Chapter 2
Designing for Context-Aware and Contextualized Learning

Christian Glahn and Marion R. Gruber

Abstract Contextualized and context-aware learning refer to active and passive approaches of utilizing contexts in educational designs. Both are at the core of many mobile learning solutions. For scaling mobile learning in educational institutions, it is important to understand that mobile learning is neither an independent nor a stand-alone educational approach, but part of a rich repertoire of tools and practices that shape complex learning processes and are embedded in increasingly smart environments. Moreover, mobile learning combines solutions for a range of different educational interventions. Educators have to choose and integrate each solution into their educational concepts in order to utilize the ubiquitously available technologies for leveraging on the learners' contexts. This requires a better conceptual understanding on the role and function of context in educational design. Seamless learning addresses this understanding by generalizing contextual influences on learning processes beyond mobile learning, which is lacking in conventional educational design models. However, seamless learning is not an educational design model that educators can use directly for deducing design principles. Seamless learning is rather a concept that best understood in relation to integrated approaches of context-awareness and contextualization that contrast of existing educational design models. Because much research on mobile learning focuses on the active role of contexts, the question comes into mind, whether context is always an explicit design element? This chapter addresses this question in two parts. First, by operationalizing the concept of seamless learning for planning and orchestrating contextual and context-aware mobile learning. Secondly by analyzing potential contextual affordances of a mobile app with minimized contextual dependencies.

Keywords Activity theory · Blended learning · Context · Contextualization · Context-awareness · Educational design · Learning design · Mobile learning · Mobile apps · Seamless learning

---

C. Glahn (✉)
Zurich University of Applied Sciences (ZHAW), Winterthur, Switzerland
e-mail: christian.glahn@zhaw.ch

M. R. Gruber
University of Zurich, Zurich, Switzerland

S. Yu et al. (eds.), *Emerging Technologies and Pedagogies in the Curriculum*,
Bridging Human and Machine: Future Education with Intelligence,
https://doi.org/10.1007/978-981-15-0618-5_2

2.1 Introduction

Digital natives (Prensky 2001) expect unconstrained access to information and knowledge in all parts of their lives. Mobile technologies play an important role to satisfy such expectations. These technologies are omnipresent in daily life and expand their users' abilities, open and connect different contexts, and create new perspectives. From the viewpoint of designing educational technologies, mobile learning is particularly challenging because it is often unclear how the new technologies influence and change learning processes and experiences (Traxler 2007; Sharples et al. 2009).

One barrier for mobile learning is that it challenges the educational design repertoire of educators and instructional designers. This creates uncertainties among educational practitioners because learning experiences are often designed in ways that do not integrate well new functions of mobile technologies: Mobile learning breaks the dichotomy of analog and digital learning experiences that is underpinning concepts such as blended learning (Rovai and Jordan 2004; Garrison and Vaughan 2008). Newer developments such as ubiquitous learning (Hwang et al. 2015) and seamless learning (Wong and Looi 2011) address this limitation and emphasize the capability of networked mobile technologies to bridge between learning settings and contexts. These developments include technological support for in-class and out-of-class experiences (So et al. 2015) that go beyond the conventional separation of non-technologically-enhanced face-to-face and technologically-enhanced self-study experiences. Such approaches depend on tools that rely on new forms of human-computer interactions as well as mediated interactions between humans.

Our journey started with promoting mobile technologies into existing higher education courses (Glahn et al. 2015). Lecturers found it hard to integrate mobile modes into their educational approaches. This was not due to the technological novelty, but because in their perception the new technology targets learning practices and settings that were already well supported by other technologies. In the course of more fundamental educational transformation projects, we found similar perceptions hindering the adoption of new pedagogical approaches, such as video lectures for the inverted classroom (Lage et al. 2000). The perceived invariability of educational modes and sequences as well as the apparent lack of contextual factors in educational designs appeared as a common theme in these developments. Consequently, we recognized seamless learning as an educational design concept for planning and orchestrating contextual and context-aware learning. This operationalization is particularly relevant for integrating new interactive technologies for learning as well as for combining such solutions into complex learning experiences.

This chapter explores the role of context as a design element and provides a brief overview on it in educational design models, as well as by isolating and integrating contextual factors into an extended activity theoretical perspective. On this foundation, we analyze the question, whether context must be actively considered in educational design or can educational design draw on context-related affordances of learning resources? We answer this question on the grounds of the findings of a multi-year implementation of a mobile app that minimizes contextual dependencies that allow learners to expand their learning environment into new or alternative contexts independently from explicit educational interventions.

2.2 What Is Context?

Context is a complex concept in education. It covers many different aspects that influence learning experiences and educational interventions. The aspects include learning modes, educational settings, social relations, environmental identifiers, accessibility, media and device modality, procedural and system dynamics, as well as cognitive framing (Luckin 2010; Wong and Looi 2011). Learning experiences can be perceived as transitions between settings that are defined by these aspects. It has been noted, that the effectiveness of complex learning depends on the educational capability to moderate and integrate the different contextual learning experiences, which leads to *seamless learning* (Kuh et al. 1994). Mobile seamless learning centers on context as a key educational design principle for mobile learning experiences (Wong and Looi 2011).

The role of context has been identified as an important functional driver for interactive technical systems. Systems that can identify and respond to the contexts, in which they are embedded, are called "*context-aware systems*". For such systems, Dey (2001) defines context as "*any information that can be used to characterize the situation of an entity*", where this definition refers both, *people* as well as *objects* as entities. Such situations are separate of an entity and of activities and processes that are performed by an entity. However, context is not independent from the entity, because presence, performances, and artefacts may influence the context. The influencing information can be grouped into the categories: "individuality", "activity", "location", "time", and "relations" (Zimmermann et al. 2007).

- Individuality refers to the characteristics of an entity, such as a person or an object. Information related to this category helps identifying presence of persons or objects in a given setting.
- Activity refers to the dynamics of and within a setting. The related data allows determining action disturbances, e.g., through noise levels or amount of movements.
- Location refers to the position in a setting and time is its temporal counterpart. Data of both categories support to locate or trace actors or objects.
- Relations point to social relations, such as organizations, communities or hierarchies, relations between physical and social entities, such as ownership or access, as well as relations between objects, such as structures or systems.

