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Aligning with complexity: system-theoretical principles for research on differentiated instruction

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Abstract

Differentiated instruction is a teaching philosophy and practice that deals with responding appropriately to student heterogeneity. In order to gain deep understanding of this complex concept, research methodology is challenged to use appropriate data collection and data analysis. The aim of this paper is to reflect on how system theory may be used as ontological and epistemic grounding for research on differentiated instruction. Three challenges for this research are presented: to focus on the interplay between the individual and complex collective behaviour; to acknowledge the external influences in research design; and to describe patterns of non-linear causality and emergence. Three design principles for research on differentiated instruction are presented to address these challenges: organic design, interaction and reflectivity. By using these principles, we believe research on differentiated instruction would be aligned with the theoretical foundations of the concept.

Keywords: differentiated instruction – system theory – complexity – emergence – nestedness – forest-tree perspective

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1. The methodological need for a forest-tree perspective

In an increasingly diverse world the call for teachers to provide instruction that caters for different learning needs sounds ever clearer. Teachers are expected to design instruction that takes diversity among students seriously (Schleicher, 2013). Research over the last years has taken a lot of effort to find and study new ways of teaching that respond to diversity in heterogeneous classes (Gay, 2002; Ware, 2006). A central challenge for teaching in heterogeneous classes is to adapt teaching strategies which are designed, organised and assessed at the classroom level, taking into account the apparent student diversity. Theoretically this is described by Bronfenbrenner's (1977) analytical stance that calls for a naturalistic perspective on psychological research. Bronfenbrenner argues that, in order to understand the complexity of education, phenomena must be studied from diverse perspectives. His ecology of human development is defined as: "the scientific study of the progressive, mutual accommodation, throughout the life span, between a growing human organism and the changing immediate environments in which it lives, as this process is affected by relations obtaining within and between these immediate settings, as well as the larger social contexts, both formal and informal, in which the settings are embedded." (p. 514).

Bronfenbrenner uses different systemic levels to describe interactions between individuals and their surroundings. He defines the microsystem as a "complex of relations between the developing person and […] the immediate setting containing that person" (p. 514). Phenomena related to students' individual experiences are thus described as the individual level within a learning ecosystem, whereas phenomena related to dynamics among (groups of) students are described as the micro-level of the learning ecosystem. Also interactions between a teacher and students are situated at the micro-systemic level. Other aspects which may influence learning (such as school culture or leadership) are described as the meso- or macro-level. Scholarly research is challenged by Bronfenbrenner's approach to take different perspectives in order to study the complexity of the phenomena: the study of the phenomena with an exclusive focus on one systemic level would thus be seen as reductionist.

A metaphor proposed by Jacobson and Kapur (2012) describes the scope of the challenge to teach in heterogeneous classes. They suggested that, in order to increase our understanding on learning environments, not solely individual phenomena or phenomena at a collective level must be studied, but rather the combination of both. Metaphorically, they suggest, not solely a forest perspective must be taken, nor solely a tree perspective, but rather a forest-tree perspective. With regard to teaching in heterogeneous classes, Jacobson and Kapur's (2012) metaphor stresses the vital role of distinguishing individual perspectives of particular students from the collective behaviour within the microsystem. Hence, also within the microsystem, it should not be assumed that all students act and react similarly to changing conditions. The forest-perspective addresses the microsystem of a particular class. Meanwhile, a focus on the learning of individual students would be seen as a tree-perspective.

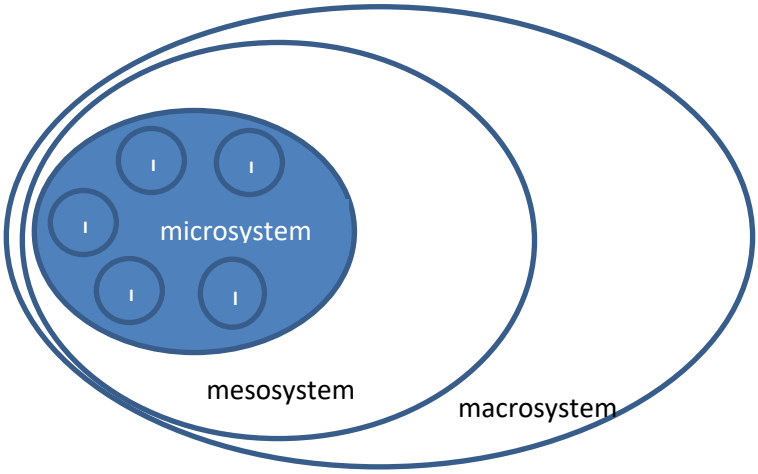

Figure 1: The forest-tree perspective: multiple individuals within a learning ecosystem

In this reflective study the concept of differentiated instruction takes a central place, as this concept tends to merge the perspective of teaching to heterogeneous groups, the micro-level of the learning ecosystem, with the perspective of the learning of heterogeneous individuals. It essentially takes heterogeneity of classes as a given fact and, therefore, assumes that each teaching process needs to be not only based on the targeted learning goals, but also on the apparent student diversity.

