Course Design Approaches and Behavioral Patterns in Massive Open Online Courses for Professional Learning

Marc Egloffstein
Muhittin Şahin
University of Mannheim, Germany

Dirk Ifenthaler
University of Mannheim, Germany
Curtin University, Australia

Abstract
Despite their growing importance, differential, process-oriented research on Massive Open Online Courses (MOOCs) for professional learning is scarce. This paper explores learner behavior in Enterprise MOOCs using lag sequential analysis. Data from 13 MOOCs on business and technology-related topics with a total of N = 72,668 active learners were examined. Starting from consistent high-level behavioral patterns, a deeper analysis reveals variations in interaction sequences according to the underlying course design approach. Lecture-oriented, system interaction-oriented, and discussion-oriented courses share a set of common patterns but also differ in various interaction sequences. Results point towards an isolated role of video playbacks across all course clusters, consumerist patterns in lecture-oriented courses, and a positive influence of metacognitively oriented interactions on learning outcomes. Accordingly, initial design recommendations include integrating interactive instructional elements in videos, promoting learner engagement in lecture-oriented courses, and fostering metacognition. Connecting interaction and achievement data may uncover promising behavior patterns that can be further supported by course design. Based on the initial findings, implications for future research and development are discussed.

Keywords: sequential analysis, MOOC, professional learning, learning analytics

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More than ten years after their inception, Massive Open Online Courses (MOOCs) have gained a foothold in academia and have also become a viable alternative for professional learning (Littenberg-Tobias & Reich, 2021) and corporate training (Egloffstein & Ifenthaler, 2017). In this light, current discussions center around the transfer and recognition of MOOC credits between higher education and continuing education (Moore, 2022), as well as the evolution of the course format through modularization to better align with education and training requirements (Serth et al., 2022).

While many companies are not yet fully realizing the potential of MOOCs for training and development (Condé & Cisel, 2019) or lack adequate support for employees taking MOOCs (Hamori, 2021; 2023), others are operating their own platforms, offering corporate (internal focus: courses for employees) or enterprise (internal and external focus: courses for stakeholders) MOOCs (Egloffstein, 2018). For instance, openSAP, an open learning platform for the information technology sector, implements so-called openSAP Enterprise MOOCs (Schwerer & Egloffstein, 2016) to transfer relevant knowledge within the organization as well as to external stakeholders and the public (Renz et al., 2019).

Considering the persisting challenges associated with MOOCs in terms of instructional quality (Margaryan et al., 2015; Egloffstein et al., 2019) or low completion rates (Reich & Ruipérez-Valiente, 2019; Li et al., 2015), openSAP strives to optimize its offering and continuously improve the learning experience based on scientific evidence. Following the idea that learning analytics can be a solution to current MOOC handicaps (Bozkurt, 2021), openSAP initiated several collaborative research projects aimed at improving the learning design of MOOCs (Ifenthaler, 2017) and advancing the state of research on online learning in training and professional development.

This paper reports an exploratory study focusing on learner behavior in different openSAP Enterprise MOOCs. Building on previous research findings (Rohloff et al., 2020; Şahin et al., 2021), the study seeks to (a) identify behavioral patterns in openSAP Enterprise MOOCs and (b) determine differences according to course design as well as learner achievement in order to derive evidence-based design recommendations. The study illustrates how learning analytics approaches can inform course design and facilitation.

Background

Research Context: openSAP

SAP is a major multinational software company based in Germany. As part of SAP's digital education strategy, the openSAP learning platform was launched in 2013 to meet the increasing demands of partners, customers, and suppliers for SAP-related knowledge on time. OpenSAP delivers knowledge via scalable online courses based on the xMOOC principles, thus suitable for larger audiences. The main topic areas are technology and software, business, or design; while some additional courses provide insights on corporate social responsibility-related topics. The technical infrastructure is based on a MOOC platform developed at the Hasso Plattner Institute (HPI) in Potsdam, Germany. According to company data provided by openSAP, the platform had more than 1,300,000 registered participants from over 200 countries, of which about 85% had a professional background, with more than six million enrollments in over 200 different courses in 2022.

