Studying Learning in Nonformal Digital Educational Settings

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Introduction

With the rapid growth of interest in learning analytics, the field continues to mature in all aspects of its analytical methods and techniques, application into practice, and theoretical contributions. As it was initially defined in 2011, learning analytics is “the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs” (Long, Siemens, Conole, & Gašević, 2011, p. 3). The development of learning analytics research was driven primarily by advances in educational technology and the emergence of large-scale data about students’ learning, along with the willingness of educational institutions and corporations to make sense of such data. Learning analytics has emerged as a broad area of inquiry, exploring the multidisciplinary connections that could effectively enhance understanding of individual and collective learning processes (Dawson, Drachsler, & Rose, 2016).

Learning analytics has the potential for studying learning in various educational settings (e.g., online, blended learning) and advancing learning processes (Baker & Inventado, 2014; Gašević, Dawson, Rogers, & Gašević, 2016). Besides traditional online settings or blended learning environments, learning analytics also is applicable in more or less formal educational settings that support learning at scale, such as massive open online courses (MOOCs). MOOCs emerged as a significant trend in changing the landscape of formal, informal, and nonformal learning (Joksimović, Kovanović, Skrypnyk, et al., 2015). Designed as (relatively) short, open (in terms of access) online courses and delivered by various universities, MOOCs could be categorized as a mode of nonformal education, bridging formal and nonformal learning in networked environments. Thus bringing promise of shifting educational paradigms and expanding access to learning for everyone, MOOCs also introduced a challenge to applying learning analytics in researching learning in networks.

Although research in learning analytics in general and learning analytics for MOOCs in particular have attracted significant attention, most of the current studies on learning in traditional online and non-formal educational settings has failed to account for learning theories (Gašević et al., 2016; Wise & Shaffer, 2015). Various researchers have criticized MOOC research for being primarily observational and failing to provide a causal relationship between observed metrics of student engagement in networked settings and learning (Reich, 2015). Regardless of a vast amount of data available on students’ activity in different MOOC platforms, there is still a very little or no evidence on what aspects actually contribute to learning in MOOCs (DeBoer, Ho, Stump, & Breslow, 2014; Reich, 2015). One of the nuances of contemporary MOOC research also stems from the understanding that learning in nonformal educational settings differs from that in more traditional forms of education in many aspects (e.g., the magnitude and format of data about students’ learning, diversity of students’ background, intents, or socioeconomic status) (DeBoer et
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The main goal of this research was therefore to advance learning analytics methods for assessing learning quality in non-formal digital educational environments. Specifically, we propose a conceptual analytical model for assessing learning in networked settings that offers a definition of the model constructs along with their mutual relations, operationalisations for the measurement of those constructs, and automated methods that can scale up the applicability of the proposed model.

Theoretical Framework

In the development of the conceptual model for understanding and assessing learning in diverse and complex nonformal digital educational settings, we drew on the evidence-centered design (ECD) framework (see Figure 1) (Mislevy, Almond, & Lukas, 2003). ECD is a modular process that allows for building complex measurement models, scaffolding assessment designers in modeling learning goals and articulating assessment decisions (Mislevy et al., 2003). The ECD framework is built on previous work on evidentiary reasoning in assessment (Mislevy, 1994), graphical probability models (Almond, 1995), and intelligent tutoring systems (Steinberg & Gitomer, 1996). The ECD framework consists of five parts: (1) domain analysis, (2) domain modeling, (3) conceptual assessment framework, (4) assessment implementation, and (5) assessment delivery (Mislevy et al., 2003). Our focus here is on the conceptual assessment framework (CAF), which allows for dividing assessment design into its functional components. Central to CAF are the student model (defines a set of attributes to be assessed), the evidence model (defines a set of rules about the observations that constitute evidence about the student model attributes), and the task model (provides a framework for obtaining the evidence needed for the evidence model). Thus, our research is centered around the following objectives:

1. **development of an analytical model of learning in networks** that offers a definition of the model’s constructs along with their mutual relations (i.e., student model),
2. empirical validation of the conceptual analytical model (i.e., task model),
3. operationalization for measurement of those constructs (i.e., evidence model), and
4. **development of automated methods** to scale up the applicability of the proposed conceptual analytical model.

