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Requirements for Learning Analytics in Flipped Learning

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Abstract: Learning analytics needs to collect and use data originated from various learning environments and analyze them to help learners, instructors, and institutions achieve the goal to improve learning and teaching. The selection of data to be collected and analyzed depends on the requirements of the learning analytics. The requirements in turn are typically derived from use cases of learning activities in the learning model. Most use cases for learning analytics, however, are based on traditional learning methods and thus do not reflect new types of learning methods such as flipped learning. In this paper, we present new use cases and requirements derived from the new pedagogical models and propose a standardization area to encompass new pedagogical models.

Keywords: Learning Analytics, Flipped Learning, Pedagogical Model

1. Introduction

Flipped Learning is a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter (Flipped Learning Network, 2014). Flipped learning has the advantage of being able to concentrate more on leading the students' learning and reducing the dropout rate of the students (EDUCAUSE, 2012). Furthermore, flipped learning utilizes a variety of multimedia equipment and systems to effectively communicate learning materials and support learning in the classroom, and has environmental characteristics suitable for producing and analyzing learning activity information.

Based on our previous design and implementation of a reference model for learning analytics (Choi, Cho & Lee, 2014; Bae, Cho & Lee, 2015; Choi, You & Lee, 2016; ISO/IEC TR 20748-1:2016), recently we carried out a project to conducts a pilot application of learning analytics in the flipped learning classroom. In this project, we designed two pedagogical models on the basis of the flipped learning model and found intrinsic limitations of existing data models for learning analytics. In this paper, we present new use cases and requirements derived from the new pedagogical models and propose a standardization area to encompass new pedagogical models.

2. Pedagogical Model For Flipped Learning

The flipped learning model is a pedagogical model for improving the learning effect by expanding the participation and autonomy of the learners. Flipped learning as a type of blended learning reverses the traditional learning environment by delivering instructional content before class and moves learning activities, including homework in the traditional learning, into the classroom. In this paper we present a participatory learning process performed as a group activity. The learning process consists of,

1. *Pre-Learning* step where the scope of the content are defined and contents are delivered to students so that students are familiarized with new material before class;

2. *Pre-Class* step where students are motivated to prepare before class by asking students to respond to open-ended questions or attempt to solve some problems, taking into consideration of the characteristics of the students;
3. *In-Class* step where students participate in collaborative group activities and engage in active learning to deepen understanding; and
4. *Post-Class* step where evaluation and assessment occurs to extend student learning and to assess student understanding and mastery by reflecting on the design of the course.

In the following subsections, we describe two pedagogical models from which to derive new use cases of learning analytics by identifying the required functions in the model. We assume that a dedicated LMS-based platform is available to support the application of learning models.

2.1. Co-Authoring Model

Co-authoring model is a discussion-based learning model that combines problem-solving learning, collaborative learning model, and the jigsaw model with flipped learning, and concentrates learning tools on the discussion. Problem-solving learning is a teaching model that solves problems through experiential learning experiences, focusing on the process of reaching rather than the outcome itself. In cooperative learning model, a small group of diverse students are set up to form common goals, to help each other and share responsibility to achieve the goals. In the Jigsaw Classroom (The Jigsaw Classroom 2017), as the name suggest, each member of a small group is responsible for a part of the task and is organized to achieve the goal of the whole small group so that everyone can actively interact without any participant being isolated. The goal is to collectively realize intellectual cooperative learning for problem solving and to exploit the effect of collaborative learning through collaborative authoring in conjunction with learning analytics. The learning process of co-authoring model is summarized in Figure 1.