Concerning instructional design (ID), openSAP Enterprise MOOCs follow an elaborate xMOOC model, providing structured and well-organized course offerings (Bonk et al., 2015). The courses are open to everyone free of charge, providing videos, quizzes, and interaction over a fixed period. Every course has a fixed start and end date with a registration period of several weeks in advance. Once the course has started, new content is released week by week, mostly with video elements of approximately 15 minutes in length. Every video element is followed by a short, ungraded self-test with multiple-choice and multiple-answer questions to reflect on the content. Hands-on exercises can complement this, e.g., in interactive coding assignments in programming courses. Every openSAP course has a course-specific discussion forum available, allowing participants to interact with peers and content experts who are available during the course run. A set of collaborative tools is provided in so-called Collab Spaces, which allow dedicated breakout sessions or working in smaller groups. At the end of each week, a graded assignment about the content enables participants to reflect on and document their learning performance. The average workload per week is four to six hours. A course usually concludes with a final exam covering all the course content, counting for 50% of the highest attainable score. OpenSAP offers two kinds of certificates. Learners receive a “confirmation of participation” (CoP) by accessing at least 50% of the overall course content (= “progress”). Moreover, participants will obtain a “record of achievement” (RoA) when achieving at least 50% of the points available in graded assignments (= “performance”).

Related Research: Sequential Analysis of Learning Behavior

As learning analytics research increasingly focuses on exploring the process nature of learning (Ifenthaler et al., 2021), a plethora of methods are being employed. Examples include epistemic network analysis, temporal process mining, or stochastic process mining (Saint et al., 2020). Approaches for analyzing activity sequences involve sequential pattern mining, Markov chains, and hidden Markov models (Boroujeni & Dillenbourg, 2018). As a long-established method of inferential statistics (Wald, 1973; Bakeman & Gottman, 1997), sequential analysis is also used for investigating the behavior of learners in online learning systems (Hou et al., 2010; Şahin et al., 2020). Identifying latent patterns in learner behavior based on sequences of system interactions can offer valuable insights for aligning course design with individual learning processes, thereby leveraging the use of instructional technologies and ultimately enhancing learning success.

Thus, sequential analysis has been applied in several MOOC settings: Boroujeni & Dillenbourg (2018) detected latent study patterns comparing a hypothesis-driven approach and an unsupervised, data-driven approach. Their methods could be deployed during the course, enabling real-time support and feedback. Shang et. al. (2020) adopted Lag Sequential Analysis (LSA) to explore the factors affecting learning efficiency of adult learners. The study found 92 types of significant behavioral transformation sequences reflecting the characteristics of adult learners, such as task orientation, active exploration, and self-regulation ability, as well as correlations with learning efficiency.

Liu et al. (2021) investigated the differences between certificate achievers and explorers. Eleven behaviors were extracted, with six essential behaviors highly related to certificate achievement. Compared to explorers, certificate achievers exhibited more bidirectional behaviors in terms of interactive and course-related activities, as well as more repetitive behaviors in terms of course-related and graded assessment activities.

Li et al. (2021) explored MOOC learners' time investment patterns and their relationships with learning performance, session time allocation, and learning sequences by analyzing the data from a Chinese MOOC. Seven time-investment patterns of MOOC learners were defined, and learning performance differed among them.

Most recently, Li et al. (2022) detected the differences in learning engagement and learning patterns amongst three groups of learners with different achievement levels (failed, satisfactory, excellent). The study found differences in both learning engagement and learning patterns among the three groups. All those studies were conducted with the explicit intention of improving the underlying learning environment and advancing instructional design as well as course facilitation. However, none explicitly focused on professional learners, and none employed a differential perspective concerning course design.