In order to achieve the objectives of our research, we defined the following research questions:

1. How can learning analytics methods be used to construct a comprehensive model for understanding learning in nonformal educational settings?
2. How can this new model be operationalized? Specifically, how are the constructs of the model and their mutual relationships defined?

3. What variables should be used in such a model? That is, how can we measure the proposed constructs, and how are these variables conceptualized in the context of learning in nonformal settings?

4. To what extent can such a model enable the development of automated methods for assessing learning in nonformal settings?

Answering the research questions will result in several contributions to the body of knowledge in learning analytics. First and foremost, we offer a comprehensive - and possibly the first - conceptual (analytical) model that allows for studying learning and knowledge in non-formal digital educational settings. Further, this research will provide an extensive set of variables to measure proposed constructs so as to enable instructors to design appropriate learning interventions. Finally, we will propose methods for automated extractions of the variables that comprise the developed model.

**Figure 1: Overview of the theoretical approaches applied in modelling conceptual analytical framework**

- **Conceptual Model Validation**
  - Social Network Analysis
  - Discourse Analysis
  - Qualitative Analysis

- **Student Model**
  - Discourse Structure Dynamics
  - Environment Behavior Personal Characteristics

- **Evidence Model**
  - Text cohesion
  - Count of viewed videos
  - Count of blog posts
  - Average quiz completion

- **Task Model**
  - Forum participation
  - Viewing lectures
  - Social media activity
  - Assessment activity

- **Networked Learning**
  - Social Cognitive Theory

- **Model of Student Engagement in Non-formal, Digital Education**
  - MOOC Research
  - Student Engagement

- **Empirical Evaluation of the Proposed Conceptual Analytical Model Using Learning Analytics Methods**

- **Conceptual Assessment Framework (Evidence-Centered Design)**

- **Theoretical underpinnings - theories & frameworks**

- **Broader area of inquiry**
Student Model - A Conceptual Model for Understanding Learning at Scale

Theoretical Underpinnings

Arguing for the importance of conceptualizing learning analytics research on the basis of existing learning theories, Gašević et al. (2016) claimed that “a theoretically driven approach leads to an ontologically deep engagement with intentions and causes, and the validation of models of learning, learning contexts, and learner behavior” (p.70). Thus, the proposed conceptual analytical model for studying learning in non-formal digital settings builds on networked learning research to inform development of the constructs for the proposed model, as well as their mutual relationships. Specifically, the proposed student model takes the form of a conceptual analytical model that relies on learning analytics methods and techniques to provide a comprehensive understanding of learning in non-formal digital education. The constructs of the proposed model and their mutual relationships are formulated based on the existing research in networked learning and validated through a series of empirical studies.

This research focuses on networked learning in technology-mediated environments. Networked learning, an emerging paradigm in the learning and social sciences with theoretical, pedagogical, and practical importance (Dirckinck-Holmfeld, Hodgson, & McConnell, 2012), is defined as a learning approach that relies on information and communication technologies to support connections among learners, between learners and teachers, and between learners and learning resources (Goodyear, 2002, 2004). The use of technology affects every aspect of learning and mediates connections within a learning community. Therefore, the main goal of networked learning research is to understand how various technological affordances can influence pedagogy and learning design to foster deep and meaningful learning (Dirckinck-Holmfeld et al., 2012; Steeples & Jones, 2002). In recent years, networked learning research takes a broader critical approach in studying collaborative and cooperative learning in formal and informal learning settings. According to such new perspectives, the central topics of networked learning research are connections and human-human interaction that occur in a networked learning community (Goodyear, 2004; Dirckinck-Holmfeld et al., 2012). With the technological advances and development of education technology, various theories and methods have emerged with aims of advancing research of networked learning (Gee, 2004; Wenger, 1998).

