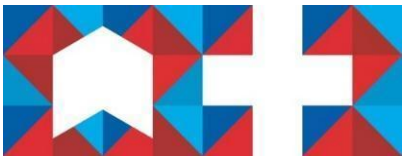

CiC NEXTBOOK

Co-created Interactive Courseware

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Intellectual Output 2: Learning Analytics for Interactive Courseware and Co-creation

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1. Background and focus

Learning Analytics (LA) is an emerging educational technology that can strengthen technological solutions for interactive courseware and co-creation. Long & Siemens have introduced the most popular definition of Learning Analytics: "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" [Long & Siemens, p. 1]. In general, Learning Analytics aims for the collection and analysis of data from students and their context and for using this data to improve learning. In this output we focus on Learning Analytics to improve learning and teaching in the context of interactive courseware and co-creation.

Learning Analytics Dashboards (LAD) provide a visual display of the core information obtained from Learning Analytics [Verbert et al. 2013 and 2014]. They are designed such that they provide the user with a summarizing visual overview of the information most relevant to them. The goal of LADs is to bring the Learning Analytics to the user to trigger insight, reflection, and in the end positively impact the learning or teaching process [Verbert et al. 2013].

Interactive courseware refers to course material that is augmented with interactive elements that allow users to interact with the course material (e.g. highlighting, commenting, editing, liking) or with other users in the context of social learning (e.g. discussing, asking questions). Adams stated "With properly designed interactive training applications, employees can learn a lot more, learn it more quickly, and remember it longer than through any other form of training.", highlighting the potential of interactive learning or training material for supporting the learning/teaching/training process [Adams, 1992] .

Co-creation is the process of collaboratively developing new value with different stakeholders. In education, the value that is being developed in co-creation will depend on the particular educational setting, learning context, task, .. Possible examples are co-creation of a curriculum, co-creation of a handbook, co-creation of the teaching strategy, co-creation of a project outcome (design, product, software, etc.) co-creation of an interaction moment. The stakeholders in the educational setting are mainly students and teachers, but could also involve experts, researchers, parents, lay-man, etc.

The focus of this document is to describe the potential for Learning Analytics, and Learning Analytics Dashboards in particular, in the process of using interactive courseware or co-creation where a technological platform is used.

2. Data available for Learning Analytics

This section discusses the data that is available for Learning Analytics. First, an important nuance regarding the interpretation of a digital trace as a learning trace is provided. Second, a general overview of the type of data available for Learning Analytics is provided, followed by an overview of the digital traces available in the Nextbook platform used in the project. Finally, we use the "data recommendations" from the STELA Erasmus+ project [Van Staalduinen et al, 2018b] to reflect on which data would be useful in the context of Learning Analytics for interactive courseware and co-creation.

2.1. Digital traces vs Learning Traces

If co-creation happens on a technological platform, learning and teaching activities could lead to digital learning traces. In the former sentence, the "could" is essential. There are in fact a couple of challenges to capture digital learning traces:

- **The learning activity does not lead to a "digital" activity.** Even when learning material is presented on a digital platform, students or teachers do not necessarily interact with the digital platform while learning or teaching. Students might for instance print the course material and study it from the printed version. Teachers can teach without the use of the digital platform and for instance rely on the chalkboard in the classroom.
- **The digital activity is not captured in a digital learning trace.** Even when a digital activity is done it might still not be captured or stored as a digital learning trace. A student might for instance be reading from the screen, but if the student is not using a digital highlighting tool or if we do not have additional sensors that can for instance track the eye-movements of the students, the reading will not be captured. Additionally, digital platforms might not have been equipped (deliberately or not) with trackers. A video streaming platform might for instance decide only to track if a student accessed a video or not, but not how often or how long the video was watched.