Notwithstanding the great potential of differentiated instruction for the sciences of teaching and learning, we believe that research on it is faced with important challenges. A key methodological challenge for educational science is how to design research which merges the forest and tree perspectives, to a forest-tree perspective. At present this forest-tree perspective is largely absent in research on differentiated instruction. Thus, Bronfenbrenner's naturalistic approach remains a challenge for this research. Much research on differentiated instruction is currently being conducted. In the next section we provide more details of the construct. Two main research focuses may be discerned in research on the topic: first some studies focus on the role of teachers in a differentiated classroom. These studies, as a consequence, do not address the role of students in a differentiated classroom, nor do they focus on teacher-student interactions (De Neve, Devos, & Tuytens, 2015). Other studies on differentiated instruction focus on the learning outcomes of (groups of) students for a particular type of strategy (e.g. Chen, Yang, & Hsiao, 2016; van Klaveren, Vonk, & Cornelisz, 2017). We do not contest the added value of such a perspective on differentiated instruction, however it is argued in this study, that both these approaches are reductionist. The epistemic assumptions that underpin such approaches focus on parts of the teaching process instead of documenting interactions within the microsystem throughout the teaching process.

It is argued in this study that the central idea of differentiated instruction lies in the responsive act(s) of a teacher which links the chosen teaching strategy to the given heterogeneity of the group. In order to grasp the full complexity of this idea, we argue for system-theoretical epistemology and hence for the use of research designs which are methodologically aligned with it. Insofar as system-theoretical concepts are already in use in various fields of educational research, we discuss their usefulness ontologically, epistemologically and methodologically to underpin research on differentiated instruction. To do so, three design principles are proposed at the end of this study: organic design, interaction and reflectivity. In what follows, more details are provided on the concept of differentiated instruction in order to be able to reflect on the methodological challenges the concept poses to research.

2. Differentiated instruction

Given the fundamental characteristics of differentiated instruction, it may be noticed that the concept entails difficulties for scholars trying to study it. Differentiated instruction has been proposed as a teaching philosophy and practice that intends to maximise learning outcomes of all students in a class by responding to students' different learning needs, namely their readiness level, interest or learning profile (Tomlinson, 2000). The added value of Tomlinson's approach is that it merges a microsystem-perspective of heterogeneous classes with the perspective of individual students with particular characteristics. Hence, she implicitly uses the aforementioned forest-tree perspective: teachers are supposed to teach a heterogeneous class (the forest), however their instructional design is supposed to be adaptive, and thus based on students' individual perspectives (the tree). In doing so, differentiated instruction encompasses other strategies that focus on student heterogeneity, such as cultural responsive teaching (Gay, 2002) or inclusive education (Schumm & Vaughn, 1995) that focus on specific types of student heterogeneity. Tomlinson accepts heterogeneity as a given fact without detailing the origins of it. Differentiated instruction rests on the constant responsiveness of the teaching based on these perpetual changing characteristics.

Tomlinson's work at the beginning of the 21st century (Tomlinson, 2000, 2001; Tomlinson et al., 2003) pioneered instructional design to a broad range of student differences. A lot of enthusiasm has arisen for her practice-oriented publications. The idea is not to address any target-specific type of diversity such as learning disabilities or students at risk of academic failure, rather differentiated instruction intends to foster learning by giving the proper attention to heterogeneity in the broad sense. Students' readiness levels, interests and learning profiles are the three large, overlapping and constantly changing categories of heterogeneity used to adapt instruction. As differentiated instruction stresses the role of tailoring instruction to students' characteristics, Tomlinson's ideas were initially picked up primarily by scholars in the activity theory tradition (Shabani, Khatib, & Ebadi, 2010; Wass & Golding, 2014). Yet now, the concept of differentiated instruction is also commonly applied in more cognitive scholarly approaches which focus, for instance, on the learning effect of differentiated instruction (e.g. Deunk, Doolaard, Smale-Jacobse, & Bosker, 2015; Prast, Weijer-Bergsma, Kroesbergen, & Luit, 2015).