The proposed analytical model is primarily rooted in the work of Goodyear (2002) and Jones (2008) and the assumption that “networked learning is inherently social” (Goodyear, 2002, p. 51). Moreover, it relies on the premises of social cognitive theory and Bandura’s work (Bandura, 1977, 1986). The model constructs are grouped within two broad categories. In the central part are elements related to collaborative and cooperative learning in networked settings. Specifically, these are the determinants of
learning in non-formal settings that emerge from students’ interaction with their peers, media, and/or learning resources within a given platform. The second category of model properties focuses on a student’s individual agency. Context, personal student characteristics, and student behavior provide a framework for more salient inferences about the learning processes in the observed environment.

Networked Learning Analytics Demystified

The three central elements of the proposed analytical model are structure, discourse, and dynamics (Error! Reference source not found.). The proposed elements are interdependent in the sense that the model also observes how social interaction factors shape discourse properties, as well as how temporal dynamics frame network structural properties and influence development of discourse. The structure of students’ social interactions explains the regularities in communication between peers and instructors, revealing main (social and technical) factors that frame this interaction and influence learning processes. Student-generated discourse provides further insight into the quality of learning. Relying mainly on linguistic indicators of text cohesion and coherence, the construct explains the level of students’ cognitive and affective engagement, as well as a comprehension of learning materials. Dynamics examines the importance of the temporal dimension for the association between students’ activity and learning. It also accounts for the development of behavioral variables. The three constructs of structure, discourse, and dynamics have been empirically validated in our research that is presented here.

The proposed framework also accounts for contextual, behavioral, and personal characteristics to i) comprehensively describe the learning environment, learning context, and learners, and ii) enable for a holistic interpretation of the model constructs and their relationships. Thus, the contextual analysis accounts for the factors that define the specific learning context and the nature of interaction between two or more individuals in a social network that is derived from the collective behavior. Personal characteristics include students’ demographic data, motivational factors, and previous experience, among others. Behavioral variables describe aspects of the academic, affective, and cognitive students’ engagement within a given course. Further sections provide an operationalization of the variables used to explain those three characteristics, along with the proposed methods for the automated extraction of the metrics used to measure each of them.
Studying Learning in Non-formal Digital Educational Settings

Figure 2: Elements of the proposed student model for studying learning in non-formal, digital educational settings

Structure

Studying the structure of interactions in networked learning settings is essential for understanding processes that drive learning in non-formal education. The importance of interactions among students, between students and teachers, and between students and resources has been highlighted in the definition of networked learning provided by Steeples and Jones (2002). Steeples and Jones further posited that the definition implies the social nature of learning, where knowledge is socially constructed and represents a potential outcome of the use of networks. It should be noted that Steeples and Jones did not envision a necessary connection between increased use of networks and knowledge gain. However, they did observe networked learning as one of the aspects of a networked society (Castells, 2000) that considers knowledge construction as related to the knowledge flow in networked settings (Steeples & Jones, 2002).

Illich (1971), when discussing learning webs and how educational institutions should develop, said that we need such relational structures that will enable each student to define themselves or herself by
learning and by contributing to the learning of others. In a somewhat broader context, Illich also argued that we should not start with the question "What should someone learn?" (p. 77), but rather with "What kinds of things and people might learners want to be in contact with in order to learn?" (p.78) highlighting (perhaps indirectly) the importance of interaction within a network of learners. More recently, Goodyear (2002) stressed the importance of moving beyond merely acknowledging the importance of the social context of individual learning and acknowledging that a learners’ cognitive activity will be influenced by interaction with their peers and teachers. This interaction and students’ ability to define themselves by learning should be depicted in the structure of the emerging network or networks. The tendency to form different types of connections should provide insight into the learning patterns in the network of learners and into the knowledge or more general information flow in networked learning settings. Finally, the importance of studying the emerging network structures could be implied from Fox's (2002) argument that studying learning in networks should primarily focus on “identification of collaborative and competing networks and their characteristic learning patterns” (p.89) as ways of understanding how such networks learn.