The contextual categories help the design of sensor networks that provide data about an entity's situation (Zimmermann et al. 2007).

The viewpoint of context-aware systems highlights that context is situational for an entity: While different entities can share some situational characteristics, each entity may have other unique characteristics. Therefore, context is not objectively identifiable and static, but dynamic and subjective, which is relevant for educational settings and learning experiences: Context "is complex and local to the learner [and educator]. It defines a person's subjective and objective experience of the world in a spatially and historically contingent manner. Context is dynamic and associated with connections between people, things, locations and events […]. Technology can help to make these connections in an operational sense. People can help to make these connections have meaning for a learner." (Luckin 2010: 18).

2.3 Context in Educational Design

Educational design describes approaches for creating educational arrangements that ground on educational theories, while not a theory of learning itself (Laurillard 2012). The challenges of designing for new pedagogies and/or technologies become apparent in contrast to the various educational design models and embedded concepts of context. The following analysis excludes instructional production and life-cycle models, such as ADDIE (Gagné et al. 2004) or RASE (Churchill et al. 2016), because these models do not focus on educational rationale but on the production processes for learning experiences.

Luckin (2010) provides an overview on the perceptions of context in education, philosophy, culture and technology. The overview indicates a range of interpretations of context and its influence on learning. These interpretations are also present in experience-centric educational design approaches, which can be grouped into four categories:

- Context agnostic;
- Context as delivery modes;
- Context as a passive environment;
- Socio-centric context.

The following review focuses on prominent educational design models with relevance to technology-enhanced learning. These models are used as examples for the related category.

2.3.1 Context Agnostic Models

Context agnostic educational design models lack an explicit representation of context. Educational designers that rely only on context agnostic models can address context only implicitly. One example for context agnostic educational design models is the "four-component model for instructional design" (4C/ID-model). The 4C/ID-model structures design elements of learning processes and their quality indicators (Merriënboer and Kirschner 2013). The model isolates characteristic elements of educational processes that are relevant for educational designs: "learning tasks", "supportive information", "procedural information", and "part-task practices". The interplay of these elements leads to learning outcomes. The important aspect of the 4C/ID-model is the connection of learner performance in the learning tasks and educational interventions in the form of supportive and procedural information. Besides the roles of the actors, the model is context free, which means that it has no explicit notion of context or a learning environment.

2.3.2 Context as Delivery Modes

The second group of educational design models consider context as delivery or interaction modes. Such models do not typically mention context or the learning environment explicitly but differentiate interaction modes that are implicitly connected to an environment or setting.

The delivery modes imply contextual framing in which learners perform an activity. Gagné et al. (2004) suggest a sequential model for educational design. This model takes a primarily resource-centric approach to learning activities that guide learners through a learning process. Each learning activity contributes to learning outcomes that are used for assessment. Instructional designer structure and arrange learning resources for the various activities according to subject matter needs. Context is only acknowledged in the form of different delivery modes, such as computer-supported and online learning, and face-to-face activities. Many blended learning concepts rely on shifting between analog and digital delivery modes, as it is found for example in the inverted classroom approach (Lage et al. 2000).

A similar viewpoint is taken by UCL's Arena Blended Connected (ABC) curriculum design method (Evers 2018; Young and Perovic 2016). The ABC method builds on the six activity types associated to Laurillard's conversational model (Laurillard 2012). The ABC method arranges learning activities along a term-centric week-schedule. Each activity is associated to an activity type, to which the interaction modes of conventional teaching methods and digital technologies are associated. An educational design may use either mode or mix them.

2.3.3 Context as a Passive Environment

The third type of educational design models consider context as environments that frame or constrain learning activities. Models of this type have a notion of context as framing, mode of interactions, or container.

Romiszowski's instructional systems (1981) take a system-theoretical approach to instructional design. Central to this model is the relation between educational objectives and learner performance. In this model, learning activities are design elements that help to indicate the achievements of an objective through the learner performance.

Different to Skinner's concept of programmed instruction (Skinner 1958), the educational scripts in Romiszowski's model are not stimulus-response interactions but for dynamic system with feedback loops. Four main "quadrants" influence the design of each learning activity. The quadrants include "prior knowledge", "task frequency", "performance consequences", and "task organization". The latter two quadrants refer to environmental or contextual factors. Romiszowski distinguishes between a system's *internal* environment that educational design decisions can influence, and a system's *external* environment that cannot.

Reigeluth's educational design model (Reigeluth 1983; Reigeluth and Keller 2009) defines educational processes as the integration of organizational strategies, content strategies, instructional strategies, and assessment strategies. In this model, learning environments are part of the organizational strategies. A learning environment defines the framing constraints for learning activities and thereby structures the learning experience. This model explicitly emphasizes the learning environments' role as an educational design element that arranges different resources (Reigeluth and Keller 2009) or allows to integrate digital tools and online services into the learning process (Koper 2003). However, the model only considers the learning environment for locating learning activities (Reigeluth and Carr-Chellman 2009). This assigns a passive-structuring role to the environment. The model suggests that social roles and social relations are part of the instructional strategies. This model provides the theoretical foundation for IMS Learning Design that limits the learning "environment" to a collector for bundling learning resources and tools without any influence on the learning process or notion of variability (Koper et al. 2003).

Laurillard (2012) introduced the conversational model for abstracting design principles for complex learning. While Romiszowski's model focuses on the systemic relations of different educational design practices and Reigeluth's concept of educational design addresses the procedural nature of educational processes, the conversational model provides a meta pattern for designing educational experiences. The conversational model distinguishes between the teacher and the learner role, who interact either directly on the conceptual level or through the "environment" on the performance level. The model suggests that activity at the conceptual level generates performances in the environment. In response, such performances refine the mental concepts at the conceptual level. This dynamic is present and observable for both, the learners and the teachers, and is the core of educational "conversations": The model attributes the teachers' performance to the environment as "model performance" as well as a source for feedback. The basic principles are extended to collaboration, where peer "communication" takes place on the conceptual level and "peer modeling" is attributed to performances in the "environment". The environment itself has no other function than serving as the framing in which performances manifest and teachers as well as learners can observe these performances and their outcomes.