Following Tomlinson, teachers must carefully consider which teaching strategy is appropriate at which particular moment for a particular group of students. Multiple teaching strategies are used, based on flexible grouping, to build learning paths respecting the unique group composition. A cyclical approach to teaching is proposed in which it is the teacher's responsibility to engage in ongoing assessment and to adapt instructional design based on that. It is a 'key principle that assessment and instruction are inseparable' for differentiated teaching (Tomlinson, 2000, p. 20). While practising differentiated instruction, teachers use the output of a learning sequence as the starting point of a subsequent one. Dependent on students' readiness, teachers build on prior knowledge, or on previously acquired strategies and schemes. Also, teachers may respond to differences in students' interests or learning profiles. This relationship between input and output is a fundamental characteristic of the instructional design of differentiated instruction. It marks the cyclical – responsive – character of the approach. Further, we elaborate on how this cyclical character of differentiated instruction challenges research design.

Dweck's (2008) growth mindset theory is often proposed as an essential characteristic that guides teaching in a differentiated classroom (Coubergs, Struyven, Vanthournout, & Engels, 2017). This theory stresses the importance of an incremental theory of intelligence or, in other words, the idea of the potential growth of students' talents in order to maximise learning outcomes (Rattan, Savani, Chugh, & Dweck, 2015). Teachers responding to the learning needs of their students will need a growth mindset in order to fulfil the learning potential of all students. Teaching in a differentiated classroom seems to be closely tied to such a growth mindset, as a teacher needs to see and develop the student's growth potential. Moreover, also students' growth mindsets need to be developed, in order to fulfil their full learning potential.

In summary, differentiated instruction stands for responding to students' heterogeneity based on a cyclical process of formative assessment and observation. The principles of growth mindset are used to guide teachers' practice in a differentiated classroom. Building on these intertwined characteristics we believe that scholarly study of the concept cannot solely rely upon classic reductionist empirical epistemology. In the following paragraph, we detail insights of systems theory, which provides a useful conceptual framework for ground research on differentiated instruction. Further we elaborate how systems theory can be used to build the needed ontological and epistemic foundations to study the concept of differentiated instruction.

3. Systems theory and complexity

Systems theory has its roots in physics and environmental sciences (Von Bertalanffy, 1968). For decades it has taken effort to use concepts and metaphors to describe comparable patterns across different scientific fields (Luhmann, 2013). Essential for systems theory is the notion of open systems, which stands opposed to closed systems. Open systems have interactions with external surroundings. Often open systems are described as complex in the sense that the properties of a system as a whole cannot necessary be derived from the properties of individual components within a system (Prigogine, 1980). By conceptualising a classroom as a learning ecosystem (see §1) we are able to understand better the complexity in education (Bakker & Montesano Montessori, 2016). The 'open' character of this systemic approach lies in acknowledging its interactions between the microsystem and other systemic levels. Systems theory has built a reputation for helping understanding counterintuitive phenomena. Its ambition is to fully acknowledge the complexity of phenomena. By doing so it stands in opposition to more reductionist scientific approaches which aim at more specific insights (Sawyer, 2002). Morrison (2008) stresses it is vital to see complexity theory as a collection of ideas, metaphors and concepts to describe and not to prescribe educational phenomena. Thus, with this reluctance for the prescriptive ambitions, systems theory seems to stand in a postmodernist ontological and epistemological tradition. It may therefore be criticised as relativist (Morrison, 2008). We agree that some system-theoretical notions (e.g. emergence or nonlinearity, see further) make insights into causal relationships hard to achieve and, as a consequence, limit the prescriptive ambitions of educational science. However, describing patterns of change may in itself be a sufficient added value to gain deeper understanding of teaching and learning in a differentiated classroom, and thus to legitimise a system-theoretical perspective.

Table 1

Systems theory compared to modernistic approaches

Ontology	**Epistemology**	**Methodology**
Modernist	Truth lies in gaining understanding through insight into specific parts	prescriptive
Systems theory	Truth lies in gaining understanding through description of complex patterns of change	Descriptive

Jacobson, Kapur, and Reimann (2016) proposed a framework that conceptualises the role of complexity in the learning sciences: the Complex Systems Conceptual Framework of Learning (CSCFL). This framework intends to reframe the traditional situated versus cognitive debate among educational scholars. For decades scholars have discussed ontological and epistemological issues on how learning processes must be interpreted (Derry & Steinkuehler, 2003). The discussion on the primacy of the cognitive (Anderson, Reder, & Simon, 1996) or situated perspectives (Engeström, 2001; Greeno, 1997) has so far not yielded a sustainable consensus (Jacobson et al., 2016). The CSCFL adds a new

perspective to this debate based on systems theory: it intends to harmonise both views, building on notions of complexity science. Two central domains of the framework are: (1) complex collective behaviour in systems, and (2) behaviour of individual agents in systems. Each of these domains is characterised by concepts which illustrate the complex character of learning.