Vice-versa one should be careful when interpreting the digital learning traces as learning activity:

- **The digital trace does not ensure a learning activity.** Let's take the example of students downloading a course document from the virtual learning environment. The download itself will not guarantee that the student actually read and processed the information in that document.
- **The digital traces are misleading.** It is possible to track if students have a document open on their screens. However, having the document open does not ensure that the student is actually reading it.
- **"Gaming the system".** A behaviour further complicating the interpretation of digital learning traces as learning activity, which is in fact strengthened by using Learning Analytics, is "gaming the system". Behaviour named as "gaming the system" concerns the process where students/teachers "fake" digital learning traces because they know that these will be interpreted as learning activity. This is done to mislead themselves or others.

2.2. What digital traces are typically used in Learning Analytics

Different types of digital traces can be used for learning analytics (see also Nistor & Hernández-Garcíac, 2018 and Staalduinen et al, 2018b). Below we focus on the types potentially relevant for developing Learning Analytics and Learning Dashboards around interactive courseware and co-creation.

Digital Traces from Learning Management Systems (LMS) or Virtual Learning Environments (VLE)

Student and staff activity in LMS's or VLE's lead to digital traces that are often captured in log files. These log files provide a detailed but often unstructured overview of the activities performed and still require processing, summarizing, and interpretation before they can be used as a source of learning traces for Learning Analytics and Learning Dashboards.

Remark that digital traces can concern the current cohort (students and staff), but also previous cohorts (e.g. digital traces of a cohort of students in the previous academic year).

Other log data from digital platforms (library, dedicated platforms, video service)

VLE's are often supplemented with dedicated digital learning solutions such as a link to the online library, a video service, fora, social annotation platforms. These digital platforms can also provide digital traces, which often have the potential to decrease the gap between the digital trace and the interpretation as a learning trace. An obvious challenge is that data from students' learning is scattered in different platforms. Thanks to standards such as Learning Tools Interoperability (LTI), exchange of data between the VLE and these dedicated platforms can however be realized. LTI specifies how a conversation between the VLE and the other digital tool should be carried out: it specifies a methodology to exchange the data and the set of parameters that has to be communicated. Standards such LTI therefore have the potential to pull the digital traces into a bigger repository, creating one bigger database of digital traces. This comes at the cost of potentially losing some of the specificity of the digital traces in the dedicated digital learning solutions, which can hinder interpretability.

Academic achievement and progress

Traditional data sources of academic achievement (e.g. grades) and progress (e.g. years until graduation) should not be overlooked in Learning Analytics. These data sources are present in any higher education institute, as they are responsible for providing diplomas based on academic achievement and progress of students. These data sources are therefore also of high quality and are more easy to interpret than digital traces from e.g. virtual learning environments. A particular challenge is that this data often resides in a separate silo within the higher education IT architecture.

Background student/staff information

Higher education institutes often have data regarding the background of staff and students. This can concern prior education, the fact the students commutes or not, gender, granted adaptations for learning disability or topsport status , scholarship status, etc. A first challenge, as for the academic achievement and progress, is that data typically resides in separate data silos. A bigger challenge however is related to privacy and ethics. Regarding privacy, these data are often considered as personal data and are therefore subject to the EU-GDPR regulations, which strongly regulate the use of personal data and provide very strict laws regarding for instance profiling. Even if the privacy-legal aspects are handled, using these data for Learning Analytics often results in ethical concerns: do you want to base your analysis on non-changeable characteristics that are beyond the control of a student or staff member? Do you want to use data on e.g. scholarship status in feedback, even if scholarship status contributes to the prediction of student success?

Self-reported data: surveys and micro-interactions

Self-reported data is often overlooked in Learning Analytics. Nevertheless, they can often provide a high-quality data source that can be controlled by the higher education institute. The first possibility is to use surveys of students and/or staff. A type that is often used are the validated questionnaires. These questionnaires are the result of a scientific study and are designed such that they measure particular underlying constructs (e.g. the Motivated Strategies for Learning Questionnaire (MSLQ) measuring learning strategies and motivation). But also non-validated questionnaires can provide a valuable data source. One example are the student or staff satisfaction questionnaires.

