaptation of long-range plans, materials, and grading criteria were considered least desirable.

The mere well-intentioned and deliberate application of DI practices by teachers does not, however, necessarily lead to positive effects on students' learning. Hence, empirical research has concentrated on its effects. In a quasi-experimental study (Valiandes, 2015), students in classrooms where DI was implemented performed better compared to students in classrooms without DI. Likewise, the use of DI strategies resulted in better reading fluency and comprehension (Reis et al., 2011). Baumgartner, Lipowski, and Rush (2003) found that DI practices such as flexible grouping, student choice of tasks, and increased time and materials resulted in an increase in students' reading achievement. Similarly, Santangelo and Tomlinson (2009) as well as Chamberlin and Powers (2010) reported positive effects of DI in addressing the needs of college students. Further information on the effects of DI can be found in Tomlinson's narrative review of research (Tomlinson et al., 2003).

In summary, although extensive research on the use of DI has been carried out, most studies are limited to reporting the mere frequency of DI or the impact of one global one-dimensional construct of DI on student achievement. Some specific DI practices such as peer tutoring or staggered nonverbal learning aids have not been sufficiently submitted to empirical research. Additionally, DI can also be expected to impact non-achievement outcomes such as motivation or academic self-concept (ASC) and should not be neglected in DI research.

3 DI practices: proposal of a taxonomy

Given the lack of systematic research in this field, there is an essential need for a systematization of the DI construct and for a precise categorization of the very diverse ways of dealing with student heterogeneity inside the classroom. To this end, this paper introduces a taxonomy whose main feature is to categorize DI practices that aim to support the instructional decisions of teachers within secondary school education.

3.1 Methodology behind the DI Taxonomy

The taxonomy is framed within the basis of the current literature and empirical research on DI (see section 2). In this line, following a descriptive design (Mayring, 2014), the categories adhered to the taxonomy were deductively drawn on the basis of DI models by Tomlinson (2017), Hall (2002), and Lawrence-Brown (2004) (see table 1, 2, and 3 for examples). Additionally, pedagogical guidebooks aiming at practitioners were also revised to identify potential DI practices (e.g. Klippert, 2016; Leuders & Prediger, 2016; Silver, Moirai, & Jackson, 2011; Strickland, 2009; Tomlinson, 2003; Tomlinson & Cunningham, 2003; Tomlinson & Demirsky, 2000; Tomlinson & Imbeau, 2010; Tomlinson & Murphy, 2015; von der Groeben, 2013). Of note, teachers tend to turn to expert teachers, internet pages, counselling literature, or handouts issued by institutions outside the scientific community[6] when searching for solutions to pedagogical or practical problems (Hetmanek et al., 2015) as these sources appear more trustworthy or applicable than scientific reports such as abstracts from journal publications (e.g. Rosman & Merk, 2019). Hence, we also explicitly included such grey sources providing practical examples for implementing DI into in the review.

Overall, the revision of the literature was conducted from March 2018 to November 2018 and included a total of 123 articles, books, pedagogical guidebooks and grey literature aimed at teachers, as well as diverse national educational reports (e.g. Germany, Austria, and the United States of America among others) dealing with DI in the language of English and German. Literature published in a different language to the previously mentioned and that discusses the practice of between-class grouping was excluded.

The categories of DI practices within our taxonomy are: I. *Tiered assignments*, II. *Intentional composition of student groups*, III. *Tutoring systems within the learning*

6 In Germany's two-phased model of teacher education, only the first (theory-oriented) phase occurs in scientific (university) institutions. The second (practice-oriented) phase is in the hands of ministry-run teacher training institutes whose staff is expert teachers, but not scientists. Materials issued by these institutes are, however, salient and easily accessible for student teachers and hence influence their teaching significantly.

Table 1: Example of deductive categorization – Tiered assignments.

Author	Identified Practices	Category
Tomlinson (2014)	Tiered activities based on different levels of complexity	Tiered assignments
Excerpt "*Using tiered activities allows all students to focus on essential knowledge, understandings, and skills, but* ***at different levels of complexity, abstractness, open-endedness, and independence****. By keeping the focus of the activity the same but* ***providing routes of access at varying levels of difficulty****, the teacher maximizes the likelihood that each student comes away with pivotal skills and understandings and all students are appropriately challenge*." (Tomlinson, 2014, p. 133)		

Table 2: Example of deductive categorization – Intentional composition of student groups.