Complex collective behaviour of agents or elements within a system follows the idea of self-organisation or emergence. This means that dynamics within and between systems are sensitive to initial conditions and are nonlinear. The notion of emergence is pivotal for systems theory, it is used to describe patterns of change. Sawyer described it as an 'attempt to bridge the micro-macro divide' (2005, p. 210). Using this concept of emergence, systems theory describes counterintuitive phenomena. Resnick (1996) famously referred to the emergence of traffic jams or termite constructions. "Strong emergence presents a direct challenge to determinism (the idea that given one set of circumstances there is only one logical outcome). With strong emergence, what emerges is always radically novel" (Osberg & Biesta, 2007, p. 34). It gives an insight into how non-linear patterns of interaction influence the relationships among individual agents of systems and how complex collective behaviour emerges out of it. These patterns are then fed by positive or negative feedback loops which result in these sometimes unexpected outcomes. Essentially, Jacobson et al. (2016) describe learning as not ontologically determined - something that is - rather as emergent. Understanding learning and teaching through this prism evidently challenges research methodology.

The idea of *nestedness* (Burns & Knox, 2011) is used to describe interactions between individual agents within systems and other systemic agents at, for instance, the meso- or macro-level. Interactions within a classroom or interactions with external influences are, therefore, crucial to grasp why dynamics may be different among systems. It refers to the common idea of the contextual nature of learning (Greeno, 1997). However, Jacobson et al. (2016) use the term *nestedness*, which is more common in systems theory across many disciplines.

An essential consequence of system theory is that teaching and learning must be understood as interaction between elements or agents in a system. This organic view sees the interactions in a class as fundamentally related. This contrasts with a mechanistic world view in which all elements of a system can be understood separately. A major question is therefore whether elements of the teaching process should be studied separately or not. Following systems theory, agents within a system are in continuous interaction with the system in which they are active. It is therefore crucial to see the role of complex collective behaviour and of individual agents in systems. If learning must be interpreted as a complex phenomenon for which these characteristics are genuinely valid, this poses a tremendous challenge for our concept of the role of a teacher in it. Davis and Sumara (2007) described the shift from a mechanical view on teaching to a more organic one. Damsa and Jornet (2016) comparably argued to reframe learning as 'collective achievements of whole ecosystems' (p. 39). Some distinctive properties, compared with mechanical management, are that knowledge in organic systems is said to be structured anywhere in the system, compared to top-down knowledge structures. Communicative relations are horizontal rather than vertical in organic systems. And individual tasks within organic systems are said to be continuously adjusted and refined, compared to mechanical structures where tasks are specialised and differentiated. Resnick (1996) argued for a decentralised concept of social institutions in order to account for self-organisation and emergence. 'From the perspective of complexity multidimensional relationships and dynamic interactions among agents and elements, rather than predictable linear effects, are responsible for patterns and phenomena' (Cochran-Smith, Ell, Ludlow, Grudnoff, & Aitken, 2014, p.5). Davis and Sumara (2007) comparably argue to reposition the role of teachers and teaching: teaching is not to be understood any more by what a teacher *does* or *intends*.

Tomlinson's ideas on the responsiveness of teachers and reliance on formative assessment as grounds for differentiated instruction align with this repositioning of teaching and learning. Differentiated instruction is here not a linear type of instructional design initiated by the teacher. The responsiveness of differentiated instruction is characterised by a decentralised concept of teaching. It accounts for the *nestedness* of learning and for patterns of emergence at a level of complex collective behaviour. Moreover, it accounts for interactions within and across (open) systems.

4. System-theoretical grounding for research on differentiated instruction

The concept of differentiated instruction is multifaceted. It invites teachers to adopt a growth mindset. It involves formative assessment to gather data on student heterogeneity and it is essentially characterised by the act of responding to these differences. System theory provides a useful theoretical framework to understand more deeply the complexity of differentiated instruction. In particular, we believe the notions of *nestedness* and emergence (combined with non-linearity) are of particular value for the study of differentiated instruction. In the following paragraph we link the fundamental properties of the concept of differentiated instruction to systems theory. We argue that, to fully acknowledge the complexity of differentiated instruction, empirical data are needed which are grounded on systems theory. In this section, three methodological challenges are presented which could increase our understanding of teaching in a differentiated classroom. Although the challenges partially overlap, we present them in three different sections.