2.3.4 Socio-Centric Context

The fourth group of educational design models include socio-centric contexts. Socio-centric refers to contexts that are determined only by social relations, such as networks or hierarchies of people. The socio-centric perspective differentiates social contexts from social interactions for determining different aspects of a learning experience.

A prominent model that includes socio-centric contexts is Engeström's activity theory (Engeström 2015). Similar to the 4C/ID-model it focuses on the characteristics of (learning) activities. The model attributes six components to activities that jointly lead to an activity's outcomes: "Subjects", "tools", "objects", "rules", "community", and "division of labor". According to the model, these components structure the productive part and the framing of an activity, where "subjects", "tools", and "objects" are considered as productive, and "rules", "community", and "division of labor" as framing. Community refers to the social context of an activity, that sets demands, regulates and embeds the performances of the active subjects, and consumes the activities' outcomes. The social context of activity theory is not a passive framing for an activity, but actively influences the possible performances.

Before educational designs can draw on Engeström's model, the models' components need to be adapted to the educational application (Fig. 2.1). This change allows to relate this model to other educational design models: The "subject" refers to the *actors* in a learning activity and the "object" to the *topic* and *learning objectives*. "Tools" refer to the technologies that support the actors' interactions with a topic, which includes *learning resources*, such as text material or infographics, and *interactive tools*, such as educational apps or working sheets. While rules and contexts remain unaltered, "division of labor" is uncommon in educational settings. It refers to the different *tasks* performed by the actors according to their *roles* in an activity.

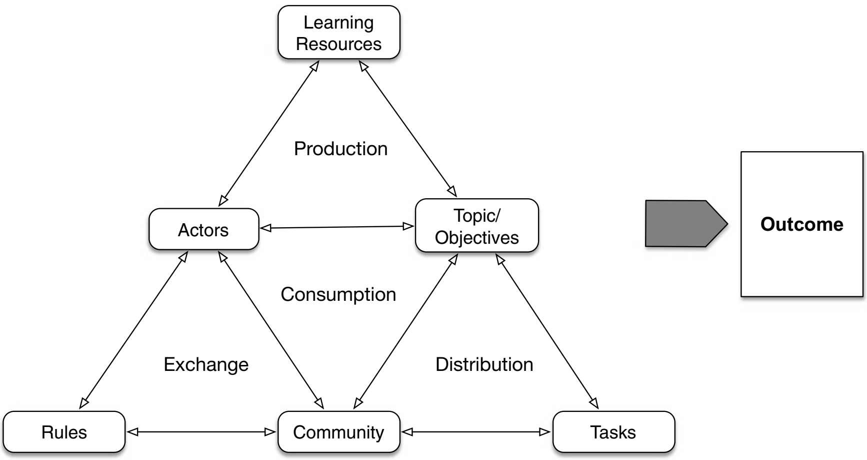

Fig. 2.1 Engeström's activity theory model with adaptations of educational design

The socio-centric perspective on contexts can be also found in Dillenbourg's orchestration graphs (Dillenbourg 2015). The orchestration graph model focuses on operationalizing social interactions in learning experiences. The model consists of "activities" that are connected by "operators" and the activities' outcomes. Activities can take place at different social planes, such as "individual", "group", "class", "cohort", "friends" or "school". The transition between social planes is coupled to special operators. The operators consume the learning outcomes of preceding activities for triggering the following activities. The arrangement of activities and operators across social planes is based on the design decisions of the educator. Different to Engeström's activity theory, the social context is not external to the activity, but characterizes the possible performances and data sources for an activity.

2.4 Contextual Factors of Learning

The limited recognition of context in educational design does not imply that context is new to the domain of education and learning on a broader perspective: Lave and Wenger (1991) introduce context as a driver of situated learning in communities of practice. The authors highlight that learning is always situated in contexts, which are not naturally given, but the result of a communal process that sets rules and responsibilities for communication and collaboration. Situated learning must not get confused with episodic and spaced learning (Melton 1970). Instead, situated learning refers to the set of socio-environmental practices into which learning is embedded. This implies that educational designs can be context agnostic but never context independent (Lave 2009). An integral part of situated learning processes is related to resolving conflicts between situated practices and the underpinning models along with six contextualizing dimensions: processes, peers, events, participation, concepts, and environment (Lave 1993).

Wenger (1998) independently focused on the contextual influences on communal learning processes. In the author's view, temporal, location-related, and social aspects as well as boundaries for differentiating contexts characterize contexts and the learning within. Wenger identifies 12 contextual factors that influence learning processes. The combination of the factors influences the selection and impact of supportive technologies for learning and socializing processes (Wenger et al. 2005, 2014). In return the selection of tools pre-structures contexts and their application contextualizes the activities in a community.

The relation between Lave's context dimensions to Wenger's contextual factors allows to move between different granularity levels (Glahn 2009). The relation also shows a strong emphasis of Wenger's concepts on social dimensions of peers and participation similar to the notion of context in Dillenbourg's and Engeström's models (Table 2.1).

The concept of "ambient information channels" (Specht 2009, 2015) addresses the forms of adaptation for different technologies in order to support learning of mobile actors through information technologies that are available in a setting. Information

Table 2.1 Context dimensions and context factors

Lave (1993) → Wenger (1998) ↓	Process	Peers	Event	Participation	Concept	World
Presence		×	×	×		
Rhythm	×		×			
Interaction		×		×		
Participation				×		
Values		×			×	×
Connections		×			×	×
Personal Identity				×		
Communal Identity		×		×		
Relations		×				
Boundaries		×		×		×
Integration	×	×				
Community building	×	×		×		

channels are learning resources with contextual meta-data. The underpinning model relies on interactive learning environments, that can draw on *sensor* networks as well as mobile-, personal-, room- social-based, as well as Internet of Things technologies as *actuators*. The learning experience is tailored to the learners' context by matching their contextual dimensions with those of an information channel and the conditions of the present setting. This matching is different from activity rules because it is not part of the educational design but inherent to the learning resources and the learners' context.