Author	Identified Practices	Category
Tomlinson (2001)	Flexible grouping Heterogeneous readiness-based level grouping Homogeneous readiness-based level grouping	Intentional composition of student groups
Excerpt "*Students are part of many different groups –and also work alone- based on the match of the task to student readiness, interest, or learning style. Teachers may* ***create skills-based or interest-based groups that are heterogeneous or homogeneous in readiness level****. Sometimes* ***student group assignment are purposeful****…*." (Tomlinson, 2001, p. 102)		

group, IV. *Staggered nonverbal learning aids*, V. *Mastery learning*, and VI. *Open education/granting autonomy to students*. For an overview of the taxonomy categories, please refer to Table 4. In an ongoing study, preliminary qualitative results from interviews of in-service secondary school teachers revealed that the underlying categories within this taxonomy cover all relevant areas of a DI (Letzel & Otto, submitted). Furthermore, based on teachers' responses to their in-classroom differentiation practices, it was possible to inductively itemize specific DI practices within each of the categories.

3.2 Category I. Tiered assignments

Tiered assignments are the most applied instructional DI practice. They focus on a specific learning goal, topic, or concept and provides different instructional alternatives for students to achieve understanding and address learners' preferences, learning profiles, and/or motivation (Pierce & Adams, 2004). In our model of DI practices, we consider tiered assignments to be any differentiating practice that includes variations of materials, worksheets, and tasks (Leuders & Prediger, 2016). This conceptualization allows tiered activities to be adapted and varied in terms of quantity (amount of tasks and/or time available) and/or quality (varying the complexity) (Richards & Omdal, 2007; Prast et al., 2015). Tiered activities guide students towards different ways of processing information. They allow low-achieving students to engage in meaningful learning, increase their academic achievement, and provide high-achieving students with the opportunity to expand and deepen their knowledge as well as to transfer their understanding to other contents (Richard & Omdal, 2007; Tomlinson, 2001).

The use of tiered assignments does not necessarily imply that the teacher assigns the tiered tasks to different students or groups (a method largely in line with the teacher's transmissive beliefs). Students can also freely select the tasks they want to work on (which corresponds with constructivist beliefs). Both approaches may have their advantages and disadvantages. The teacher-allocation method might have a detrimental outcome if, for example, a teacher does not assign tasks based on the students' needs. In contrast, student choice would fail if the students themselves are unable or unwilling to select tasks that correspond to their real ability level (e.g. when too simple tasks are chosen in order to avoid effort).

The effectiveness of tiered assignments depends largely on teachers having a highly developed ability to correctly assess students' prior knowledge, preferences, and level of achievement (Helmke, 2014; Praetorius,

Table 3: Example of deductive categorization – Mastery learning.

Author	Identified Practices	Category
Lawrence-Brown (2004)	Standards-based instruction Additional support Enriched curriculum	Mastery learning
Excerpt (1) *"Making multilevel instructional decisions (e.g., **who learns at what level?**)in a way that is manageable within a **standards-based instructional context**."* (Lawrence-Brown, 2004, p. 37) "*Differentiation can be thought of as serving two broad goals. The first is to **maximize attainment of the grade-level general curriculum standards for all students**."* (Lawrence-Brown, 2004, p. 38) "*The second broad goal is to provide **adapted curricula for students who need it***." (Lawrence-Brown, 2004, p. 38)		
Excerpt (2) "Additional Supports" to allow ***struggling students to achieve the general curriculum standards*** are represented in Figure 1 as the trapezoid-shaped foundation that supports "Grade-level General Curriculum." For these students, ***"grade level standards are appropriate, but very challenging**. Without Additional Supports, many of these students will fail."* (Lawrence-Brown, 2004, p. 39)		
Excerpt (3) *"Enriched Curriculum for students (...), indicating that opportunities **for more challenging and/or creative work are provided above and beyond grade-level curriculum standards**."* (Lawrence-Brown, 2004, p. 46)		

Table 4: Summary of the DI taxonomy.