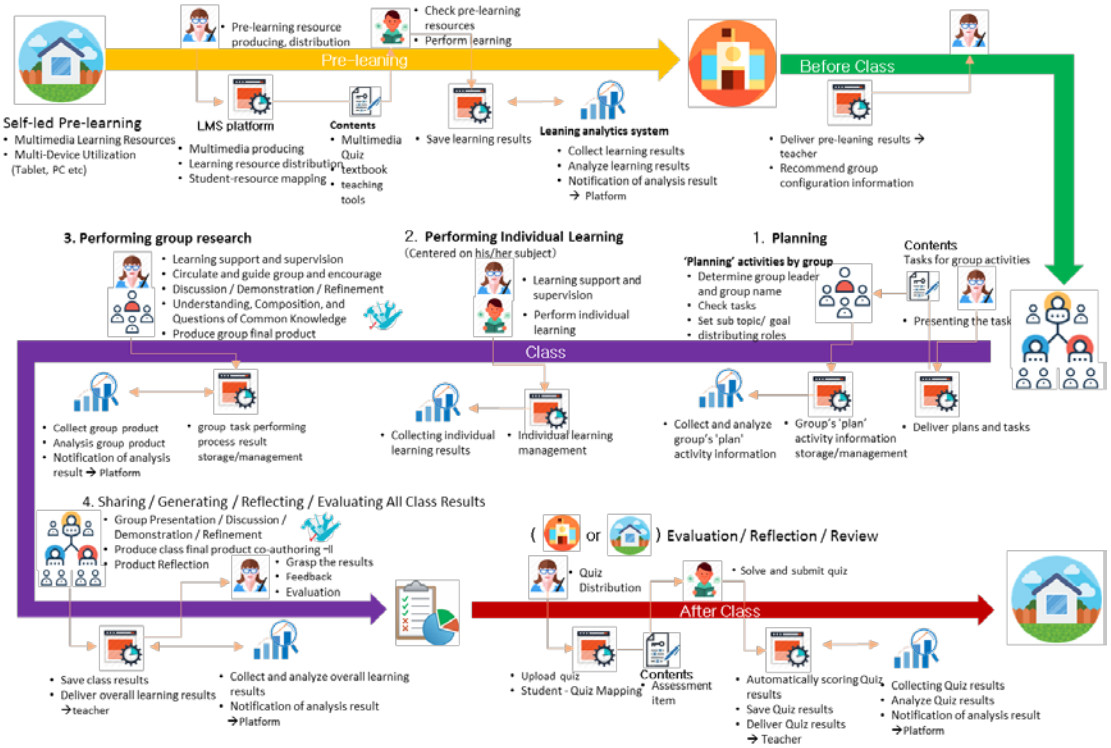

Figure 1. Flow Chart of Co-Authoring Model

2.1.1. Pre-Learning

Pre-learning involves the process of distributing and performing prior learning materials, and analyzing results and analyzing related activities. In pre-learning, the teacher writes and distributes pre-learning resources with the support of a dedicated platform, and the student connects to the platform and conducts learning. The results are stored on the platform again and transferred to the analysis system, which analyzes the information about the performance and the performance of the learning.

Table 1: Pre-Learning Activities

Actor	Activity
Teacher	○ Pre-learning resource producing and distribution
Student	○ Check pre-learning resources ○ Perform learning
Platform	○ Multimedia producing function ○ Learning resource distribution function ○ Learning - resource mapping function ○ Save learning results
Analytics Prediction	○ Collect and analyze learning results ○ Notification of analysis result to the platform
Content	○ Multi media ○ Quiz ○ Textbook ○ Teaching tools

2.1.2. Pre-Class

In the Pre-Class step, a process of constructing a heterogeneous small group is performed based on the pre-learning result. In this step, the platform may recommend group formation to the teacher along with the pre-learning result. In this way, teachers can organize learners into small groups considering various factors such as personality and preference.

Table 2: Pre-Class Activities

Actor	Activity
Teacher	○ Identify the results of a small group consisting of 4 to 6 people - It is possible to reconstruct a small group considering not only learning ability but also personality and preference of learners.
Platform	○ Deliver pre-learning results to the teacher ○ Recommend group formation

2.1.3. In-Class

The In-Class consists of planning, individual learning, and group exploration. In each process, the teacher utilizes the functions of the dedicated platform to perform tasks, provide learning support, and feedback, and the student connects to the platform and conducts learning. The results of each process are collected by the analysis system through the platform, and the analysis system analyzes this information and applies it to the subsequent learning process.