Research Questions

Building upon previous research findings and grounded in the corporate research context, this study aims to investigate behavioral patterns in openSAP Enterprise MOOCs and explore their relationship to the underlying course design as well as to learner performance. The guiding research questions were:

RQ1. Are there behavior patterns in enterprise MOOCs for professional learning?
RQ2. Do interaction sequences differ according to the underlying course design approach?
RQ3. Are there interaction sequences for high-achieving learners?

Method

Data Collection and Participants

User events from 13 openSAP Enterprise MOOCs were analyzed with regard to learner behavior patterns. The courses in the sample were intentionally selected by openSAP to represent the full spectrum of their offering. They show variations in terms of length, effort, and design parameters like assessment configuration or additional instructional design elements (e.g., reflection prompts, coding exercises, or team peer assessments). Based on the underlying course design approach, openSAP grouped these courses into three clusters: lecture-oriented courses (strictly following the video-based xMOOC format), system interaction-oriented courses (featuring interactions with the platform as an integral element, e.g., programming courses), and discussion-oriented courses (featuring communication as an integral element). Data collection was carried out in line with openSAP's data protection policy, based on the participants' consent when accessing the platform. Accordingly, no personal data that could have identified individuals was analyzed. The sample reflects the overall population of openSAP learners, who consist predominantly of professional learners with an academic background, aged 25 to 40, participating voluntarily and without financial compensation. Table 1 provides an overview of the sample. Additional information on the courses can be found in Appendix A.

Table 1
Descriptive Information on the Courses in the Sample

Course design approach	Course code	Topic area[1]	Course length (wks)	Work-load (hrs)	Assess-ment confi-gura-tion[2]	Addi-tional ID ele-ments	Enroll-ments[3]	CoPs issued[4]	RoAs issued[5]
Lecture-oriented	xm1	biz	1	3	w	0	4609	1679	1318
	leo2	biz	2	8	w+f	1	10542	2576	1687
	sbw1	biz	6	24	w	1	11664	1274	967
	build1	des	4	16	w+f	2	7749	1429	849
	ieux1	tech	1	4	w	0	13431	3944	2719
System interaction-oriented	java1	tech	5	30	w+e+f	3	21693	2941	2318
	mobile3	tech	5	25	w+f	1	10374	1652	1195
	s4h15	biz	4	16	w+f	0	18265	5149	3884
	sps2	tech	3	12	w+f	1	10940	2607	1896
	sps3	des	5	20	w+p	1	6629	932	651
Discussion-oriented	cwr1-1	des	3	12	w+p	2	1810	412	253
	dafie1	des	5	20	w+p	2	5283	1101	651
	pa1-tl	biz	3	12	w+f	1	6904	1888	1333

Note. [1] biz: business; des: design; tech: technology
[2] w: weekly assignment; f: final exam; e: graded exercise; p: peer assessment
[3] at course end
[4] CoP: confirmation of participation
[5] RoA: record of achievement

The dataset consists of learners' interactions with the digital learning environment based on traceable system states and events. In the preceding data preparation step, the event data generated by platform interactions were coded for each learner. A total of N_A = 10,454,430 activities of N_L = 72,668 learners were analyzed.

Procedure and Analysis

We applied a two-stage procedure, exploring two levels of analysis. At the aggregate level, we followed the predefined system-side mapping of learner events to four global categories, depending on the area of the platform in which the interactions take place: learning (L), discussion (D), progress (P), and announcement (A). We further examined learners' sequential behavior patterns on the more granular level of system interactions. These interactions belong to 20 system event types, such as submitting assignments, downloading presentations, submitting surveys, visiting textual instructions, visiting videos, playing videos from category

(L), posting comments, posting replies for category (D), visiting progress in category (P), and visiting announcements in category (A).