Category	Description	Intention	Classroom Practices	Effectiveness on student achievement reported in single studies/meta-analysis
I. Tiered assignments	Qualitative and/or quantitative variation of materials and tasks according to challenge level, complexity, outcome, process, product, and/or resources	Each student works on an assignment adapted to his or her own needs.	Provide extra assignments to high achieving students Provide less complex assignments to low achieving students Design tasks with a range of complexity Faster students may advance to the next assignment	Hattie (2009): $d = 0.23$ Richard & Omdal (2007): low ability students $d = 1.06$; middle ability students $d = 0.22$; high ability students $d = 0.08$ Tieso (2005): $d = 0.62$
II. Intentional Composition of student groups	Establishing decidedly homogeneous or heterogeneous groups based on performance, readiness, interests, etc. Students are grouped accordingly to either homogeneous or heterogeneous grouping.	Heterogeneous grouping: High-ability students support low-achieving students within the groups. Homogeneous grouping: Teacher focuses on the low-ability students, while high-ability students work in their own group.	Based on teacher's intentions, establishing homogeneous or heterogeneous groups. Without neglecting social needs (cf. Lou et al., 2000), teacher must plan and reflect how to best accommodate/sit students in groups. When working with homogeneous groups, teacher focuses his or her attention on the low-achieving group. Especially for homogeneous grouping, teacher must adapt the materials according to the grouping system.	Hattie (2009): $d = 0.16$ Kulik & Kulik (1992): $d = 0.25$ Lou, Abrami, Spence, Poulsen, Chambers, & d'Apollonia (1996): $d = 0.17$ Saleh, Lazonder, & Jong (2005): strong effects Tieso (2005): $d = 0.66$

Continued **Table 4:** Summary of the DI taxonomy.

Category	Description	Intention	Classroom Practices	Effectiveness on student achievement reported in single studies/meta-analysis
III. Tutoring systems within the learning group	High ability students take up the role of teacher assistants and tutor low ability students. This role may be established for a long term.	Both high ability students and low ability students are able to benefit from tutoring: Low ability students are able to receive another explanation of the content. High ability students have a deeper learning of the content.	Teachers need to carefully select high ability students, as well as to provide them with adequate training. Teachers must provide clear roles to both tutors and tutees. Teacher must establish a productive learning atmosphere for both high and low ability students.	Hattie (2009): $d = 0.55$ Hawkins, Musti-Rao, Hughes, Berry & McGuire (2009): strong effects Wentzel (1999, 2000)*
IV. Staggered nonverbal learning aids	Carefully designed series of learning aids that range in complexity level. The learning aids must only contain the minimal information necessary for a student to overcome an obstacle.	Students have the possibility to access nonverbal aids when facing difficulties or challenges.	Based on experience, teachers must reflect on students´ learning processes and identify the areas where they could encounter problems. As a result, teachers design learning aids which include: Questions Prompts Learning cards Help cards In addition, digital devices can serve as potential tools to provide learning aids in digital formats.	There is a lack of empirical research. Most papers discussing nonverbal aids are limited to conceptual papers. There is no category related to staggered nonverbal learning aids in Hattie´s (2009) work; it is highly aggregated into other instructional practices.
V. Mastery learning	Practices which ensure that all students achieve at least minimum standards (in combination with higher standards for the more advanced students). This involves close monitoring of students´ learning progress.	All students are able to reach minimum standards.	Define minimum, norm/intermediate, and maximum standards according to learning taxonomy (e.g. Bloom taxonomy). Mastery learning works tightly together with Category 1. Therefore, teachers must: Prepare assignments for low-ability students designed to reach minimum standards. Design enrichment or extension activities for high-ability students. Organize group tournaments or competitions which ensure involvement of low-achieving students.	Guskey & Gates (1986): elementary $d = 0.89$; junior high $d = 0.93$; high school $d = 0.72$ Hattie (2009): $d = 0.57$ Kulik, Kulik & Bangert-Downs (1990): $d = 0.71$ Slavin (1987): $d = 0.04$

Continued **Table 4:** Summary of the DI taxonomy.