Another way to collect self-reported data, and which can be seen as "mini-questionnaires", is to use micro-interactions. Micro-interactions aim at querying the student or the staff member in a minimally intrusive way by popping up a question (or a very limited set of questions) while they are mainly working on another (digital) task (see Figure below).

Example of a micro-interaction: "This score makes me feel …." [Broos et al. 2018]

Activity within learning dashboards

When data is presented to stakeholders in learning dashboards, the interaction (or non-interaction) of the stakeholders with the dashboards are creating new digital traces. Examples: entering (or not entering) a learning dashboard providing feedback, interacting with particular elements on the learning dashboards, time spent on the learning dashboard, .. Learning dashboards themselves can therefore be used to create new learning traces that can again be used for learning analytics and in learning dashboards.

2.3. Digital traces available in the Nextbook platform

The nextbook platform (for a "sample course" see https://nextbook.io/book/sample-course), creates online interaction with textbooks. It has features for personal and shared annotations and highlighting, reading text out-loud, automatic summaries, questions and answers connected to the textbook, etc. It can therefore be considered as a platform for social annotation and interaction around a textbook.

The nextbook platform offers the following digital traces:

- Entering the platform
- Opening the course on the platform
- Usage of navigation pane or next/previous section buttons
- Highlighting of text
- Placing of personal notes
- Placing of social comment/question
- Answering of comment/question
- Liking of comment/question
- Answering of multiple-choice or open question in handbook
- Interactive videos, 3D models, applets
- Downloading of content
- Reading out loud
- Changing of personal settings (color scheme, typeface)

For each of these digital traces a user and timestamp are available.

2.4. Following up recommendations around data

In the Erasmus+ project STELA (Successful Transition from secondary to higher Education using Learning Analytics) recommendations were made regarding data for Learning Analytics. Below we apply these recommendations to the current CIC Erasmus+ project.

Start with the available data

The project will first of all use the data traces that are available from the nextbook platform. However, the project will focus on making **pedagogical recommendations** on how to use a social interaction platform such as nextbook to teachers. These pedagogical recommendations will also include the idea on how to generate useful digital traces that can subsequently be used in Learning Analytics that will be connected to the platform. In particular, the pedagogical recommendations will focus on the use of interactive features such as discussions or questions and answers connected to the textbook and interactive elements in the textbook, as these elements have to potential to generate digital traces that are directly linked to actual learning, and would therefore act as valuable data for learning analytics.

Look beyond the obvious data

The obvious data in the case of nextbook would be to look at the **digital traces** that are collected from the interactive textbook, as is. In the pedagogical recommendations however (see also previous paragraph), we want to provide tips to stimulate interaction around the course material. From the data-point-of-view, as the goal is to provide useful analytics, the recommendations will highlight interactive features that also produce digital traces.

Additionally, the project will look at **academic achievement and progress data** and connect these to the digital traces. This is because the correlation between the summarizing activity indicators derived from the digital traces in nextbook and academic achievement and progress is seen as a possible way to validate the digital trace as a learning trace: if the summarizing features indicate more learning activity, we would on average also expect a higher learning outcome. This validation step is important, but not necessarily a show-stopper. This connection is important especially if feedback is provided in for instance a Learning Dashboard that aims at stimulating students to be more active in the digital platform, as that would lead to higher achievement. However, even if the connection between the digital traces and academic achievement cannot be shown, data visualization in a Learning Dashboard is still possible, but should be designed with care, to prevent undesired interpretations by the user.

Not all data is usable

One of the goals of the project is to determine if the digital traces in the nextbook platform are usable for Learning Analytics ánd to provide recommendations that can potentially create digital traces that are useful (pedagogical recommendations). These pedagogical recommendations should support the interpretation of the digital traces as learning traces. However, it is still possible that (part of) the digital traces can't be interpreted as learning traces and will therefore not be useful for Learning Analytics and Learning Dashboards.