The first phase of the analysis was centered around the process of Lag Sequential Analysis on the aggregate level. In the first step, event sequences were created for each learner based on their interactions with the learning platform. An example of such an event sequence would be: LLLLDDLLLPDAALLLL. In the second step, transitional frequency matrices were created to represent the number of transitions between system interactions. Subsequently, the transition probability matrices were mapped out, which indicate the statistical probabilities of given transitions between system interactions. Transitional probability is a conditional probability; events occur at different times and 'lag' is used to express these time differences (Şahin et al., 2020). To test the statistical significance of the transitions, z-scores were calculated, together with a Bonferroni adjustment to determine the z-score threshold. In the Bonferroni adjustment, the α-value is divided by the number of cells in the table, a new α-value is determined, and the equivalent of this value in the two-way critical z-value is calculated. Cells for which the absolute value of the corrected residual is greater than the newly determined critical z-value are interpreted as contributing to significance (Terzi Müftüoglu et al., 2023). A state transition diagram was generated to display the results in the last step. In addition to the overall view, a differential analysis for the three course clusters was conducted to determine whether the course design approach impacted possible high-level patterns.

The second phase of the analysis includes LSA with the 20 system event types on the level of system interactions. First, LSA was carried out separately for the three course clusters based on the underlying course design approach. Second, LSA was carried out separately for different achievement groups within those clusters. Following the openSAP certification guidelines, we focused on a rather broad group of high-achieving learners (over 50% progress and performance, eligible for both CoP and RoA) in the context of this study.

Results

Behavioral Patterns Over All Courses (RQ1)

For the 13 courses in the sample, significant transitions between the four main categories could be traced. Table 2 shows the respective z-scores.

Table 2

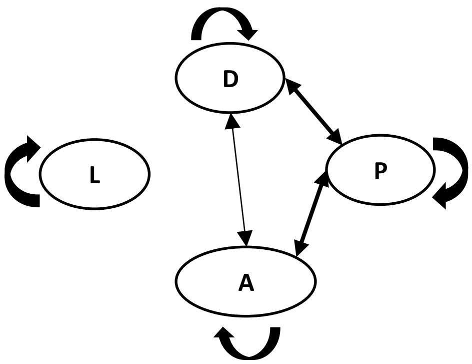
Z-scores Based on Interaction Categories for the Overall Sample

Categories	Announcement	Discussion	Learning	Progress
Announcement	**197.144***	**11.319***	-86.617	**45.578***
Discussion	**8.932***	**460.772***	-310.098	**35.690***
Learning	-101.585	-304.711	**269.246***	-78.470
Progress	**70.902***	**17.189***	-73.601	**60.690***

Note. z-score threshold: 2.96; * statistically significant transitions

The respective state transition diagram for statistically significant transitions is shown in Figure 1.

Figure 1
State Transition Diagram for the Overall Sample



The state transition diagram shows significant transitions between all the main categories except for the learning category. From the perspective of high-level interaction categories, the biggest category regarding captured events is rather isolated. We further analyzed these high-level patterns in a differential approach, looking at the high-level transitions in each course cluster (Table 3).

Table 3
Z-scores Based on Interaction Categories for the Course Clusters

Categories	Announcement	Discussion	Learning	Progress
Discussion-oriented courses				
Announcement	**225.416***	-4.178	-37.202	-2.670
Discussion	-4.251	**436.478***	-362.705	**59.893***
Learning	-48.962	-377.085	**477.399***	-278.262
Progress	-4.523	**68.285***	-306.144	**376.757***
Lecture-oriented courses				
Announcement	**265.408***	**6.900***	-88.170	**65.215***
Discussion	**6.203***	**1004.308***	-806.506	**55.079***
Learning	-108.899	-781.635	**722.747***	-162.965
Progress	**98.560***	**19.281***	-140.481	**167.670***
System interaction-oriented courses				
Announcement	**289.587***	**34.922***	-104.917	**66.849***
Discussion	**23.674***	**1347.325***	-1042.840	**20.147***
Learning	-116.352	-1019.694	**852.753***	-92.554
Progress	**96.786***	-15.873	-68.575	**102.990***

Note. z-score threshold: 2.96; * statistically significant transitions

Besides some obvious differences related to the course design, the central global pattern, i.e., the “isolated” learning category, can still be found in all course clusters. A closer look at these results reveals that learners interact primarily within the learning category (e.g., with learning materials) and then log off, rather than interacting with or in the other main categories, announcement, progress, and discussion.