Category	Description	Intention	Classroom Practices	Effectiveness on student achievement reported in single studies/meta-analysis
VI. Open education / granting autonomy to students	Students are responsible for their own learning process and may autonomously decide on materials to work upon. Examples include: Station work Project-based learning Learning journals Portfolios Jigsaw puzzles Interest-based centers Weekly work schedules	Following constructivist ideas, the learner obtains autonomy and responsibility for his or her own learning. Focus is not only placed on the development of learning, but as well, on developing social competencies, communication skills, creativity, etc.	During instruction, a teacher´s role is swift to a facilitator/ coach role. However, the teacher must ensure that materials are planned thoroughly and well-designed. Teachers must take care of classroom organization and must make sure that every students knows what they have to do.	Blumberg, Möller, & Hardy (2004)* Giacona & Hedges (1982)* Hattie (2009): $d = 0.01$ Horowitz (1979)*: not significant Peterson (1979)* : not significant

*Note**: the identified articles report evidence on other non-achievement variables such as interest, self-concept, creativity, social competence, curiosity, and attitudes towards school.

Lipowsky, & Karst, 2012; Smit & Humpert, 2012), and students being able to assess their own abilities correctly and be willing to select assignments that are challenging enough (Tomlinson, 2001).

Intervention studies on tiered assignments have revealed positive significant effects on student achievement. Richard and Omdal (2007) used a quasi-experimental pre-post and follow-up design in order to examine the effects of tiered assignments on academic performance in a secondary science course. Students were randomly assigned to either the treatment group (tiered instruction) or to the control group (non-tiered instruction). Results indicated that students benefited from tiered tasks: (a) Low and middle achievers performed better than the control group learners, and (b) high achievers performed equally well in both the treatment and control group. Tieso (2005) also examined the effects of differentiated tiered tasks on student achievement in mathematics using a pre-posttest design. The students who were assigned to the treatment group demonstrated significantly higher posttest scores than the students in the control group.

3.3 Category II. Intentional composition of student groups

Homogeneous and heterogeneous within-class grouping are two salient types of intentional grouping commonly used as DI practices (cf. Lou, 2013; Lou, Abrami, & Spence, 2000; Misset, Brunner, Callahan, Moon, & Azano, 2014) as the teacher is able to cater to the needs of these groups by implementing different DI practices. From the teacher's point of view, homogeneous within-class grouping often implicitly or explicitly pursues the goal of devoting particular attention to the weaker groups and supporting them individually, while the stronger groups work autonomously on specific demanding tasks. Also, homogenous groups with different levels of academic readiness naturally call for the provision of tiered assignments as teachers need to adapt the instruction and strategies to students (or to the group of students) to the different learning needs and ability levels (Lou et al., 2000). By contrast, deliberate heterogeneous within-class grouping implies that helper or tutoring systems are formed within the groups.

Research into the effects of within-class ability grouping is comprehensive. Kulik and Kulik's (1992) early meta-analysis indicated that on average students in within-class grouping settings performed better than students with no grouping, regardless of the grouping format ($d = 0.25$). Higher effects were observed for high-ability students than for medium- and low-ability students. Saleh, Lazonder, and Jong (2005) reported similar effects on achievement when comparing homogeneous- and heterogeneous-ability grouping. Hattie (2009) found an overall small effect size ($d = 0.16$) of within-class grouping on student achievement. However, this overall small

effect of within-class grouping may be attributable to a lack of a clear differentiation between homogeneous and heterogeneous grouping when looking at the effects.

More interestingly, a study by Lou, Abrami, Spence, Poulsen, Chambers, and d'Apollonia (1996) examined not only the effects of within-class grouping in comparison to no grouping, but also the effects of intentional homogeneous versus heterogeneous within-class grouping. They found a small overall positive effect of within-class grouping on students' academic achievement compared to no grouping ($d = 0.17$). Also, the effects of both homogeneous ability groups ($d = 0.16$) and heterogeneous ability groups ($d = 0.19$) were similar in comparison to no grouping. The crucial finding in this meta-analysis was, however, an aptitude-treatment interaction (cf. Cronbach & Snow, 1977; Snow, 1989) between the type of grouping and student ability: Low-ability students specifically benefit more when working in heterogeneous within-class grouping, whereas medium-ability students profit more from homogeneous within-class grouping. High-ability students profit equally in both types of ability grouping. Following a similar line of analysis, Tieso (2005) not only found significant positive gains in high achievers when grouping them homogeneously according to their ability, but also found small effects on low-ability students. Hence, only complex analyses reveal that different intentional grouping practices can be expected to produce differential effects for low, middle, and high achievers.