The ambient information channels provide a framework for operationalizing learning contexts and transitions between them. The framework presumes that contexts are defined by interactions of actors with their environment that are measurable through sensors. It connects the technical level of sensors in mobile technologies with Lave's abstract context dimensions. This makes context accessible as a technical and educational design element and allows to operationalize seamless learning concepts for designing learning experiences. By mapping the contextual categories suggested by Zimmermann et al. (2007) to Lave's (1993) educational dimensions, we can link sensor-level context types to the educational framing (Table 2.2). The mapping shows that not all educational context dimensions are directly mapped to specific sensor types. Instead, it shows that some contextual dimensions of educational approaches depend on more than one sensor-level dimension. The mapping supports the design of data collection and processing for orchestrating contextual learning activities and interactions.

Sharples et al. (2009) indicate that Engeström's "community" element can be generalized as "context" so the model becomes suitable for designing mobile learning experiences. This broadens the perception of activity theory's elements towards activities that consider contextual dimensions beyond social relations. The authors

Table 2.2 Relation between Lave's context dimensions and Zimmermann's context awareness dimensions

Lave (1993) → / Zimmermann et al. (2007) ↓	Process	Peers	Event	Participation	Concept	World
Activity	×			×		
Relations		×		×	×	×
Time			×			
Identity		×			×	
Location						×

illustrate this wider context definition for the "location" context in location-based learning scenarios. However, broadening the model's scope of context adds little to guide the design of situated and contextualized learning experiences and the related tools (Fig. 2.2).

The extended function of the context element becomes more apparent when Engeström's activity model is inverted as depicted in Fig. 2.3. By re-aligning the

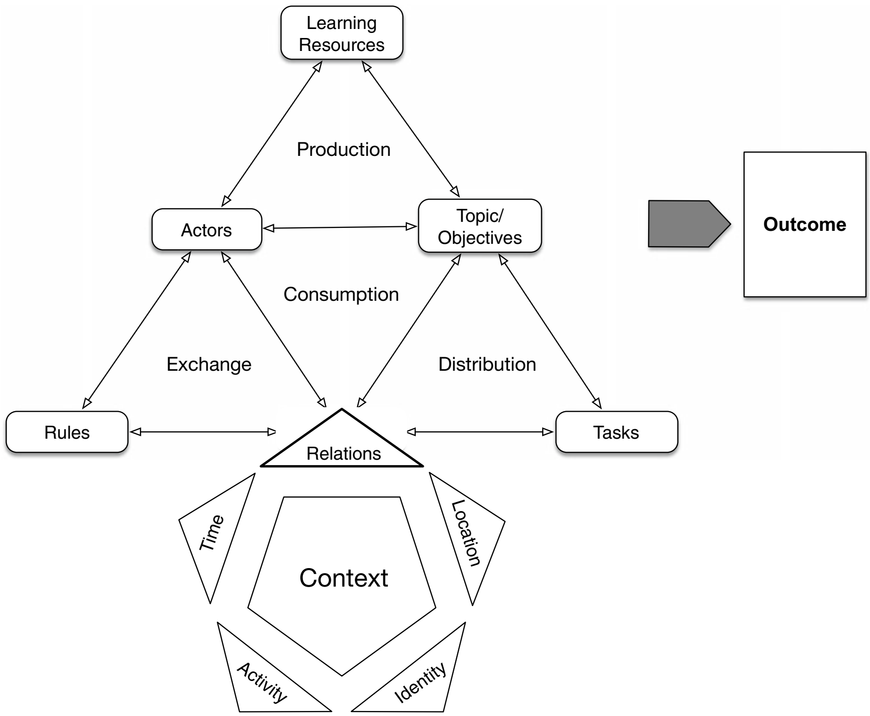

Fig. 2.2 Integration of context with Engeström's activity theory model

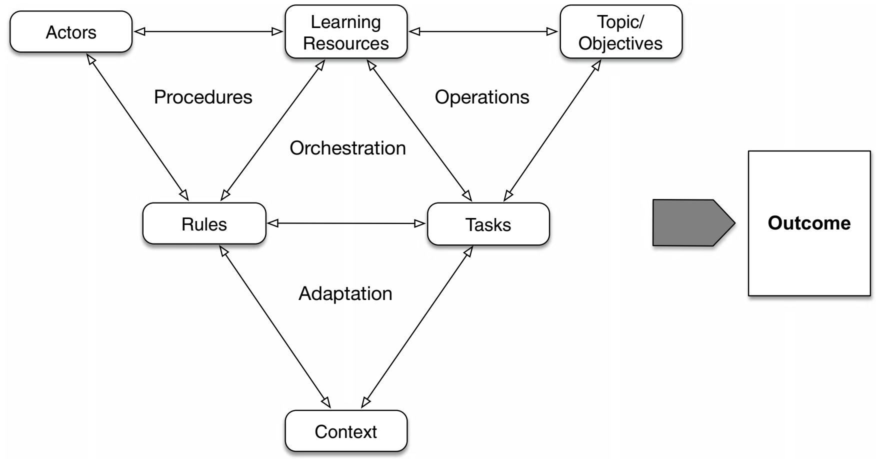

Fig. 2.3 Inverted activity theory model

productive triangle of the original model, we identified new relations between the components in technology-enhanced activities: Our changed perspective emphasizes the impact of technologies and context on learning activities that were previously hidden behind to the dominant emphasis on the interaction of actors with a topic. It also shows four tension areas for educational designs that were hidden in the original presentation:

- "Procedures" define when and how actors can, should or must use learning resources;
- "Operations" refer to the alignment of learning resources, tasks and learning objectives;
- "Orchestration" focuses on tasks, resources, and rules that influence the flow of learning processes;
- "Adaptation" targets the interplay between rules and tasks in and across contexts.

The tension area of "adaptation" includes adaptive variants such as *personalization*, *recommendation*, *localization*, and *synchronization*:

- Personalization refers to adaptation along the *identity* dimension.
- Recommendation refers to adaptation along the *activity* dimension.
- Localization refers to adaptation along the *location* dimension.
- Synchronization refers to adaptation along the *temporal* dimension.