4.1 Focus on the interplay between the individual and complex collective behaviour

Generalisation is often thought to be one of the main quality criteria in educational sciences (Hammersley, 1997). With regard to teaching effectiveness, many educational scholars tend to generalise the validity of their ideas (Cohen, Manion, & Morrison, 2007). Cochran-Smith et al. (2014) have noticed that these claims of generalisation in the educational sciences are challenged by complexity science. Building on this claim, we add that, in a differentiated classroom generalised claims cannot account for all deviant profiles of individuality. Therefore, scholarly research on differentiated instruction is challenged to describe the interplay between individual behaviour and complex collective behaviour.

An exclusive focus on one type of agent of the differentiated classroom does not permit study of the interplay between all systemic agents. Empirical data with an exclusive focus on the individual level (the role of teachers or students in a differentiated classroom) or on the microsystem-level (instructional design) may have an important added value for the debate on differentiated instruction. However, they do not permit a comprehensive insight into the complexity of it. To do so, the interplay between individual agents and complex collective behaviour within systems also needs to be studied. For differentiated instruction, this idea would imply the systematic study of the responsive act of teaching in a heterogeneous class, meaning analysing the impact of it at both student- and teacher-level. Such studies would add substantially to our understanding of the responses within a differentiated teaching process.

To monitor both the individual impact on students and the collective behaviour of a group of students are therefore important challenges for research on differentiated instruction. Rarely, however, do studies seek to understand the link between phenomena at an individual level and the management of collective behaviour, which essentially is the teaching process in a differentiated class. As differentiated instruction essentially intends to maximise learning opportunities for all students in a class by taking their individual characteristics into account, a randomly composed research sample that undergoes a homogenised treatment, or that aims at reaching a common goal, is exactly the opposite of what the idea of differentiated instruction is. Differentiated instruction essentially intends to take into account, not only the average student in a class (the microsystem-level), but also acknowledges deviant or changing profiles and characteristics of individual students (the individual perspective). This core characteristic of differentiated instruction makes scholarly research about it standing at odds with classic randomised research designs which aim at generalised research conclusions. Methodologically these assertions bring us to plea for empirical data that inform on the interactions between agents in a learning system. With its responsive approach, differentiated instruction stands in an interactionist tradition (Mead, 1934). Building on Blumer (1973), a long research tradition has focused on studying interactions in detail in order to understand the relationship between the social and the individual. Classic interactionist methodology that documents 1-on-1 interactions is now critiqued for not (fully)

accounting for the complexity of the interactions (e.g. Sawyer, 2005). From a systems perspective, interactions between all systemic agents must be documented in order to gain deep insight into the interplay between the individual and complex collective behaviour. With regard to differentiated instruction, such an approach should lead to documenting, at least, the interactions among students and describing teacher-student interactions in a differentiated classroom.

4.2 Interdependence with other systems

The actual heterogeneity of a class changes throughout the year. Students who drop out may influence opportunities for collaborative learning. Moreover, newly arrived students may lack sufficient prior knowledge in order to participate in learning activities. It also occurs that less visible changes in the class influence the actual learning process when motivation, or other personal characteristics, change as a result of external influences. If a student experiences anything interesting or emotional in his or her personal life (e.g. a trip to a foreign country, the death of relative, an unusual encounter) this could, in a differentiated classroom, be a relevant take-off point for instruction. This *nestedness* of differentiated instruction is described by Tomlinson as follows: "Teachers who care about their students as individuals accept the difficult task of trying to identify the interests students bring to the classroom with them." (Tomlinson, 2001, p. 53).

Empirical methodology that intends to control data collection and data analysis cannot account for this *nestedness*. Classic research designs make an effort to control the variables they study, and hence to wipe out the effects of external influences (Sansone, Morf, & Panter, 2004). From a mechanistic point of view, these influences are apt to be avoided or neglected. By controlling for external bias, external validity of research conclusions may be increased (Tipton, 2013). It needs to be questioned whether the idea of (semi-)controlled research conditions can result in external validity towards situations where external variables will have considerable influence. It is exactly for the lack of external validity of experimental research that Bronfenbrenner's naturalistic approach (1977) to research was grounded. A systemic perspective on data collection intends to account for externals instead of neglecting them. It could be assumed that research conclusions have stronger external validity when external influences are not ignored but seen as part of the complex reality. In system-theoretical terminology this would be described as accounting for the *nestedness* of systemic patterns. The philosophy of differentiated instruction implies that influences at the meso- or macro-level on the teaching process are taken into account. Therefore it would be useful to build on the tradition that argues for the relevance of this stance. Cultural-historical activity theory argues that this addresses the challenges and possibilities of inter-organisational learning (Engeström, 2001). Moreover a multi-systemic approach intends to stress cross-boundary relationships of agents in educational systems (Akkerman & Van Eijck, 2013; Bronkhorst & Akkerman, 2016). In order to obtain a deep understanding of differentiated instruction, it must be targeted to describe concisely the *nestedness* of teaching and learning in a differentiated classroom. Methodological choices for empirical research on the matter need to be informed by this *nestedness*. Building on this argument some scholars ask for increased attention for the researcher's role of reflexive methodology (Alvesson & Sköldberg, 2009) to acknowledge this *nestedness*.