Interaction Sequences According to Course Design (RQ2)

On the level of granular interactions, there are twenty interaction categories and numerous subsequent transitions. An excerpt of the table of significant transitions for three interaction categories is presented in Table 4. For our explorative analysis, we purposefully selected *Video play* as a typical MOOC-related learning activity, *Assignment submit* as the main activity for demonstrating performance, and *Progress* (i.e., viewing the progress page) as a metacognitive activity for managing the learning process. Detailed information about the whole set of significant transactions for all interaction types can be found in Appendix B.

Table 4

Selected Interaction Level Transactions According to Course Cluster

	Lecture-oriented courses [L]	**System interaction-oriented courses [S]**	**Discussion-oriented courses [D]**
Assignment submit	→ Assignment submit [LSD] → Progress [LSD] → Textual discussion prompt visit [LSD] → Textual download visit [LSD] → Textual instructional visit [LSD] → Survey submit [L] → Video download [L]	→ Assignment submit [LSD] → Progress [LSD] → Textual discussion prompt visit [LSD] → Textual download visit [LSD] → Textual instructional visit [LSD] → Announcement [S]	→ Assignment submit [LSD] → Progress [LSD] → Textual discussion prompt visit [LSD] → Textual download visit [LSD] → Textual instructional visit [LSD] → Video visit [D]
Progress	→ Announcement [LSD] → Assignment submit [LS] → Discussion visit [LS] → Final-exam submit [LSD] → Progress [LSD] → Survey submit [LSD] → Textual discussion prompt visit [LSD] → Textual download visit [LSD] → Textual instructional visit [LSD] → Video download [L]	→ Announcement [LSD] → Assignment submit [LS] → Discussion visit [LS] → Final-exam submit [LSD] → Progress [LSD] → Survey submit [LSD] → Textual discussion prompt visit [LSD] → Textual download visit [LSD] → Textual instructional visit [LSD]	→ Announcement [LSD] → Post reply [D] → Post visit [D] → Final-exam submit [LSD] → Progress [LSD] → Survey submit [LSD] → Textual discussion prompt visit [LSD] → Textual download visit [LSD] → Textual instructional visit [LSD]
Video play	→ Video play [LSD]	→ Video play [LSD]	→ Video play [LSD]

Note. [xxx] indicates significant transitions for all three course clusters; [xx] indicates significant transitions for two course clusters as indicated by the letters in parentheses; [x] indicates significant transitions that only apply to the respective course cluster

The results show several similarities among the significant interactions. Both for *Assignment submit* and *Progress*, there are significant transitions to *Progress* and the textual interaction categories for the three course clusters. For *Progress*, *Announcement* (i.e., viewing the announcement page) and *Final exam submit* are additional joint transitions. For *Video play*, there is only one joint transition, which is the one to the *Video play* category itself. Notable singularities, i.e., significant transactions that only appear in one single course cluster, are as follows: *Assignment submit* to *Video download* for lecture-oriented courses, to *Announcement* and *Progress* for system interaction-oriented courses, and to *Video visit* for discussion-oriented courses, as well as *Progress* to *Video download* for lecture oriented courses and to the discussion categories *Post reply* and *Post visit* in discussion-oriented courses.

Interaction Sequences According to Learner Achievement (RQ3)

In the differential analysis for the three selected interaction types, several significant transitions could be exclusively associated with high-achievement learners (high "progress" and high "performance"). For lecture-oriented courses, *Progress* to *Textual download visit* is a high achiever pattern. For system interaction-oriented courses, *Assignment submit* to *Announcement* is a high achiever pattern. For discussion-oriented courses, high achiever patterns are: *Progress* to *Final exam submit* and *Progress* to *Survey submit*. The metacognitively oriented interactions *Progress* and *Announcement* are part of all these high-achievement patterns, either as starting or following interaction.