Alternative techniques of within-class grouping would be to group students based on their academic self-concept (Nielsen & Yerzinski, 2016), interests, motivations, and other student characteristics (Lou et al., 2000; Tomlinson, 2001). In contrast to research on the effects of grouping on achievement, there is only limited research into the effects of DI on students' self-concept and other motivational and affective components (Lou et al., 2000). Here again, intentionally implementing homogenous vs. heterogeneous within-class grouping in the classroom may also produce differential effects on weaker or stronger learners (Lou et al. 1996).

3.4 Category III. Tutoring systems within the learning group

In connection to heterogeneously composed workgroups as characterized in the previous category, establishing tutoring systems ("learning by teaching" or peer tutoring) is a key DI practice. Peer tutoring is an instructional setting in which high-ability students (temporarily) adopt the role of teacher assistants and tutor lower-ability students. The goal is that the tutees benefit from receiving individualized additional instruction, while the tutors may benefit from explaining and teaching the learning content in their own words and from becoming responsible for the learning processes (Hattie, 2009).

Peer tutoring cannot be implemented "on-the-spot", teachers should establish roles, clarify tasks, define behavioral rules on how and when tutees may approach tutors, and outline the tutors' duties and responsibilities. Furthermore, the weaker tutees must accept the tutors and be motivated and open to consult them with confidence, while the tutors must feel committed to their role or receive a personal reward when their efforts are successful. This implies that tutoring systems are more likely to render desired effects when combined with other organization form that foster social competences (e.g., in connection with heterogeneous within-class grouping and/or group tournaments).

Research into peer tutoring has shown positive effects on achievement in different school subjects. In an experimental, Hawkins, Musti-Rao, Hughes, Berry, and McGuire (2009) provided evidence on the effectiveness of tutoring systems in increasing fifth grade students' multiplication fact fluency. Oddo, Barnett, Hawkins, and Musti-Rao (2010) investigated the impact of peer tutoring on oral reading fluency and comprehension in fourth-grade students. The tutees' overall comprehension was increased and met grade-level goals. Additionally, peer tutoring fostered positive interactions between the students. As described in other narrative studies (Wentzel, 1999, 2000), academic and social motivation for learning can be enhanced by collaborative tutor and tutee interaction. According to Hattie (2009), peer tutoring has a large effect size of $d = 0.55$ on students' overall performance.

3.5 Category IV. Staggered nonverbal learning aids

Nonverbal learning aids in the form of help cards[7] represent one distinct form of scaffolds (Collins, Brown, & Newman, 1989). Students only resort to these cards when they need help during the course of the assignment. Allowing students to use cue cards helps them focus their efforts on applying the prompt rather than remembering it (Rosenshine & Meister, 1992). Moreover, the nonverbal

7 Traditionally, help cards are printed items students can make use of. Given the rise of digital educational supports, help prompts may also be provided and recalled in digital formats.

cues also foster self-regulation processes as students can control and monitor their academic progress while they work on assignments (Conderman & Hedin, 2015).

Staggered nonverbal learning aids are a carefully and purposely designed series of learning aids, which may range from a simple explanation serving as a learning cue, to a more complex clarification or representation of a procedure used to solve the task at hand. For example, a first card might only paraphrase or clarify the task itself. If, after reading the card, the student still has difficulty understanding the task, a second card might provide additional information and guidance while working on the task. If this still does not lead to the desired result, a third and final card might provide full modelling of the procedure (Hänze, Schmidt-Weigand, & Stäudtel, 2010; Puntambekar & Hübscher, 2005). An optimum use of staggered nonverbal learning aids is only feasible if they are used following a "minimally invasive" principle (Becker, 2008): including the minimal information necessary for a student to overcome a difficulty. Providing too much information or support may be counterproductive as it might lower students' efforts.