The inversion of the model highlights the functional design elements of seamless learning with context as the focal point for design decisions. It visualizes that contextual designs depend more on learning tasks and rules in order to situate activities in contexts or bridge between contexts.

2.5 Contextualization Beyond Context-Awareness

The recent research on seamless learning indicates an active role of context in learning experiences. Interactive learning environments can source contextual information by aggregating data from sensor networks in the learning environment. From the perspective of designing seamless learning experiences this raises the following question.

Is contextualization the result of explicit educational arrangements or exist contextualizing aspects that are inherent to tools, rules, or tasks?

This question is of particular interest for designing interactive learning environments as well as educational experiences: If contextualization is constrained to active design decisions, then the agency of contextualization is always with the educational designer, teacher, or lecturer. Such designs require pre-arranged learning processes for every supported context. However, the concept of situated learning suggests that all learning is contextually situated (Lave and Wenger 1991). This implies that arrangements in educational designs could have affordances towards certain contexts without being explicitly tailored to them. Different to context-aware approaches, which depend on tight context relations, contextual affordances would rely on the learners' situational perception of learning opportunities.

Answering the question requires educational design elements that *minimize* contextual dependencies. Such dependencies include context-specific tasks, rules, or learning resources, as well as implicit contextual requirements such as presentation requirements of multimedia resources, connectivity requirements for online activities, or the learning resources' handling time. If minimizing contextual dependencies for learning activities have *no* contextual affordances, then learners should primarily perform these activities in the same settings as they would while using the non-minimized counter parts.

To test the above assumption, an existing educational design could be extended with a mobile app that provides minimized variants of already existing learning activities. The mobile solution would be available and easily accessible in a wide variety of contexts, which allows for analyzing how learners experience their learning environment. The following analysis uses the *Mobler* app for presenting alternative learning activities in an educational design of an introductory module at the University of Zurich with five consecutive cohorts.

Mobler (Glahn 2013; Glahn et al. 2015) is a mobile learning app for Android and iOS smartphones that implements the micro-learning approach. Micro-learning describes learning processes that consist of short and complete learning activities (Glahn et al. 2004; Gassler et al. 2004). Any micro-learning activity has three phases: an activity activation or task description, a performance with a measurable outcome, and feedback on the learners' performance. A micro-learning activity is only given if an activity cannot get further divided into smaller activities that have all of these phases (Glahn 2013).

The app is designed for facilitating practices and it uses test items that are provided by a learning management system (LMS). Such test items would normally be used in

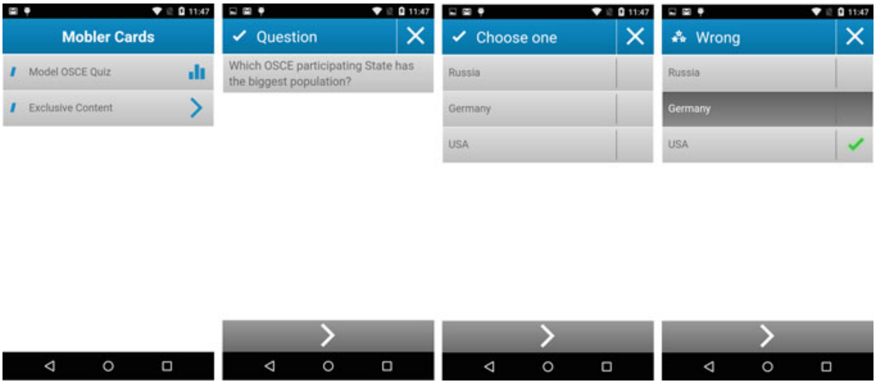

Fig. 2.4 *Mobler* Screenshots (Android version)—from left to right: course selection, question (task affordance phase), question answering (performance phase), feedback by showing the correct response in comparison with the provided response

tests and e-assessments. *Mobler* relies on interoperability standards for exchanging data with an LMS. While conventional e-assessments bundle test items and require the learners to complete all items in one attempt, *Mobler* isolates each test item and presents it independently. Based on the learners' responses and overall progress the app chooses the most suitable test items for the next activity. Immediately after the learners complete a task performance, they receive feedback on their performance. This feedback is automatically generated based on the test item's scoring definition. Educational designers can enrich the automated feedback with optional qualitative information. All test items are arranged as an endless loop that learners can interrupt at any time and continue at a later point. Figure 2.4 shows the user interface for these steps.

The app uses no device sensors or push-notifications for active contextualization. *Mobler* minimizes contextual dependencies through the following features.

- Offline caching of test items and learner performance;
- No gamification through challenge modes;
- Non-interactive data synchronization with the LMS;
- Isolating test items into independent micro-learning activities;
- Pseudo-random selection of test items based on the learners' prior performance.

The features reduce the explicit activity context only to the framing course and the present learning activity. The offline function and the non-interactive data synchronization minimize network-related constraints that would otherwise restrict learners to contexts with sufficient network bandwidth and latency. These features also allow the learners to initiate and stop learning activities anywhere as long they have access to their mobile phone. This minimizes the preference towards learning contexts.

The *Mobler* app has been used between 2014 and 2018 with five consecutive student cohorts in an annually recurring introductory lecture on communication sciences (Table 2.3). The app was a voluntary addition to the blended learning design of

Table 2.3 Enrolled course participants and **Mobler** usage per cohort

Cohort (year)	2014	2015	2016	2017	2018
Enrolled students	410	343	323	342	327
Mobler adoption rate (%)	74	83.9	84.8	84.8	87.7
Mobler weekly use (%)	32	51.6	44.1	47.5	43.1
Mobler daily use (%)	24	26.9	30.5	27.1	36.9
Questionaire response rate (%)	12	27	18	17	20

the lecture. The test items presented in the app were also available to the students in online tests for self-assessment. The adoption rate of this optional component started at 74% and consistently grew to 87% in 2018.