Discussion

Findings and Implications

The findings of this study illustrate how learning analytics approaches can be applied to open online courses in professional learning to provide insights for course design and facilitation. We explored typical behavioral patterns in openSAP Enterprise MOOCs and possible variations according to course design approaches on an aggregate level and the granular level of system interactions. Findings indicate that (1) there are consistent patterns and that (2) several distinctive transitions become evident when a differential perspective is adopted concerning the underlying course design. Among the top-level categories, the learning category, which contains the majority of system interactions, remains isolated from the other categories, both from the holistic and a differential perspective, according to course design. This might be due to a clear learner focus on working through the content and towards the assignments, while the announcement, progress, and discussion categories are more likely to be addressed at the beginning or the end of a learning session. Moreover, announcements are also communicated via additional channels (e.g., via email), and the learner's progress is partly visible in the learning area, too. If there is a need to better connect learning activities to collaborative (e.g., discussions) or metacognitive (e.g., announcements or progress visits) activities, it cannot be decided at this level of analysis.

Hence, the following analysis focused on the interaction level and differentiated courses according to the underlying design approach, where common and distinctive patterns could be found. Perhaps most striking is the isolated role of videos for all course clusters. Following the traditional xMOOC-model, one would expect learners to interact with a video and then with a self-test or other content elements (Li et al., 2015; Ou et al., 2019). However, the findings show that learners play videos without subsequent significant transitions afterward, which does not fit the linear way that learning typically is organized in MOOCs (Chew et al., 2017). From a research perspective, a more detailed analysis is needed here. For example, video metrics could be considered (Li et al., 2015; Yoon et al., 2021). Based on this result, a preliminary design recommendation could be directly integrating interactive instructional elements like quizzes into the videos.

Moreover, the distinctive transactions in lecture-oriented courses connecting performance display and metacognition with video downloads seem to represent a rather consumerist pattern that needs to be questioned from a learning science perspective (Ogunyemi et al., 2022; Shah et al., 2022) and considering the discussion of instructional quality (Margaryan et al., 2015). A global design recommendation would be to supplement the classic, sometimes rigid xMOOCs model with (mandatory) additional instructional elements to promote learner engagement.

Looking at the high achiever patterns within the scope of this analysis, the role of metacognitively oriented interactions becomes evident. So, another initial design recommendation could be to foster those interactions by integrating metacognitively oriented elements further into the course structure (Zhu & Bonk, 2019), e.g., by adaptive metacognitive prompts or an advanced progress indicator. To sum up, we can conclude that there are typical behavior patterns in openSAP Enterprise MOOCs that differ according to course design and that it seems feasible to connect those patterns to learner achievement to derive evidence-based design recommendations.

Limitations and Future Research

Subsequent research must substantiate those results, extending the scope across interaction categories and additional achievement groups (e.g., low achievers) to gain more comprehensive insights. Bearing in mind that especially for professional learning, course completion (or attrition) does not account for the diversity of learner enrollment motivations (Moore & Blackmon, 2022; Schwerer & Egloffstein, 2016), alternative achievement groups or engagement patterns (Huang et al., 2023) need to be delineated to develop suitable design recommendations for different learner groups.

Within the scope of this research, LSA was conducted based on system events. In addition, other metrics, such as time spent, could be included (Boroujeni & Dillenbourg, 2019), allowing for the discovery of more in-depth patterns and a deeper understanding of the learning process (Ifenthaler et al., 2018; Knight et al., 2017). Despite bringing in various learner data from different course design approaches, our research was limited to only one platform. When platform capabilities strongly influence what is done pedagogically (Blackmon & Major, 2017), it seems rather obvious that platform capabilities also limit the scope of possible learner interactions. Therefore, expanding our research on different providers and platforms for MOOCs for professional learning would be desirable. Methodologically, this would imply a generalization of the current operationalization beyond the context under consideration, with possible changes towards more generic interaction categories.