4.3 Non-linearity and emergence

The character of differentiated instruction implies that teachers respond to student diversity. The cyclical process of teaching, learning, adapting teaching and further learning is essential to it. If teaching is not (only) to be seen as an activity with linear causal consequences, but as an agent (the teacher, the student) within a system that adds to the emergence of complex collective behaviour (such as learning and interactions between learners), then research is challenged to study the dynamics of the relationship between these two perspectives. These patterns are non-linear, they are cyclical in the sense that feedback mechanisms are at work. To illustrate the importance of non-linearity for differentiated instruction, we elaborate here on the role of mindset theory. If, indeed, a growth mindset is a central concept that facilitates the application of differentiated instruction both for teachers and students, then the influence of this factor should always be taken into account for studies on differentiated instruction.

Many studies have described spectacular results based on growth mindset interventions (Blackwell, Trzesniewski, & Dweck, 2007; Dweck, 2015; Rattan et al., 2015). Linear mechanistic research interventions have studied whether a growth mindset affects learning by isolating the growth mindset-factor from other motivational components in the learning process. In a systems-theoretical perspective on research methodology, however, this factor may not be isolated from other factors. A systemic approach will, in consequence, not study whether there is an effect of a growth mindset, but *describe how* growth mindset affects learning. It could, for instance, be hypothesised that feedback mechanisms between a growth mindset and goalsetting or tenacity of students result in the emergence of learning. Differently stated: from a systems-theoretical perspective this influence of growth mindset on other aspects of the teaching process must not be isolated, rather must it be studied how feedback-mechanisms influence the outcomes of the learning process.

If research is designed to be static or linear it is restricted in its scope to describe patterns of emergence between systemic agents. Systems theory, however, contrasts with linear-causal thinking, given the assumption that, as a result of feedback mechanisms, the outcome of processes are thought to be unpredictable (Brown, 2016; Osberg & Biesta, 2007). Therefore, also patterns of non-linear causality need to be studied in order to understand fully the complexity of differentiated instruction. To incorporate feedback mechanisms in research designs means to challenge research to study patterns of non-linearity and emergence. As long as a mechanistic view on teaching and learning is adopted, this cyclical approach on learning does not necessarily pose problems for research design. With its focus on ongoing assessment and adaptive instructional design, differentiated instruction holds an iterative view on teaching. It acknowledges differences in learning pace between students and, consequently, adjusts the teaching process for students depending on the pace at which learning occurs. The use of formative assessment is seen as fundamental to document students' learning needs and, hence, optimal learning chances are provided for all students in the classroom (Coubergs et al., 2017; Hall, 2006; Tomlinson, 2015). Building on ideas of non-linearity and emergence, this cyclical approach on learning would provide important new insights for scholarly research on differentiated instruction. Classic planned experimental design-based research is difficult to align with these concepts of non-linearity or emergence. Data collection that opens up for emergence is needed to mirror the complexity of learning processes in a differentiated classroom. As Long (2001) states: "Intervention is an on-going transformational process that is constantly re-shaped by its own internal organizational and political dynamic and by the specific conditions it encounters or (…) creates" (p. 27). This implies that data collection goes further than describing linear patterns of change, but includes more complex patterns of change within educational systems. Describing these mechanisms at work is a major challenge for research on differentiated instruction.

5. Design principles for research on differentiated instruction

Generalised knowledge on the micro-level of a classroom stands at odds with the concept of differentiated instruction. Moreover, ideas of emergence and *nestedness* provide fundamental challenges for research designs on differentiated instruction. In this section we propose three design principles for this research that aim at aligning research design with the philosophy and practice of differentiated instruction such as proposed by Tomlinson. Examples of existing empirical research are added to illustrate these principles. Although these examples all refer to learning in heterogeneous settings, not all of them explicitly refer to the construct of differentiated instruction such as proposed by Tomlinson.