The use of staggered nonverbal learning aids requires relatively little teacher effort during the lesson itself (Hepp, 2006). However, teachers have to invest some time in designing the cards, which requires them to reflect on their students' learning process and anticipate typical problems (Maloch, 2002; Carolan & Guinn, 2007).

Help cards can be applied to different subject domains. In science education, for example, help cards support or guide students when conducting experiments or when working with context-based problem solving tasks (Haagen-Schützenhöfer, 2012; Leisen, 2014). Likewise, Wray (2001) has suggested their potential use particularly in non-fiction writing exercises to support students in developing their writing skills.

In contrast to the other categories in this taxonomy, there is a lack of empirical research in this field. Most papers (a) focus on examining the learning effects on students with disabilities (Mason, Snyder, Sukhram, & Kedem, 2006; Baker, Chard, & Ketterlin-Geller, 2009; Murphy & Korinek, 2009), (b) are limited and purely discuss empirical findings in a narrative manner (Piloneta & Medina, 2009) or (c) are mainly conceptual, providing theoretical foundations and practical examples (Carolan & Guinn, 2007; Harris, Graham, Mason, & Friedlander, 2008; Conderman & Hedin, 2015). Furthermore, there is no distinct category related to staggered nonverbal learning aids in Hattie's (2009) work as it is aggregated into other instructional practices.

3.6 Category V. Mastery learning

The principle of mastery learning has been considered as a powerful DI practice in the literature and research (Hattie, 2009; Guskey, 2007; 2010; Tomlinson & Imbeau, 2010). Bloom's (1968) mastery model, commonly identified as the classic theoretical conceptualization (Kulik, Kulik, & Bangert-Downs, 1990), implies that in order to ensure continuous learning progress, teachers need to cater to the learning needs of the weakest and ensure that these at least reach a basic competence level. Even though it seems that in mastery learning most of the focus is on weak performers, high performers may also profit from it. For example, teachers design enrichment activities that imply complex cognitive processing based on higher-order thinking skills in which students need to apply and transfer their knowledge to solve the task (Anderson et al., 2014). Examples of enrichment activities are academic games or puzzles, multimedia and/or technology projects, mind maps, and developing research (Anderson et al., 2014; Cimino, 1980; Hunt & Cotton, 1992).

In order to differentiate according to mastery learning principles, teachers must reduce the curriculum. This technique is labelled curriculum compacting (Reis, Burns, & Renzulli, 1992) and consists first on defining the standard levels: (1) Minimal standards, the baseline level every student (regardless of ability level) must achieve; (2) norm/intermediate standards, the average level of performance to be achieved, and (3) maximum standards, the highest level of performance that can be expected or achieved. Once these standard levels are defined, teachers then determine the information most students will understand, develop corresponding learning activities, and establish learning goals corresponding to these standard levels (Niggli, 2013; Tomlinson, 2005a, 2005b). Niggli (2013) proposed cooperative mastery learning design options such as group tournaments or competitions in which the overall group result is assessed and graded, instead of the students' individual achievements. In this way, teachers explicitly create a learning arrangement that "obliges" the high-achieving students to support the weaker group members, while the weaker members present the work results in order to achieve rewards or tokens for the whole group.

The effects of mastery learning have been long documented within meta-analyses. Kulik, Kulik, and Bangert-Downs (1990) analyzed 108 studies with students from college, high school, and upper-elementary school. Ninety-six of these studies indicated that mastery learning programs had positive effects on students' achievement, mostly with moderate effect sizes. Moreover, 69% of

the studies reported stronger effects for low-achieving students while 31% indicated stronger effects for high-achievers, which suggests potential aptitude-treatment interactions. Other meta-analyses have reported larger effects (Guskey & Gates, 1986) or smaller effects (Slavin, 1987) than Kulik et al. (1990). These differences may be due to the selection criteria used in the meta-analysis (Zimmerman & DiBenedetto, 2008). Hattie reported (2009), however, a substantial overall positive effect (d = 0.55) of mastery learning on student achievement.