**Discourse**

Regardless of the educational setting, learning has been related to a certain form of student-generated artefacts (Jones, 2008; Wenger, 1998). Thus, studying learning in social settings, various researchers focused on analyzing student-generated discourse to examine the association between discursive activity and learning (Gee & Green, 1998). For example, arguing for a significant connection between knowledge and discourse, Ohlsson (1996) claimed that “human beings employ their understanding, not in action, but in the generation of symbols” (p. 51). Specifically, Ohlsson and more recently Goodyear (2004), discussed “understanding” as a key construct of learning in higher education, claiming that it is closely connected with the production of discourse.

Language and discourse further represent primary means of information exchange in computer-mediated communication, implying that the majority of (if not all) interactions are confined to the interaction with learning discourse—either brought into the learning space (e.g., textbooks, learning materials) or generated by students within it (artefacts) (Jones, 2008). This further means that to a certain extent, student’s peers “also appear through artefacts rather than in person” (Jones, 2008, p. 620). Finally, Stahl & Rosé (2011), among others, contended that language and discourse can provide a valuable insight into the learning dynamics and cognitive processes in social learning settings. Therefore, our model also argues for the importance of understanding *student-generated discourse* in order to provide more salient insights into the learning dynamics in a non-formal distance education context. Analyzing student discourse, we aim to observe linguistic indices of *student cognitive and affective engagement*, as defined by Reschly and Christenson (2012) and re-operationalized in learning in networks by Joksimović et al. (2016).
Student-generated discourse, however, should not be observed without accounting for particular social settings. As defined by Hicks (1995), the term discourse refers to the communication that is "socially situated and that sustains social 'positionings'" (p. 49), implying that the understanding of the association between language and learning is possible only within a given social context. This perception of discourse as being inherently social is rooted in the work of Bakhtin (1986) and Vygotsky (1986), who made similar conclusions that the meaning of language can be operationalized only through social adoption. More recently, this thinking has been reflected in Gee and Green's (1998) conceptualization of "situated meaning," referring to the interpretation of discourse as context dependent. This notion of discourse as being socially situated is also depicted in our conceptual analytical model by considering two constructs—structure and discourse—as mutually dependent, whereas the emergence of both constructs and their mutual relationship have been mediated by contextual factors.

**Dynamics**

The term learning has been used very broadly, with different meanings in various contexts (Illeris, 2004, 2007). However, regardless of the definition or the context, there is a single constant with respect to the concept of learning: *Learning is a process*. Therefore, learning theories are more concerned with a process of knowledge construction rather than "with the value of what is being learned" (Siemens, 2005, p. 2). In networked settings, learning is observed as a dynamic and complex process that involves student interactions (with other students, between students and teachers, and with content) and content creation (Goodyear, 2002; Halatchliyski, Moskaliuk, Kimmerle, & Cress, 2014). Finally, the networks emerging from interactions within non-formal education settings are not static by any means. As Halatchliyski et al. (2014) observed: "Networks are constantly changing as neither their nodes nor their links are enduring entities" (p. 102). Therefore, we tend to argue that failing to account for the temporal aspects of learning in MOOCs could lessen our understanding of learning processes in such settings.

**Individual agency**

Learning in online and networked settings has created a shift in power between students and teachers (Steeples & Jones, 2002). Online learning transforms education from instructor centered (traditional classroom) to student centered, where students have more responsibility for their learning (Koch, 2014; Peterson, 2008). Given that students are able to choose what to learn, when to learn, and who to learn with, a certain level of self-directedness is necessary to succeed in an online course. With the emergence of open educational resources and MOOCs in particular, the importance of an individual student’s agency has become perhaps even more important. Learning in networks is inherently less structured than traditional (more formal) online courses. As noted in various studies, the easy and no-cost access to MOOCs usually attracts a large number of students to enrol, often without a real intent to complete the course but rather with diverse personal learning goals. Therefore, the conceptual analytical model
proposed in this work also accounts for students’ individual agency and contextual variables that frame interactions in non-formal networked educational settings.