2.1.3.1. Planning

The Planning step is the process of preparing the task from the teacher's task assignment and preparing the goal setting and role sharing to solve each task. Teachers communicate tasks through a dedicated platform, and groups use platforms to identify tasks, set goals, and perform role sharing. The 'Plan' activities performed by each group are stored on the platform and delivered to the analysis system.

Table 3: Planning Activities

Actor	Activity
Teacher	○ Present the task
Student	○ 'Planning' activities by group - Determine group leader and group name - Check tasks - Set sub topic/ goal - distributing roles
Platform	○ Deliver plans and tasks ○ Group's 'plan' activity information storage/management
Analytics Prediction	○ Collect and analyze group's 'plan' activity information
Content	○ Task for group activity

2.1.3.2. Individual Learning

In the Individual Learning step, individual learning takes place under the supervision and support of the teacher. Teachers can support students' individual learning process through a dedicated platform, and students perform individual learning based on their own topics. The platform stores the student's individual learning results and delivers them to the analysis system, which collects the results.

Table 4: Activities of Individual Learning

Actor	Activity
Teacher	○ Learning support and supervision
Student	○ Perform individual learning
Platform	○ Individual learning management
Analytics Prediction	○ Collecting individual learning results

2.1.3.3. Group Research

In the Group Research step, the co-authoring of the final result is carried out through discussion of the students in each group under the supervision of the teacher. In group research, the teacher performs group supervision and support, circulates the group, and conducts guidance and encouragement. Group compose and understand common knowledge through discussion, and as a result of these discussions, the final result is produced. The platform saves the task execution process and results of the division and sends it to the analysis system. The analysis system analyzes it and applies it to the subsequent learning process.

Table 5: Activities of Group Research

Actor	Activity
Teacher	○ Learning support and supervision ○ Circulate and guide group and encourage
Student	○ Discussion / Demonstration / Refinement ○ Understanding, Composition, and Questions of Common Knowledge

	○ Produce group final product
Platform	○ group task performing process result storage/management
Analytics Prediction	○ Collect group product ○ Analysis group product ○ Notification of analysis result to Platform

2.1.3.4. Sharing, Generation, Reflection, and Evaluation

In the Sharing, Generation, Reflection, and Evaluation step, a series of processes from presentation and discussion of results by group, to analysis of activities related to generating and evaluating the overall class results are performed. Teachers use the platform to understand the results of each class and provide feedback and evaluation. All students also use the platform to produce the final results of the entire class through group presentations and discussions. The learning results of all students are collected by the analysis system through the platform and used in the subsequent learning process.

Table 6: Activities of Sharing, Generation, Reflection, and Evaluation

Actor	Activity
Teacher	○ Grasp the results ○ Feedback ○ Evaluation
All student	○ Group Presentation / Discussion / Demonstration / Refinement ○ Produce class final product co-authoring ○ Product Reflection
Platform	○ Save class results ○ Deliver overall learning results to Teacher
Analytics Prediction	○ Collect overall learning results ○ Analyze overall learning results ○ Notification of analysis result to Platform

2.1.4. Post-Class

In the Post-Class, the activity of evaluating, reflecting, and reviewing of the learning result and analyzing related information is performed. The teacher distributes the quiz through a dedicated platform, and the student uses the platform to perform quizzes and submissions. The platform stores the quiz results and delivers them to the analysis system. The analysis system collects and analyzes the quiz results and applies them to the subsequent learning process.