- *Principle 1: Organic design*. Understanding the complexity of teaching in a differentiated classroom implies a holistic focus on the interaction between agents and components of systems instead of mechanical design which isolates particular agents or components. This means that what happens at the level of these agents or components is not necessarily seen as representative on a higher (meso-)level. Only a holistic analysis can bring about the necessary understanding

on teaching and learning in a differentiated classroom. Jacobson et al. (2016) claim the concept of emergence must necessarily be considered when reflecting on causal relationships with regard to teaching and learning. Moreover, certainly with regard to differentiated instruction, processes of emergence must stand central in empirical data collection. Interventions that open up for non-linear patterns of change are needed for this purpose. Applied to research on differentiated instruction this would mean, for instance, studying feedback mechanisms at work within a classroom related to a growth mindset theory. The following example illustrates how non-linear interventions could be designed in order to study these types of patterns.
Jafari and Hashim (2012) described the use of advance organisers in order to improve English foreign language listening skills. An experimental intervention was designed to document students' learning progress. Advanced organisers were administered for a treatment group of students. However, depending on their actual learning progress, the strategy was differentiated. The monitoring of the learning progress of subgroups of students (higher or lower performing) permitted them to assess the strategy at this subgroup level. Repeated formative assessment was used to document students' learning progress and, hence, the further development of the intervention. In addition to monitoring students' learning progress, this study also gathered qualitative data on the affective outcomes of the chosen strategy. Again these data were related to the subgroups of students' achievement levels. This type of intervention design represents closely the instructional design as it would be applied in a differentiated classroom. Through extending the intervention for students who needed more practice or more extended direct teacher instruction, this study permitted them to gain insight into the structure of the learning process of diverse types of students within a group. Referring to Jacobson and Kapur (2012) metaphor of the forest-tree perspective, we believe that this type of study approaches the idea of merging both perspectives on teaching and learning in a differentiated classroom. The teachers set a targeted goal for a heterogeneous group of students. However, patterns of change – learning – are monitored at the level of subgroups of students in order to gain insight into how learning emerges at the level of these subgroups. The organic nature of this intervention lies in the fact that it acknowledges diverse needs of students in its data collection (cognitive and affective, high and low performing). Unfortunately, no data were provided in this study on how dynamics among students added to the emergence of learning at an individual or collective level. Evidently, data collection that provides more detailed insight of learning at the individual level of students would come even closer to this system-theoretical principle.

- *Principle 2: Interaction*. Studies on differentiated teaching must aim at matching the perspective of heterogeneous groups with learning at the level of the individuals within it. As a consequence, interactions between these levels must be monitored. Responsiveness being one of the main characteristics of differentiated instruction, this element must necessarily occupy a central position in research design. This means that the students' individual and collective characteristics are used as a basis for teaching and that the teachers' response to these depends on formative assessment of students. Students' initial characteristics are pre-assessed and their progress is monitored using formative assessment. Understanding how responsiveness of teaching is related to students' individual learning is therefore a major challenge for empirical research.

  A study of Martin-Beltran, Guzman, and Chen (2017) describes how teachers differentiate discourse in order to foster collaboration between linguistically diverse students. This study is a typical example of interaction in the sense that it studies the interaction between teachers and their students. It draws upon system-theoretical principles in the sense that it intends to describe the complexity of discourse that teachers use in order to cater for diversity in their classes. These patterns of interaction are essential to understand how differentiated instruction materialises into everyday practice. Recently the study of interactions within learning systems has attracted a lot of attention due to research design in which interactive software allows the documentation in detail of the learning processes of students. Jacobson, Kapur, So, and Lee (2011) describe, for

instance, how systems of hypermedia learning environments work when different types of scaffolding are provided. They collect data through interactive software. They argue how performance on problem solving transfer tasks is determined by the different types of scaffolding provided. Building on the interactions between software, individual students and the scaffolds provided, systemic patterns could be described.

- *Principle 3: Reflexivity*. Studies on differentiated instruction must acknowledge the interdependence of systems by adopting reflexivity. A more reflexive attitude of researchers is needed in order to achieve more transparency with regard to diverse external or internal dynamics that lie out of the control of researchers (Tracy, 2010). Building on the idea that control of all external influences is not achievable, it is our suggestion to increase reflexivity about conditions that lie out of control. The idea of proposing a research design in which all necessary factors are controlled seems unachievable with regard to teaching in a differentiated classroom. Therefore, instead of controlling all potential disturbing variables, a researcher's reflexive stance is needed to account for the systems' interdependence. The notion of reflexivity encompasses different sorts of reflections on how the choices of a particular research design influence its results. Alvesson and Sköldberg (2009) suggest that this notion should be used not only for reflexivity on the choices made with regard to the systematics of data collection and techniques of procedures of data analysis but also propose to reflect on the interpretative and political-ideological character of research. With regard to differentiated instruction where the responsive character of teaching always implies teachers and, hence, also educational researchers to make difficult choices, we believe reflexivity to be the most credible option to foster transparency in educational research.
  A study by Pilten (2016) comes close to what would be meant with the concept of reflexivity. It documents the experiences with the implementation of differentiated reading instruction of seventeen Turkish elementary school teachers. Their experiences are limited and their implementation of differentiated instruction is reluctant. Although participants in this study often see a potential advantage of the idea of differentiated instruction, most of them classify the use of differentiated instruction as impracticable and thus hard to implement in practice. Interestingly the authors of this study chose to reflect on the validity and reliability of their findings in the method section of their study. By doing so, they openly reflect on the extent to which their findings are credible. The phenomenological approach they use allows the authors to dig deep into the complexity of the participants' teaching practice. Building on the aforementioned ideas on open systems, it appears that the implementation of differentiated instruction by essence always relies on dynamics between open systems at the micro-level and other systemic levels. In this case, the implementation of differentiated instruction by the participants of this study could be mediated by external factors. This is why reflection on the validity is desirable. The act of reflecting on the way in which controlled conditions have been achieved and reflecting on potential inter-systemic relations should stand at the heart of methodological sections of studies on differentiated instruction. In the aforementioned example of Pilten's (2016) study, we believe that reflections on, for instance, growth mindset could have been an added value to strengthen further the reflexivity component of this study.