Keep Learning Analytics in mind when designing learning activities

This recommendation is in the heart of the project. Our aim is to construct pedagogical recommendations that support teachers in designing their learning activities connected to the nextbook platform such that the digital traces can be interpreted as learning traces, and are therefore potentially useful for Learning Analytics.

Learning dashboards themselves create new learning traces

When the stakeholders will be interacting with Learning Dashboards built on data from the nextbook platform, new digital traces will be created. Therefore, these digital traces themselves can be used for further analysis, which is however not part of the project.

3. Pedagogical use cases and Learning Analytics Requirements

This section focuses on different pedagogical use cases for interactive courseware and co-creation and answers three questions related to the Learning Analytics Requirements for the different pedagogical use cases:

1) Who are the users/stakeholders?
2) What are the questions they would like to have answered by Learning Analytics?
3) What are the pedagogical goals of the Learning Analytics Solution?

3.1. Handbook or course text

In this pedagogical use case a handbook or course text, constructed/authored by a course builder is offered through the interactive courseware platform to students. These students are being taught by a teacher, guiding/coaching their learning.

Who are the users/stakeholders?

Students: Students are the target users of the handbook or course text. They are expected to interact with the handbook or course text and use it as the basis of their learning.

Teachers: Teachers are the ones leading/orchestrating/guiding/coaching the learning of students by means of the handbook or course text.

Course builders: Course builders are the ones constructing the course material. In this case they could be the authors of the handbook or course text.

What are the questions they would like to have answered by Learning Analytics?

Students:

- Related to own activity:
  - How is my activity over time?
  - What activities do I spend my time on?
  - How is my activity compared to the expectations of the teacher?
- Related to the activity of others:
  - What are the most read/watched parts of the handbook?
  - What is currently "hot", i.e. what are others working on?
- Related to comparison to others:
  - How does my activity compare to my current peers?
  - How does my activity compare to the activity of past successful peers?
- Related to relation to others:
  - With which peers do I interact and how?
  - Which peers should I interact with?
  - How did I interact with the teacher?

Teachers

- What are students currently working on?
- How is the activity of students spread over time? Which activities do they do when?
- How do students progress in the course?
- On which parts of the handbook/course material do students spend most time/attention?
- Which parts of the course are students struggling with?

- Which students are at risk of dropping out, or are showing very low activity?
- Which students might need additional challenges?
- Which activities in the course are related to the academic achievement of the students in the course?
- How do students interact with each other and with me?

Course builders:

- Which parts of the handbook/course material are interacted with most/least?
- Which parts of the handbook/course material are students struggling with?
- Which parts of the handbook/course material create the most discussion?
- How do students interact with the course?
- Which interactive elements (e.g. end of chapter questions) are too difficult or too easy?
- Which elements of the course trigger interaction among peers or between teachers and peers?

What are the pedagogical goals of the Learning Analytics Solution?

Students:

- Provide students with **feedback** on their activities in the interactive courseware platform.
- Trigger **reflection** of students on their activities in the interactive courseware platform.
- Cause **change in their learning behaviour,** in particular enhance a more effective and efficient interaction with the interactive courseware platform, among peers and between peers and teacher(s).

Teachers:

- Get a **better view** on the activities of students in the class group.
- Trigger **reflection** of how the teaching impacts particular learning behaviour of students in the interactive courseware platform.
- Cause **change in their teaching behaviour,** e.g. by adapting the pace of the teaching, providing extra guidance or support for all students or particular students at-risk, providing extra challenge to all students or particular high-performing students, providing additional triggers for interaction between peers and between peers and teacher(s).