After each term, an online survey asked the students about their perceived learning behavior using the *Mobler* app. The survey was combined with the regular course evaluation, which is implemented after the end of the lecture and after the exams. The survey includes items on technology acceptance and ownership, the mobile media consumption, the acceptance as well as learning habits using the *Mobler* app (Glahn et al. 2015). The part on learning habits using *Mobler* includes items on the frequency of the mobile usage "at home", "in transit (e.g., in public transport or car)", "at work", "on campus/in the library", and "during leisure time (e.g., while meeting friends)".

The 332 student responses to the survey represent 19% of all 1745 students. The surveys indicate a 100% smartphone adoption among the participants and show daily usage of mobile apps in various contexts. The data indicate that the students use these devices irrespective of the context.

A growing number of students answered that they have used *Mobler* occasionally or frequently during the term, starting from 74% in 2014 increasing to 87.7% in 2018. The distribution app usage frequency is similar to the use of the telephony or navigation features on the smartphone, with occasional use (at least once per week) at around 45% and daily use growing from 24% in 2014 up to 37% in 2018 (Table 2.3).

The students were asked to indicate their use of *Mobler* in different contexts. The data shows that students across all cohorts used the app primarily in two contexts: "at home" and "in transit". The other contexts were of lesser relevance irrespectively of the cohort (Fig. 2.5). The home context has been expected for self-study experiences because these pointed to the primary educational intention for the self-assessment. "In transit" is a new learning context that was not planned as part of the courses' learning experience. Other contexts were less relevant for the participants' learning experience with the app.

The findings indicate that the students attribute specific contexts to the app because the students reported almost equal smartphone usage frequency for all contexts and the app minimizes contextual dependencies. This suggests that the students responded to contextualizing affordances in the mobile learning activities. The data indicate clearly that these affordances are not intrinsic to the device, but are related to the design of the app.

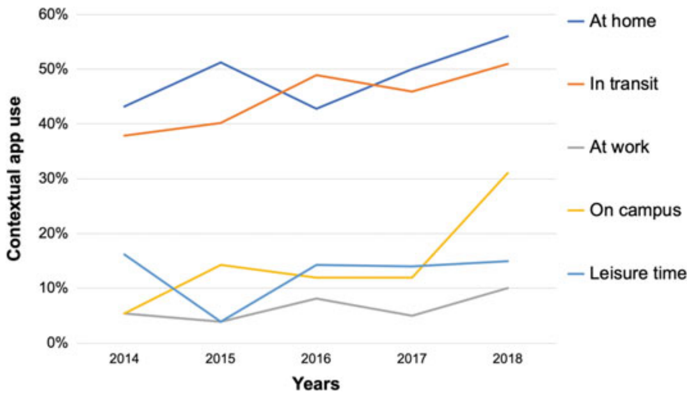

Fig. 2.5 Repeated use of the *Mobler* app per cohort, by context

The results suggest that contexts can influence the learning experiences, even if they are not explicitly part of an educational design. Instead, the affordances of a tool or learning resource may allow students to expand their learning experiences into new contexts. Different from active contextualization of context-aware systems, an affordance-guided passive contextualization can be achieved through re-organizing and re-arranging learning activities or resources.

2.6 Conclusions

This chapter focused on "context" as an educational design principle. Many educational design models do not consider context or consider context as a passive component that structures learning resources. The increasing availability and integration of sensors and actuators in mobile technologies and the Internet of Things questions the passive perception of context. Concepts such as seamless learning highlight a new perspective on context in educational designs and learning experiences.

The relation of context to existing educational design models is a major challenge because the necessary concepts are often missing. Simultaneously, there are several studies that focus on contextualization as a form of adaptation of interactive systems. This raises the question for educational design, whether only adaptation can contextualize learning experiences. The findings presented in this chapter suggest that contextual experiences are not only the result of such adaptation. Interactive environments and learning resources can also offer passive forms of contextualization by allowing learners to expand their learning environment into new settings. One approach to achieve this form of contextualization is based on minimizing the contextual dependencies of an educational tool.

Either approach to contextualization can be challenging for educational designers because it involves greater awareness about the different contextual factors that influence learning experiences. In order to abstract these underpinning relations, this chapter proposes an inverted perspective on Engeström's activity theory model. The model provides a foundation for operationalizing seamless learning as the interplay of active contextualization and passive contextual affordances of tools and learning resources. The model's key principles guide the integration of the *Mobler* app into a higher education course curriculum.

The presented findings confirm the plausibility of the initial assumptions about contextual influences on learning experiences. This points towards a new rationale for educational designs and interactive systems that reflects context as an active factor for learning experiences. Yet, further research must use our findings with caution when deducing implications for educational design theories and models. Research can overcome the shortcomings of the present study by addressing the following key questions.

1. What are the relations between the different abstraction levels of contextual dimensions and how do they influence learning experiences?
2. How do affordances of learning resources and tools, educational rules, tasks, and contexts influence each other, and are there context-specific affordances inherent to apps, devices or device types?
3. Are there universal design principles for context-awareness and contextualization that are relevant for educational design?

Glossary

Affordance The quality or property of objects or tools that define their possible uses or makes clear how they can or should be used.

Assessment Any form of comparison of performances with benchmarks or objectives.

Blended learning All forms of combining different technology-enhanced learning approaches with each other and with conventional educational practices and interventions.

Context-awareness The use of context to provide task-relevant information and services. In education, context-awareness refers to explicit use of context or contextual factors for creating and moderating learning experiences.

Contextual affordance Properties of objects or tools that bind usages to contexts. These properties are connected to contextual dimensions.

Contextual requirements The contextual preconditions that are necessary for learners to perform learning activities or to make learning experiences.

Contextualization The use of context to change information and services. In education, contextualization refers to the use of context for selecting learning activities as well as for changing the conditions of one or more learning activities.

Device sensors The sensor-network built into digital devices, such as microphone, camera, gyroscope, or compass.

Digital natives Generations who only experienced a world with ubiquitous presence of digital technologies in daily life.

Educational design Planning and arrangement of learning activities into educational processes that include the assessment of learning objectives. It complements *learning design* that focuses on the design of learning tasks and *instructional design* that primarily addresses the design of learning resources.