6. Limitations

We have sought to retheorise empirical research on differentiated instruction, drawing upon system-theoretical epistemic and ontological positions. A major critique on systems theory is that no consensus exists (yet) on the conceptualisation of some of its central concepts. According to Fenwick, complexity science remains "slippery, heterogeneous and contested" (2012, p.110). Most importantly, we notice a certain ambiguity in descriptions of how non-linearity and emergence are related to each other. In addition to this we believe that some of the concepts that are commonly used in systems theory, are sometimes differently conceptualised in more traditional educational approaches. We have built on the CSCFL which provides terminology that is accessible for scholars in both cognitive and situated

learning traditions. Our choice to draw on the classic systems-theoretical terminology of this framework does not imply a positioning in favour of, or against, conceptualisation as situated learning theory or any other research tradition. We want to broaden further and refine research on differentiated instruction, but not by disputing any approach. However, by showing complexity, we argue for the added value of a system-theoretical stance. Finally, it may be noticed that we have used a human-centred interpretation of systems theory. As systems theory originates from physics, the consequences of it cannot be strictly focused on human beings. We believe our choice to interpret differentiated instruction with a dominant human interactionist focus, may be argued referring to the existing literature of Tomlinson et al. (2003). It could, however, be worthwhile to reinterpret differentiated instruction by tracing more clearly its socio-materiality. Research on differentiated instruction has a tendency to couple learning and teaching with a strictly human-centered ontology. Fenwick (2012) argues however, against the tendency to focus on human learning *figures*: "complexity science urges a re-focusing on the relations that produce things, not the things themselves", (2010, p.111) Several scholars have treated material conditions in which differentiated instruction is enacted (Gaitas & Martins, 2017; Keuning et al., 2017). They see them as fostering or inhibiting teaching practice. Future research could determine to which extent these material conditions are actually shaping the nature of differentiated teaching and learning.

7. Conclusion

The concept of differentiated instruction describes a philosophy and an approach to teaching to adapt to diversity in heterogeneous classroom settings (Tomlinson, 2015). The complexity of the concept challenges scholarly research on it: it seeks to practice a responsive approach to teaching in which a variety of differences among students are addressed. A range of strategies is used for flexible grouping of students. Moreover a growth mindset is adopted in order to maximise learning of all students. System-theoretical insights are needed to describe concisely and to understand deeply, teaching and learning in a differentiated classroom. The notions of non-linearity and emergence, and the concept of *nestedness* challenge scholarly study on differentiated instruction to broaden and refine research methodology. They help understanding the complex interplay between individual and collective behavior in a differentiated classroom. Moreover, they provide insight in the role of interdependence with other systems that mediate learning in a differentiated classroom.

Methodology that draws upon the description of human interactions, or that includes interventions that open up for non-linearity or emergence, may be used to underpin empirical research on differentiated instruction. Moreover, scholars need to reflect on conditions that lie out of their control during data collection. Based on these ideas of systems theory, we suggest three design principles for research on differentiated instruction: organic design, interactions and reflectivity. Organic design could apply a holistic focus to differentiated instruction. Focus on interactions could draw attention to the role of responsivity of the construct. Reflexivity is needed in order to account for conditions that lie out of control of studies that focus on differentiated instruction.

Keypoints

- Differentiated instruction is a complex teaching concept that needs research aligned with this complexity
- Educational research on it is challenged to use theoretical foundations that align with this complexity, both ontological and epistemological
- Three methodological design principles are proposed to align scholarly research on differentiated instruction with the notions of non-linearity and emergence, and *nestedness*
- These principles are: organic design, interaction and reflectivity

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