Our understanding of the importance of individual agency stems from social learning theories and an assumption that human behavior is guided by constant and “continuous reciprocal interaction between behaviour and its controlling conditions” (Bandura, 1977, p. 2). Thus, in his seminal work on social cognitive theory, Bandura (1977, 2001) posits that determinants which frame students’ (or human in a more general context) behavior emerge from a constant interaction between personal, behavioral, and environmental (i.e., contextual) factors. The principle of reciprocal determinism - i.e., the product of the continuous interaction between the three factors (Bandura, 2001) - further assumes that students have an ability to modify their own behavior and environment in a meaningful manner (Bandura, 2001). Finally, Bandura’s theory posits that learning is not necessarily demonstrated as an immediate change in a behavior. In the context of the original theory, personal (or cognitive factors) include cognitive abilities, physical characteristics, personal beliefs, and attitudes. Behavioural competencies, on the other hand, include self-efficacy, skills, and social interactions, among other factors, whereas environment is defined as a social (e.g., peers, friends) and physical (e.g., classroom) environment.

Our analytical framework provides further operationalization of the three components - context, personal characteristics, and behavior - with respect to non-formal educational settings. Specifically, contextual analyses account for the factors that define specific learning context and for the nature of the interaction between two or more individuals in a social network that is derived from a collective behavior. Personal characteristics include students’ demographic data, motivational factors, and previous experience, among others. Finally, behavioral variables describe behavioral and cognitive aspects of students’ engagement within a given course, as defined described Reschly and Christenson’s (2012) model of association between context, engagement, and learning outcomes and re-operationalized within the context of MOOCs in the work by Joksimović et al. (2016).

**Defining a Task Model**

In the conceptual assessment framework, the task model defines the environment in which students exhibit the knowledge, skills, and abilities identified in the student model (Mislevy, 1994). Specifically, it enables us to identify a set of tasks and conditions necessary for assessing student model constructs. One of the important aspects of the task model definition is describing situations (i.e., tasks and conditions) in terms of the presentation format (concrete specifications of the environment), and work product (a form that will capture student performances) (Mislevy, 1994; Mislevy et al., 2003).
In the empirical validation of the proposed analytical model, we analyzed students’ learning in a variety of contexts (e.g., Joksimović, Dowell, et al., 2015; Joksimović, Kovanović, Jovanović, et al., 2015; Skrypnyk, Joksimović, Kovanović, Gasšević, & Dawson, 2015). Given the specific nature of research in non-formal digital educational settings and MOOCs in particular, there is no single environment that allows for evoking evidence about focal constructs (the knowledge, skills, and abilities) defined in the student model. Rather, the environments used to deliver MOOCs are designed to scale up to support a large number of students, which in turn allows for large-scale data collection (Daniel, 2012; DeBoer et al., 2014). Nevertheless, regardless of the platform used to deliver a course—a structured version using edX or Coursera or a distributed context using social media—all those environments should allow for data collection in a form of trace (log) data, discussion forum data, surveys, and/or assessment result, to name a few. This further implies that a concrete list of tasks, their characteristics and variable features, heavily depends on a specific instructional course design and applied pedagogies for teaching and learning.

Learning in non-formal digital educational settings is also characterized by a variety of potential task products that provide evidence for the student model constructs. These are related to the quality of student postings in a discussion forum, engagement with course content, or patterns of social media use, to name a few. In our work, we concentrate primarily on the data collected by various learning (or social media) platforms. This approach represents an unobtrusive way of data collection and does not require interruption of student behavior. However, the data collection methods could be easily extended to account for perhaps more sophisticated approaches, including multimodal data sources (e.g., eye movement, heart rate).