Learning activity Educational tasks including necessary resources, environment, intended performances, expected outcomes, as well as relevant feedback. Learning activities typically consider a learner role and a facilitator role but can also address multiple roles in different social interactions. Learning activities abstract beyond individual performances and refer to planned educational interventions.

Learning environment The setting of one or more learning activities. Learning environments provide learning resources that are needed to perform a learning activity. Moreover, learning environments determine the context of learning activities. A learning environment can bind a learning activity in terms of the activity's framing as well as it can be part of an activity in terms of structured resources.

Learning experience The sensory and emotional impressions of learners when performing a learning activity or being exposed to a learning environment.

Micro-learning Educational design patterns that utilize atomic learning activities as fundamental building blocks. Learning activities consist of a task, performance assessment, and performance feedback, learning activities are atomic, if they cannot get further separated into sub-activities with this structure intact.

Perceived learning behavior The learners' self-reported perception of their own learning and/or of their personal engagement in learning activities.

Seamless learning Seamless learning happens when persons or groups experience a continuity of learning, and consciously bridge the multifaceted learning efforts across a combination of locations, times, technologies, or social settings. In educational design, seamless learning refers to approaches that create continuous learning experiences that leverage the diverse contexts of learners to shape learning experiences. *Mobile seamless learning* refers to applications of mobile technologies such as smartphones to facilitate learning in context and/or to bridge between contexts.

Technology-enhanced learning Combines all approaches and applications, in which digital technologies are used for supporting education and learning processes. This includes but is not limited to e-learning, online learning, and MOOCs, mobile learning, game-based learning, simulations, gamification, educational approaches to augmented and mixed reality, virtual and remote labs, as well as virtual worlds.

References

Anderson, L. A., et al. (2001). *A taxonomy for learning, teaching, and assessing; a revision of Bloom's taxonomy of educational objectives*. New York et al.: Longman.

Bloom, B. S., et al. (Eds.). (1956). *Taxonomy of educational objectives, handbook 1: Cognitive domain*. New York: Longman.

Churchill, D., Fox, B., & King, M. (2016). Framework for designing mobile learning environments. In D. Churchill, J. Lu, T. K. F. Chiu, & B. Fox (Eds.), *Mobile learning design, theories and application*. Singapore et al: Springer.

Dey, A. K. (2001). Understanding and using context. *Personal and Ubiquitous Computing, 5*(1), 4–7.

Dillenbourg, P. (2015). *Orchestration graphs: Modeling scalable education*. Lausanne: EPFL Press.

Engeström, Y. (2015). *Learning by expanding: An activity-theoretical approach to developmental research* (2nd ed.). New York: Cambridge University Press.

Evers, K. (2018). Breaking barriers with building blocks: Attitudes towards learning technologies and curriculum design in the ABC curriculum design workshop. *ERUDITIO, 2*(4), 70–85.

Gagné, R. M., Wager, W. W., Golas, K., & Keller, J. M. (2004). *Principles of instructional design* (5th ed.). Orlando: Cengage Learning.

Garrison, D. R., & Vaughan, N. D. (2008). *Blended learning in higher education: Frameworks, principles, and guidelines*. San Francisco: Jossey-Bass.

Gassler, G., Hug, T., & Glahn, C. (2004). Integrated micro learning; an outline of the basic method and first results. *Interactive Computer Aided Learning, 4,* 1–7.

Glahn, C. (2009). *Contextual support of social engagement and reflection on the web*. Heerlen: Open University in The Netherlands.

Glahn, C. (2013, September, 25–27). Using the ADL Experience API for mobile learning; sensing, informing, encouraging, orchestrating. In: *Proceedings of the 7th International Conference on Next Generation Mobile Apps, Services and Technologies (NGMAST)*. Prague, Czech Republic.

Glahn, C. (2014). Mobile learning operating systems. In M. Ally & A. Tsinakos (Eds.), *Mobile learning development for flexible learning*. Vancouver, Canada: Commonwealth of Learning Press.

Glahn, C., Gassler, G., & Hug, T. (2004, June, 21–26). Integrated learning with micro activities during access delays. *Proceedings of the AACE ED-MEDIA 2004* (Vol. 5, pp. 3873–3876). Lugano, Switzerland.

Glahn, C., Gruber, M. R., & Tartakovski, O. (2015). Beyond delivery modes and apps: A case study on mobile blended learning in higher education. In G. Conole, T. Klobučar, C. Rensing, J. Konert, & É. Lavoué (Eds.), *Design for teaching and learning in a networked world* (pp. 127–140). Heidelberg et al.: Springer.

Hwang, G.-J., Lai, C.-L., & Wang, S. Y. (2015). Seamless flipped learning: A mobile technology enhanced flipped classroom with effective learning strategies. *Journal of Computers in Education, 2*(4), 449–473.

Koper, R. (2003). Combining re-usable learning resources and services to pedagogical purposeful units of learning. In A. Littlejohn (Ed.), *Reusing online resources: A sustainable approach to elearning* (pp. 46–59). London: Kogan Page.

Koper, R., Olivier, B., & Anderson, T. (Eds.). (2003). *IMS learning design information model.* IMS Global Learning Consortium. Retrieved March 30, 2019, from https://www.imsglobal.org/-learningdesign/-ldv1p0/-imsld-_info-v1p0-.html.

Kuh, G. D., Douglas, K. B., Lund, J. P., & Ramin Gyurmek, J. (1994). *Student learning outside the classroom; transcending artificial boundaries* (ASHE-ERIC Higher Education Report No. 8). Washington, DC: The George Washington University; School of Education and Development.

Lage, M. J., Platt, G. J., & Treglia, M. (2000). Inverting the classroom: A gateway to creating an inclusive learning environment. *Journal of Economic Education, 31*(1), 30–43.

Laurillard, D. (2012). *Teaching as a design science, building pedagogical patterns for learning and technology*. Abingdon: Routledge.