Table 7: Post-Class Activities

Actor	Activity
Teacher	○ Quiz distribution
Student	○ Upload Quiz
Platform	○ Student - Quiz Mapping ○ Student - Quiz Mapping ○ Automatically scoring Quiz results ○ Save Quiz results ○ Deliver Quiz results to Teacher
Analytics Prediction	○ Collecting Quiz results ○ Analyze Quiz results ○ Notification of analysis result to Platform

2.2. *Mutual Teaching Model*

The mutual teaching model, a kind of peer-to-peer learning model, combines the flipped learning model, STEAM education, and various types of experiential learning. In this model, each member of the group form an expert group with other members assigned with the same learning materials. They become experts in their field by exchanging, researching, and acquiring content about the learning materials they are working on in an expert group to teach their members. Typically learners use multi-device to conduct self-directed learning and refine results through discussion and mutual teaching. Figure 2 shows the overall process of the model.

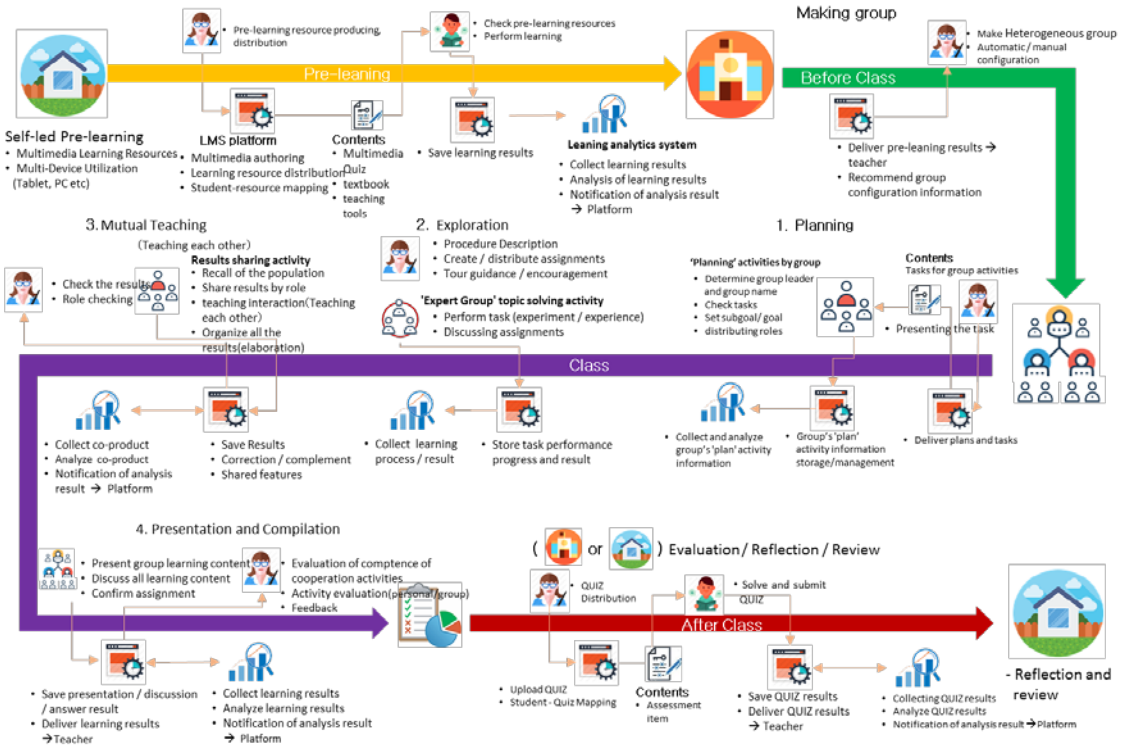

Figure 2. Flow Chart of Mutual Teaching Model

2.2.1. *Pre-Learning*

In the Pre-Learning step, individual diagnosis, learning through multimedia, and analysis of related information are performed. Teachers author and distribute prior learning materials with the help of a dedicated platform, and the student identifies and gain familiarity with prior learning resources through the platform. The results are collected through the platform and delivered to the analysis system, which analyzes it and uses it in the subsequent learning process.