Evidence Model-Operationalization of the Conceptual Analytical Model

The third element of the conceptual assessment framework is the evidence model, a model that bridges a student and a task model (Mislevy & Haertel, 2006). An evidence model provides detailed guidelines for how information about student model constructs should be updated based on specific work products and obtained from particular tasks (Mislevy et al., 2003). There are two building blocks of every evidence model: an evaluation component (i.e., evidence rules) and a measurement model (Mislevy et al., 2003; Mislevy & Haertel, 2006). The evaluation component specifies a procedure for identifying and evaluating observable variables form the student model. The measurement model, on the other hand, synthesizes evaluation results across different tasks, forming comprehensive insight into student learning.

To inform the design of the evidence model, in the proposed conceptual assessment framework we conducted comprehensive research on educational variables that are commonly used to measure
learning in MOOCs (Figure 1 and Appendix). A main challenge in defining our evidence model was interpreting learning in nonformal educational settings relying on traditional educational metrics. Specifically, contemporary research on learning in MOOCs argues for two main differences between learning in a traditional classroom setting and in networks. The primary difference is related to the nature and scale of gathered data, which are significantly higher than in more traditional learning settings (either online or face to face) (DeBoer et al., 2014; Evans et al., 2016). Second, learners in networked settings are diverse in many aspects—such as their backgrounds, intents, and reasons to register for a course (DeBoer et al., 2014; Reich et al., 2016). Therefore, we conducted a systematic literature review with a main goal of identifying the common metrics used to assess learning in MOOCs, as well as how various researchers have measured learning outcomes in this particular setting (Joksimović et al., 2016). Besides summarizing metrics used to measure and model learning in non-formal educational context, we also developed a framework that distinguishes between the factors impacting students’ learning in MOOCs. Specifically, building on Reschly and Christenson's (2012) model of the associations between context, engagement, and student outcomes, we further re-defined and re-operationalized these constructs (i.e., context, engagement, and outcome) for learning in non-formal, digital educational settings, providing a potential framework for interpretation, and contextualization of the observed variables from the student model.

Discussion and Future Work

Research on MOOCs is a relatively new field of inquiry that has proliferated in recent years (Raffaghelli, Cucchiara, & Persico, 2015). The research shows maturation of the field with diverse research paradigms having been adopted, varying from data driven to conceptual and theoretical (Raffaghelli et al., 2015). Nevertheless, the majority of studies in non-formal, digital educational settings focus primarily on observational and critical research methods, failing to provide more sustainable evidence of factors influencing learning in such settings (Raffaghelli et al., 2015; Reich, 2015).

This research contributes to the development of the next generation of research in networked settings (Reich, 2015). Following the ECD framework, we developed a conceptual analytical model for assessing learning in MOOCs, proposing definitions of the learning-related constructs that form the model, along with their mutual relationships, operationalisations for the measurement of those constructs, and automated methods that can scale up the applicability of the proposed model. Such a conceptual model should provide a common framework for the more advanced research in MOOCs so that more significant implications for teaching and learning can be obtained.

Our current research provides evidence of how the proposed conceptual model establishes a comprehensive picture of learning in networked settings, as well as why it is important to consider the
elements of the model as interdependent. Specifically, through the empirical research we proposed novel analytical methods for studying learning in non-formal educational settings, accounting for the quality of student-generated discourse, specific factors that drive interaction in such settings, as well as the temporal dynamics of discourse and structure development (e.g., Joksimović, Dowell, et al., 2015; Joksimović, Kovanović, Jovanović, et al., 2015; Skrypnyk et al., 2015). Finally, our research showed that in order to make meaningful interpretations of learning outcomes, it is necessary to account for specific contextual factors that frame social interactions in a given context (Joksimović et al., 2016).