Lave, J., & Wenger, E. (1991). *Situated learning; legitimate peripheral participation*. Cambridge: Cambridge University Press.
Lave, J. (1993). The practice of learning. In S. Chaikin & J. Lave (Eds.), *Understanding practice, perspectives on activity and context* (pp. 3–33). Cambridge: Cambridge University Press.
Lave, J. (2009). The practice of learning. In K. Illeris (Ed.), *Contemporary theories of learning; learning theorists in their own words* (pp. 200–208). London & New York: Routledge.
Luckin, R. (2010). *Re-designing learning contexts: Technology-rich, learner-centred ecologies*. Oxon, UK and New York: Routledge.
Melton, A. W. (1970). The situation with respect to the spacing of repetitions and memory. *Journal of Verbal Learning and Verbal Behavior, 9,* 596–606.
van Merriënboer, J. J. G., & Kirschner, P. A. (2013). *Ten steps to complex learning: A systematic approach to four-component Instructional Design* (2nd ed.). New York: Routledge.
Prensky, M. (2001). Digital natives, digital immigrants. *On The Horizon, 9*(5). Retrieved March 30, 2019, from http://www.marcprensky.com/writing/Prensky%20-%20Digital%20Natives,%20-Digital%20-Immigrants%20-%20Part1.pdf.
Reigeluth, C. M. (1983). Instructional design: What is it and why is it? In C. M. Reigeluth (Ed.), *Instructional-design theories and models: An overview of their current status* (pp. 3–36). New York: LEA.
Reigeluth, C. M., & Carr-Chellman, A. A. (2009). Situational principles of instruction. In C. Reigeluth & A. A. Carr-Chellman (Eds.), *Instructional-design theories and models: Building a common knowledge base* (Vol. III, pp. 57–72). New York: Routledge.
Reigeluth, C. M., & Keller, J. B. (2009). Understanding instruction. In C. Reigeluth & A. A. Carr-Chellman (Eds.), *Instructional-design theories and models: Building a common knowledge base* (Vol. III, pp. 27–40). New York: Routledge.
Romiszovski, A. J. (1981). *Designing instructional systems, decision making in course planning and curriculum design*. London: RoutledgeFalmer.
Rovai, A. P., & Jordan, H. M. (2004). Blended learning and sense of community: A comparative analysis with traditional and fully online graduate courses. *International Review of Research in Open and Distributed Learning, 5*(2).
Sharples M., Arnedillo-Sánchez, I., Milrad, M., & Vavoula, G. (2009). Mobile learning. Small devices, big issues. In N. Balacheff, S. Ludvigsen, T. de Jong, A. Lazonder, & S. Barnes (Eds.), *Technology-enhanced learning*. Dordrecht: Springer.
Skinner, B. F. (1958). Teaching machines. From the experimental study of learning come devices which arrange optimal conditions for self-instruction. *Science*, *128*(3330), 969–977.
So, H. J., Tan, E., Wei, Y., & Zhang, X. J. (2015). What makes the design of mobile learning trails effective: A retrospective analysis (pp. 335–352). In L. S. Wong., M. Milard., & M. Specht (Eds.), *Seamless learning in the age of mobile connectivity* (pp. 335–352). Singapore: Springer.
Specht, M. (2009). *Learning in a technology enhanced world: Context in ubiquitous learning support.* Inaugural Address. September 11, 2009. Heerlen, The Netherlands: Open University in The Netherlands.
Specht, M. (2015). Connecting learning contexts with ambient information channels. In L.-H. Wong, M. Milrad, & M. Specht (Eds.), *Seamless learning in the age of mobile connectivity* (pp. 121–140). Singapore et al.: Springer.
Traxler, J. (2007). Defining, discussing and evaluating mobile learning: The moving finger writes and having writ…. *The International Review of Research in Open and Distributed Learning, 8*(2).
Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge, New York: Cambridge University Press.
Wenger, E., White, N., & Smith, J. D. (2014). *Digital habitats: Stewarding technology for communities*. Portland: CPsquare.
Wenger, E., White, N., Smith, J. D., & Rowe, K. (2005). Technology for communities. In *Guide de mise en place et d'animation de communautés de pratique intentionelle.* Québec: CEFRIO.

Wong, L.-H. (2015). A brief history of mobile seamless learning. In L.-H. Wong, M. Milrad, & M. Specht (Eds.), *Seamless learning in the age of mobile connectivity* (pp. 3–40). Singapore: Springer Singapore.

Wong, L.-H., & Looi, C.-K. (2011). What seams do we remove in mobile-assisted seamless learning? A critical review of the literature. *Computers & Education, 57*(4), 2364–2381.

Young, C., & Perovic, N. (2016). Rapid and creative course design: As easy as ABC? *Procedia—Social and Behavioral Sciences, 228*, 390–395.

Zimmermann, A., Lorenz, A., & Oppermann, R. (2007). An operational definition of context. *Modeling and Using Context*, 558–571.

Zimmermann, A., Specht, M., & Lorenz, A. (2005). Personalization and context management. *User Modeling and User-Adapted Interaction, 15*(3), 275–302.

Dr. Christian Glahn is an expert for mobile seamless learning, educational technologies, adaptive educational orchestration, and the digital transformation in higher education. His research integrates educational design and smart technologies into existing digital infrastructures and organizational practices. He is presently a lecturer at the Zurich University of Applied Sciences (ZHAW), Switzerland, a research fellow at the Leiden-Delft-Erasmus Centre for Education and Learning, and the education chair of the European Association for Technology Enhanced Learning (EATEL). Dr. Glahn is the co-inventor of the microlearning concept and was leading many projects and actions on technology-enhanced learning in Austria, Germany, Greece, Switzerland, and The Netherlands.

Dr. Marion R. Gruber is an expert for educational design and technology-enhanced learning with a strong focus on the practical design of learning experiences in the digital society. She is an educator and art historian and a forerunner in digital arts education. She supports the conceptualization, development, and integration of digital projects as scientific advisor for educational-technologies at the University of Zurich, Switzerland. Her research interests combine educational design, mobile seamless and blended learning, e-assessment, digital publishing, as well as social media. Dr. Gruber has initiated and was involved in several research and digital transformation projects in Austrian, Swiss, and Dutch academia, archives and museums.