Table 8: Pre-Learning Activities

Actor	Activity
Teacher	○ Pre-learning resource producing and distribution
Student	○ Check pre-learning resources ○ Perform learning
Platform	○ Multimedia producing function ○ Learning resource distribution function ○ Learning - resource mapping function ○ Save learning results
Analytics Prediction	○ Collect and analyze learning results ○ Notification of analysis result to Platform

Content	○ Multi media ○ Quiz ○ Textbook ○ Teaching tools

2.2.2. Pre-Class

In the Pre-Class step, a partial rearrangement may be made based on the pre-learning result information. The teacher receives the pre-learning result through the platform and can make small groups considering various factors such as the learner's personality and preference.

Table 9: Pre-Class Activities

Actor	Activity
Teacher	○ Identify the results of small groups consisting of 4 to 6 people - It is possible to reconstruct a small group considering not only learning ability but also personality and preference of learners.
Platform	○ Deliver pre-learning results to Teacher ○ Recommend Group configuration information

2.2.3. In-Class

The In-Class step consists of planning, exploration, mutual teaching, presentation and compilation. In each stage, the teacher presents tasks, explains the procedure, confirms the results, and provides feedback. Students perform learning through the platform. The platform collects related information and sends it to the analysis system. The analysis system analyzes it and uses it for later learning.

2.2.3.1. Planning

In the Planning stage, the process of preparing the goal setting and the role allocation to solve the task presented by the teacher is performed. Teachers deliver tasks through a dedicated platform, and groups use platforms to identify tasks, set goals, and perform role sharing. The 'plan' activities performed by each group are stored on the platform and delivered to the analysis system.

Table 10: Planning Activities

Actor	Activity
Teacher	○ Present the task
Student	○ ‘Planning’ activities by group - Determine group leader and group name - Check tasks - Set sub topic/ goal - distributing roles
Platform	○ Deliver plans and tasks ○ Group’s 'plan’ activity information storage/management
Analytics Prediction	○ Collect and analyze group’s 'plan' activity information
Content	○ Task for group activity

2.2.3.2. Exploration

In the Exploration stage, a series of processes of organizing an expert group to perform tasks and collecting related information are performed. The teacher performs procedure description, assignment production and dissemination through a dedicated platform, and constructs expert group according to the role of each group to carry out the task. The platform collects information related to this process and delivers it to the analysis system.

Table 11: Exploration Activities

Actor	Activity
Teacher	○ Procedure Description ○ Create / distribute assignments ○ Circulate and guide group and encourage
Expert Group	○ 'Expert Group' topic solving activity ○ Perform task (experiment / experience) ○ Discussing assignments
Platform	○ Store task performance progress and result
Analytics Prediction	○ Collect learning process / result

2.2.3.3. Mutual Teaching

In the Mutual Teaching stage, the teacher confirms the results through the platform, and the students share the results of the inquiry stage and conduct mutual teaching. The results are stored on the platform and sent to the analysis system, which uses it for further learning and applies them to the subsequent learning process.

Table 12: Activities of Mutual Teaching

Actor	Activity
Teacher	○ Check the results ○ Role checking
Student	○ Reassemble of the leaners ○ Share results by role ○ Mutual Teaching (Teaching each other) ○ Collect all the results (Elaboration)
Platform	○ Save Results ○ Correction / complement ○ Shared features
Analytics Prediction	○ Collect co-product ○ Analyze co-product ○ Notification of analysis result to Platform

2.2.3.4. Presentation and Compilation

In the Presentation and Compilation step, each group presents learning contents, evaluates activities and compiles the learning results. Teachers evaluate competence of cooperation activities with the aid of a dedicated platform. All students use platform to discuss the contents assigned to each group and the whole. The platform stores information related to this process and sends it to the analysis system, which uses it for later learning results and applies them to the subsequent learning process.