3.7 Category VI. Open education/ granting autonomy to students

The idea of granting autonomy to students has varied across the history of pedagogy and cultural contexts. In German-speaking countries for example, predominantly from the late 19th century onwards, the influential movement of *progressive education* has traditionally been centered on the notion that learners themselves should take responsibility for their learning. With respect to DI, "opening" assumes that when learners are granted the autonomy to individually select their tasks and assignments, they would naturally turn to the tasks that best suit them. Nevertheless, there is still a wide range of definitions of open education. However, throughout the literature, certain features tend to be repeated: (a) Barriers are removed in order to provide freedom of movement and accessibility (in terms of time and spatial arrangement) (Marshall, 1972; Maxwell, 1995; Walker, 1994); (b) open education is learner-centered, thus, (c) the learners obtain autonomy, choice, and responsibility for their learning (Lewis, 1986; Madamba, 1980; Maxwell, 1995). Consequently, (d) teachers act as facilitators, working alongside students while providing a wide range of activities and materials (Giacona & Hedges, 1982; Maxwell, 1995).

Because open education is student-centered, it has been considered a powerful DI approach (Bohl et al., 2012; Marshall, 1972). Moreover, when granted autonomy (Herrmann, 2010), students take on greater responsibility for their learning process as they have to select the appropriate learning materials and activities. In this line, Tomlinson (2001) suggested learning centers or stations that are adapted to students' ability level that enables them to work at their own pace. Other variants of open education are project-based learning, learning journals and portfolios, the jigsaw puzzle (Clarke, 1994), think-pair-share, or interest-based centers (Tomlinson, 2001).

Older meta-analyses revealed that open education has neither positive nor detrimental effects on students' achievement (Horwitz, 1979; Peterson, 1979), as its effectiveness seems to depend on students' ability. High-achieving students tend to perform worse in traditional instruction formats (Peterson, 1979), whereas, low-achieving students tend to benefit more in structured settings (Blumberg, Möller & Hardy, 2004). Low-achieving students may easily be overburdened by the autonomy they are granted in open settings (Bohl et al., 2012).

There is a blatant lack of recent empirical analysis on the effects of open education. Even Hattie's (2009) analysis mostly refers to articles published in the early 1980s on open education and student achievement (d = .01). Although open teaching might have no effect on achievement, it may still be beneficial for fostering students' social competence and for enhancing self-concept, creativity, and positive attitudes towards school (Giaconia & Hedges, 1982). However, empirical research on this assumption is still missing.

4 Framing the taxonomy of DI practices in the context of earlier DI models and practical implications

While existing DI models (Hall, 2002; Lawrence-Brown, 2004; Tomlinson 2005a, 2005b, 2017) focus on the important tasks of pre-assessment, formative assessment, and planning and adapting instruction, they still view DI in a quite theoretical way. Thus, none of these models are fully appropriate for answering teachers' legitimate practical questions regarding the concrete options they have at hand for differentiating instruction: "How can I change my daily instructional practice in order to better respond to student heterogeneity?", "Which of the DI approaches would best suit the learning needs of my students in a specific classroom?"

In trying to facilitate such instructional decisions teachers have to take on a regular basis, our proposed taxonomy of DI practices attempts to bridge the gap between educational theory and everyday instructional practice by providing a toolbox for teachers and practitioners. Moreover, this taxonomy model acknowledges that, in order to effectively select and implement a DI practice, teachers must have internalized the need for DI in their everyday lessons, be willing to continuously reflect on the methods, gain personal experience with different DI practices, perform formative assessment, and be prepared to invest the necessary time and effort (cf. Corno, 2008; Hall, 2002; Smit & Humpert, 2012; Tomlinson, 2001; Wischer & Trautmann, 2012). The latter is particularly

delicate given the high workload teachers face worldwide (OECD, 2014). Therefore, it is of utmost importance that teachers can implement DI practices efficiently in terms of time and preparation. Additionally, even though the taxonomy is centered on secondary school education, many, if not most of its elements might as well be applicable in primary education.