Further work is primarily concerned with providing a framework for making inferences about learning based on the developed conceptual model. Currently, the model identifies the important learning-related constructs and proposes a relationship between those constructs, theorizing how they might help to explain learning in MOOCs. However, we aim to build a statistical model that would allow for testing the association between the various measures of learning in networked settings and the constructs of the theorized model. Such a statistical model will provide a sound basis for understanding factors that promote learning in MOOCs and provide a means for comparisons to be made to other settings (e.g., face to face or online).
References


## Appendix: Design Pattern

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### Summary
- Studying learning in nonformal educational settings needs to account for specificities of learning in networks as well as for students’ individual agency.
- A comprehensive understanding of learning in networked settings could be obtained through analysis of the structure, discourse, and dynamics of social interactions.
- Learning in networks is inherently less structured than in traditional (more formal) courses. Therefore, students’ individual characteristics and environmental variables should be observed as factors that frame interactions in nonformal networked educational settings.
- As a most prominent form of delivering planned learning (at scale) in networks, here we focus on massive open online courses (MOOCs).
- Emergence of MOOCs influenced the development of digital learning environments that would support large numbers of students enrolling and store the immense amount of data related to their participation and interaction.
- The data collected by these systems can include information about student background, intents, or various forms of engagement within learning environments, to name a few.

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### Rationale
- Although research in learning analytics in general and learning analytics for MOOCs in particular have attained significant attention, most of the current studies that investigate learning in traditional online and nonformal educational settings fail to account for existing learning theories.
- MOOC research is commonly critiqued for being primarily observational in nature and failing to provide causal relationships between observed metrics of student engagement in networked settings and learning.
- Moreover, learning in nonformal educational settings differs from that in more traditional forms of education in many aspects (e.g., the magnitude and format of data about students’ learning, diversity of students’ background, intents, or socioeconomic status).
- The main goal of this research is therefore to advance learning analytics methods for assessing learning quality in nonformal digital educational environments.

- Proposing definitions of the learning-related constructs that form the model of learning in networks, along with their mutual relationships, operationalisations for the measurement of those constructs, and automated methods that can scale up the applicability of the proposed model, should provide a common framework for more advanced research in MOOCs, so that significant implications for teaching and learning can be obtained.
### Student Model

**Focal construct**
- Learning in non-formal distance educational settings.
  - Structure of students' social interactions explains the regularities in communication between peers and instructors, revealing main (social and technical) factors that frame this interaction and influence learning processes.
  - Student-generated discourse provides further insight into the quality of learning. Relying mainly on linguistic indicators of text cohesion and coherence, the construct explains the level of students’ cognitive and affective engagement, as well as a comprehension of learning materials.
  - Dynamics examines the importance of the temporal dimension for the association between students’ activity and learning. It also accounts for the development of the behavioural variables.
  - To properly describe the learning environment and allow for comprehensive interpretation of the focal construct, studying learning in networks also accounts for contextual factors, behavioural factors, and metrics that describe students’ personal characteristics.

**Additional knowledge, skills, and abilities**
- Self-efficacy
- Metacognitive knowledge

### Task Model

**Characteristic features of the task**
- Given the specific nature of the research in non-formal digital educational settings (and MOOCs in particular), there is no single environment that allows us to evoke evidence about focal constructs (i.e., knowledge, skills, and abilities) defined in the student model. Rather, the environments used to deliver MOOCs are designed to scale up to support a massive number of students and allow large-scale data collection.
- Nevertheless, regardless the underlying platform used to deliver a course, all those environments should allow for data collection in a form of trace (log) data, discussion forum data, surveys, and/or assessment result, to name a few.
- This further implies that a concrete list of tasks, their characteristics, and variable features heavily depend on a specific instructional course design and applied pedagogies for teaching and learning.

**Variable features of the task**
- Learning in non-formal digital educational settings is also characterized by a variety of potential task products that provide evidence for the student model constructs. These are related to
  - the quality of student postings in a discussion forum,
  - engagement with course content, or
  - patterns of social media use, to name a few.

### Evidence Model

**Potential task products**
- A limited list of (broadly defined) potential task products includes measures of
  - academic engagement,
  - behavioral engagement,
  - cognitive engagement,
  - affective engagement, or
  - contextual variables.

**Potential frameworks**
- Extract features based on discourse properties, social-dynamic dimensions that frame social interactions in a given context, students’ engagement within a given environment, and student data in order to build models to assess learning quality during course progression.