Table 13: Activities of Presentation and Compilation

Actor	Activity
Teacher	○ Evaluation of capability of cooperation activities ○ Activity evaluation(personal/group) ○ Feedback
Student	○ Present group learning content ○ Discuss all learning content ○ Confirm assignment
Platform	○ Save presentation / discussion / answer result ○ Deliver learning results to Teacher
Analytics Prediction	○ Collect overall learning results ○ Analyze overall learning results ○ Notification of analysis result to Platform

2.3. Post-Class

In the Post-Class, the activities of evaluating, reflecting, and reviewing of the learning result and analyzing related information are performed. The teacher distributes the quiz through a dedicated platform, and the student uses the platform to perform quizzes and submissions. The platform stores the quiz results and delivers them to the analysis system. The analysis system collects and analyzes the quiz results and applies them to the subsequent learning process.

Table 14: Post-Class Activities

Actor	Activity
Teacher	○ Quiz distribution
Student	○ Upload Quiz
Platform	○ Student - Quiz Mapping ○ Student - Quiz Mapping ○ Automatically scoring Quiz results ○ Save Quiz results ○ Deliver Quiz results to Teacher
Analytics Prediction	○ Collecting Quiz results ○ Analyze Quiz results ○ Notification of analysis result to Platform

3. Requirements for Learning Analytics

In Section 2, we presented pedagogical models to improve pedagogical effectiveness through group learning within the flipped learning educational environment. In these pedagogical models, various requirements for collecting and analyzing information through learning and analytics system are presented. In the course of designing the data model for actual implementation, however, we found some aspects of model that cannot be described by existing standards such as IMS Caliper Analytics (IMS GLOBAL Learning Consortium) or xAPI (Advanced Distributed Learning 2016). In this section, we identify the limitations of current standards and suggest directions for future standards.

3.1. Group Dynamics

In the traditional learning models, the groups for collaborative learning are static in that members of a group are fixed and the groups persist throughout the learning process. However, in the aforementioned pedagogical model, a student can join more than one group at the same time and a new group can be created dynamically during the learning process. Explicit specification of groups

and memberships is thus necessary in order to represent learning events associated with groups as well as members of the group.

3.2. Roles in a Group

One of the notable features of flipped learning is that the role and membership of an individual in a group can change over time. The change itself is an event to be monitored and recorded for effective learning analytics. The history of changes also play a part of the learning analytics. Upfront specification of the changes of the role and the membership in one or more groups is thus desired for analysis of the tendency of students and the dynamics of the group.

3.3. Collaborative Work

Student evaluation and feedback are fundamental and intrinsic aspects of learning analytics. In the collaborative pedagogical model as mentioned in Section 2, each group member may move to the expert group and work on group tasks as well as individual assignments. Current standards such as IMS Caliper Analytics focus only on individual or group activities, while the new models require individual evaluation over multiple groups or evaluation of multiple authors of a collaborative work in a group. Such evaluation is possible with clear specification of the relations among a group, members, and collaborative work. Consequently the events generated from the collaborative work need to specify these contextual information.

3.4. Group as an Actor

For several learning activities in flipped learning model, the actor of the activities are best described by a group instead of a specific person. In the case of a group assignment, it may be described as a single submission by all the members of the group, but this would involve unnecessary repeated submission and transmission of events, which in turn can cause burden to the analysis process. If a group can be treated as an actor like a juridical person, the overhead caused by the repetition can be reduced and analysis can take advantage of agreed semantics about the group instead of inferencing from the raw data.

4. Conclusion

In this paper, we described two pedagogical models from which to derive new use cases of learning analytics in flipped learning by identifying the learning activities in the model. The derived uses cases are then examined to identify new requirements for learning analytics in flipped learning along with limitations of the existing standards such IMS Caliper Analytics. The key requirements come from the existence of a dynamic group that should be treated as a virtual actor. Future work includes the extended specification of existing standards to fulfill the identified requirements to encompass the proposed pedagogical models in flipped learning.

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