The DI taxonomy proposed in this paper does not conceptualize any practice as being solely "correct" or "most adequate". Beyond doubt, each practice has its advantages and disadvantages and its success will always depend on factors such as school subject, student age, group composition, individual student learning prerequisites (Prast et al., 2015), and also teachers' mindset and beliefs. Although the different practices categorized in our taxonomy imply distinct instructional methods, they are not conceptualized to be implemented alone, but rather meaningfully combined (Bruder & Reibold, 2010; Hall, 2002). Some practices may only work in an optimal way when used in combination. For example, the use of homogeneous within-class grouping would make little sense if groups did not receive appropriately adapted assignments or materials (Lou et al., 2000), while heterogeneous within-class grouping call for the concurrent implementation of peer tutoring systems (Slavin, 1987).

In other cases, different DI practices might preclude each other in the classroom. For example, mastery learning (Cat. 5) implies teachers' thorough monitoring of students' learning progress, while open education/ granting autonomy (Cat. 6) suggests the opposite. Our rationale is that specific DI practices cannot be identified as overall superior or inferior. Rather, the efficacy of each practice will always depend on context factors such as learners' or teachers' characteristics, or learning goals to be achieved (Ritzema; Deunk; & Bosker, 2016). Thus, it is not the idea of our taxonomy to provide teachers with "ready-made recipes" on how to teach successfully, but rather to provide an exhaustive categorization of practices that enable them to effectively meet the demands of learners inside heterogeneous classrooms.

Each practice listed in the taxonomy, or a combination of them, should be carefully used only when the following assumptions have been reflected upon. First, each practice requires preparation and planning beforehand. This implies that teachers must not only have profound knowledge of the practice itself, but also to be able to reflect on cost-benefit relations (Graaf, Westbroek, & Janssen, 2018). From the teacher's perspective, a new or additional DI practice must produce a worthwhile result after considering its costs (i.e., the additional time teachers need to invest in its planning). Second, it should be suitable for certain age groups, school subjects, and learning groups (Ritzema et al., 2016). Third, there should be a particular goal the teacher wants to achieve (i.e., do I as a teacher want to support all students, or only high achievers or low achievers? Do I want to support performance and/or self-concept and other motivational variables?). Finally, teachers must acquire their own in-classroom experience with each DI practice in our taxonomy. Hence, preparing, testing, implementing, conducting and, possibly, automating a set of effective DI approaches is an experience-based process teachers have to go through. The taxonomy proposed in this paper is intended to provide an extensive literature-based choice of options as starting points for this process.

5 Perspectives for research and outlook

The divergent nature of all practices in the taxonomy points towards a need for further empirical research on the individual practices. The distinct practices cannot be expected to foster the same effects for student learning, motivation, social learning, and other important outcomes, such as benefits regarding academic self-concept or social competence. Consequently, empirical researchers are well-advised to separately analyze each of the proposed DI approaches and the related instructional practices to not only explore the effects they have on students' achievement, but as well, learners' motivation and interest, social competences, self-regulation, and other variables of student heterogeneity.

In addition, future empirical research should attempt to investigate areas lacking in existing large-scale research and small-scale studies. Most research has only focused on examining the frequency with which teachers differentiate their instruction, leaving out important information such as their goals behind pursuing differentiation and whether, in a retrospective evaluation, teachers find a particular DI practice to be successful or not. Future research should focus on the purpose, quality, and perceived effectiveness of the DI practices in order to determine their value in practice. Furthermore, self-report data from teacher surveys on their DI practices should be compared to and corroborated by student data on their perceptions of DI inside the classroom and, in quest of effects on learning, learning outcomes as assessed by standardized tests.

Considering that heterogeneity among students is increasing rapidly which, in return, places greater demands on teachers, this taxonomy is thought to support practitioners and researchers in multiple ways. From a theoretical perspective, it strives to provide both teachers and educationalists with a comprehensive overview of different DI categories. On a practical level, the taxonomy may function as a guide which enables teachers to address students' heterogeneity in a reflected way as it supports them with planning, organizing, and managing DI. Further enrichening the theory- and literature-based taxonomy compiled in this paper by empirical evidence on the effectiveness of unique approaches to DI or a thoughtful combination of these is an immediate desideratum for research.

This research[8] did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgements: The authors would like to thank Amanda Habbershaw, Verena Letzel, and Laura Link for their valuable contribution and support.

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