Finally, our analysis was based on the underlying assumption that learner behavior reflects cognitive and affective learner engagement, and that learner engagement leads to learning success. While this is a common assumption in research on self-directed online learning scenarios, our findings suggest that a deeper analysis of activities and interactions may be needed to understand the learning processes in enterprise MOOCs better. Following Martin & Borup (2022) and Kimmons et al. (2020), behavioral engagement with technology can be either passive (i.e., using technology to receive information), interactive (i.e., learning activities that require learners' active involvement), or creative (i.e., using technology to create an artifact, commonly to demonstrate an understanding of the course content). The influence of these different behavioral categories on achievement in different course design formats needs to be further researched to derive substantial design recommendations. Likewise, it is important to note that there is more to learner engagement than observable interactions. In our analysis, we mainly focused on learner-content and learner-interface interactions. Other themes for research on environmental affordances for online learner engagement include presence, community, collaboration, and communication (Martin & Borup, 2022). In summary, we hope that the further development of our approach will provide deeper insights into (successful) online learning behavior in enterprise MOOCs and offer starting points for advancing these learning environments.

Declarations

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Correspondence concerning this article should be addressed to Marc Egloffstein, University of Mannheim, L4, 1, 68161 Mannheim, Germany. Email: egloffstein@uni-mannheim.de

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Appendix A

Courses Included in the Study

#	Course code[1]	Course title
1	xm1	The Power of Experience Management
2	leo2	SAP Leonardo IoT for the Intelligent Enterprise
3	sbw1	Enabling Entrepreneurs to Shape a Better World
4	build1	Design Your First App with Build
5	ieux1	Intelligent Enterprise User Experience with SAP Fiori 3
6	java1	Object-Oriented Programming in Java
7	mobile3	Build Mobile Applications with SAP Cloud Platform Mobile Services
8	s4h15	Key Functional Topics in a System Conversion to SAP S/4HANA
9	sps2	Introduction to SAP Screen Personas
10	sps3	Using SAP Screen Personas for Advanced Scenarios
11	cwr1-1	Copywriting: Improve User Experience One Word at a Time (Repeat)
12	dafie1	Design-Led Approach for the Intelligent Enterprise
13	pa1-tl	People Analytics and Evidence-Based Management

Note. [1] The courses can be accessed via: https://open.sap.com/courses/<*course_code*>

Appendix B

Interaction Level Transactions According to Course Cluster

	Lecture-oriented courses	System interaction-oriented courses	Discussion-oriented courses
Announcement	→ Announcement → Discussion visit → Progress → Survey submit → Textual discussion prompt visit → Textual instructional visit	→ Announcement → Assignment submit → Discussion visit → Post subscribe → Progress → Textual discussion prompt visit → Textual hands on visit → Textual instructional visit	→ Announcement → Discussion visit → Final exam submit → Progress → Textual instructional visit
Assignment submit	→ Assignment submit → Progress → Survey submit → Textual discussion prompt visit → Textual download visit → Textual instructional visit → Video download	→ Announcement → Assignment submit → Progress → Textual discussion prompt visit → Textual download visit → Textual instructional visit	→ Assignment submit → Progress → Textual discussion prompt visit → Textual download visit → Textual instructional visit → Video visit
Audio download	→ Audio download → Presentation download → Video visit	→ Audio download → Presentation download → Video download → Video visit	→ Audio download → Presentation download → Video download
Discussion visit	→ Announcement → Discussion visit → Post create → Post visit → Progress → Textual discussion prompt visit → Textual instruction visit	→ Announcement → Discussion visit → Post create → Post reply → Post subscribe → Post visit → Progress → Textual discussion prompt visit → Textual instructional visit	→ Announcement → Discussion visit → Post create → Post visit → Progress
Final-exam submit	→ Final-exam submit → Progress → Survey submit	→ Final-exam submit → Progress → Survey submit	→ Final-exam submit → Progress → Survey submit

	→ Textual instructional visit → Textual discussion prompt visit	→ Textual discussion prompt visit → Textual instructional visit	→ Textual instructional visit → Textual discussion prompt visit
Post comment	→ Post comment → Post visit	→ Post comment → Post subscribe → Post visit	→ Audio download → Post comment → Post visit → Presentation download → Video download
Post create	→ Discussion visit → Post create → Post visit	→ Discussion visit → Post create → Post subscribe → Post visit	→ Discussion visit → Post comment → Post create
Post reply	→ Post reply → Post visit	→ Discussion visit → Post reply → Post subscribe → Post visit	→ Audio download → Post comment → Post create → Post reply → Post visit → Presentation download → Video download
Post visit	→ Announcement → Discussion visit → Post comment → Post create → Post reply → Post visit → Progress	→ Announcement → Discussion visit → Post comment → Post create → Post reply → Post subscribe → Post visit	→ Announcement → Discussion visit → Post comment → Post create → Post reply → Post visit
Presentation download	→ Audio download → Presentation download → Video download → Video visit	→ Announcement → Audio download → Presentation download → Textual discussion prompt visit → Textual hands on visit → Video download → Video visit	→ Presentation download → Self-test submit
Progress	→ Announcement → Assignment submit → Discussion visit → Final-exam submit → Progress → Survey submit	→ Announcement → Assignment submit → Discussion visit → Final-exam submit → Progress → Survey submit	→ Announcement → Final-exam submit → Post reply → Post visit → Progress → Survey submit → Textual discussion prompt visit

	→ Textual discussion prompt visit → Textual download visit → Textual instructional visit → Video download	→ Textual discussion prompt visit → Textual download visit → Textual instructional visit	→ Textual download visit → Textual instructional visit
Self-test submit	→ Self-test submit → Video visit	→ Self-test submit → Video visit	→ Self-test submit → Video visit
Survey submit	→ Announcement → Assignment submit → Final-exam submit → Progress → Survey submit → Textual discussion prompt visit	→ Final-exam submit → Progress → Survey submit → Textual instructional visit → Video visit	→ Final-exam submit → Progress → Survey submit → Textual discussion prompt visit → Textual download visit
Textual discussion prompt visit	→ Announcement → Discussion visit → Progress → Textual discussion prompt visit → Textual instructional visit → Textual download visit	→ Announcement → Assignment submit → Discussion visit → Presentation download → Progress → Survey submit → Textual discussion prompt visit → Textual hands on visit → Textual instructional visit	→ Discussion visit → Final exam submit → Self-test submit → Survey submit → Textual discussion prompt visit → Textual download visit → Textual instructional visit → Video visit
Textual download visit	→ Assignment submit → Progress → Textual download visit → Textual instructional visit → Video download	→ Assignment submit → Progress → Survey submit → Textual discussion prompt visit → Textual download visit → Textual instructional visit	→ Assignment submit → Discussion visit → Progress → Survey submit → Textual discussion prompt visit → Textual download visit → Textual instructional visit
Textual hands on visit	→ N/A	→ Announcement → Discussion visit → Textual discussion prompt visit → Textual hands on visit	→ N/A

		→ Textual instruction visit	
Textual instructional visit	→ Announcement → Assignment submit → Final exam submit → Progress → Textual download visit → Textual instructional visit → Video visit	→ Announcement → Assignment submit → Final exam submit → Survey submit → Textual discussion prompt visit → Textual download visit → Textual instructional visit → Video visit	→ Final-exam submit → Textual discussion prompt visit → Textual download visit → Textual instructional visit → Video visit
Video download	→ Audio download → Presentation download → Survey submit → Textual download visit → Video download → Video visit	→ Audio download → Post subscribe → Presentation download → Progress → Video download	→ Audio download → Presentation download → Video download
Video play	→ Video play	→ Video play	→ Video play
Video visit	→ Audio download → Presentation download → Video download → Video play → Video visit	→ Audio download → Presentation download → Video download → Video play → Video visit	→ Self-test submit → Textual discussion prompt visit → Textual instructional visit → Video download → Video visit