Course builders:

- Get **feedback** on how the course material is actually used.
- Trigger **reflection** on how the provided material impacts the activity of students.
- Cause **adaptations to the course material** by for instance redesigning the course material, clarifying parts of the course, including additional examples, questions for reflection, restructuring the material, building additional triggers for interaction, etc.

3.2. Single flipped-teaching interaction

This pedagogical use focuses on a single flipped-teaching interaction. Flipped teaching is defined as 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" (The Flipped Learning Network, 2014). For the

pedagogical use case of single flipped-teaching interaction, the "flipping" is limited to a single dedicated interaction moment. A teacher provides preparatory material on a digital platform that students are expected to complete before the interactive session.

Who are the users/stakeholders?

Students: Students are the ones that are the target-users of the flipped teaching interaction. They are expected to prepare for the interaction moment using the provided material and are expected to actively take part in the interaction moment.

Teachers: Teachers are the ones that will be leading the interaction during the interaction part of the flipped teaching.

Course builders: Course builders are the ones constructing the material for preparation in the flipped teaching format, and might also have designed the interaction part of the flipped teaching.

What are the questions they would like to have answered by Learning Analytics?

Students:

- Related to own activity:
  - Did I prepare well for the interaction moment?
  - How much time did I spend on the preparation?
  - Which activities did I spend my time on?
  - How is my activity compared to the expectations of the teacher?
  - Is preparing for the session important to be successful in the course?
- Related to the activity of others:
  - Did others prepare for the interaction moment?
  - What are the typical activities others did?
- Related to comparison to others:
  - How does my activity compare to my current peers?
  - How does my activity compare to the activity of past successful peers?
- Related to relation to others:
  - With which peers do I interact and how?

Teachers

- How many students prepared? (percentage of the ones that should have been prepared)
- Which students completed the flipped teaching preparation (and which students did not)?
- How did the students prepare? How much time did they spend? Which activities did they do?
- When did students prepare?
- Where did students spend most time/attention in their preparation?
- Which parts of the preparation are students struggling with? What are their questions?
- How did students interact in the preparation?

Course builders:

- Which parts of the preparation are interacted with most/least?
- Which parts of the preparation are students struggling with?
- Which parts of the preparation creates most discussion?
- How do students interact with the preparation?

- Which elements of the preparation trigger interaction among peers or between teachers and peers?

What are the pedagogical goals of the Learning Analytics Solution?

Students:

- Provide students with **feedback** on their preparation.
- Trigger **reflection** of students on their preparation.
- Cause **change in their learning behaviour,** in particular enhance a better, more efficient or effective preparation possibly supported by interaction with peers and the teacher.

Teachers:

- Get a **better view** on if and how students prepare for the interaction moment.
- Trigger **reflection** on how the preparation could improve or could be stimulated.
- Cause **change in their teaching behaviour,** e.g. by adapting the interaction moment based on the preparation of students or on how to stimulate students to do the preparation, or to provide triggers in the preparation that stimulate interaction between peers.

Course builders:

- Get **feedback** on how the preparatory material is actually used.
- Trigger **reflection** on how the preparatory material is connected to the (non-)activity of students
- Cause **adaptations to the preparatory material** by for instance changing the preparatory material to better fit the knowledge level of students, clarifying parts of the course, including additional examples, questions for reflection, restructuring the material, building triggers in the preparation material that stimulate interaction between peers, etc.

3.3. Entire flipped-teaching design

This pedagogical use focuses on an entire flipped-teaching design flipped-teaching interaction. Flipped teaching is defined as 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" (The Flipped Learning Network, 2014). Compared to the use case of a single flipped-teaching session (previous section) we focus here on the differences and additional aspects connected to the entire flipped-teaching design. We assume that the preparatory material for the flipped teaching is what is provided on the digital platform. The interaction itself could also use the digital platform, but this is optional.

Who are the users/stakeholders?

Students: Students are the end-users. They are expected to prepare for each interaction session using the preparatory material on the digital platform and to actively engage in the interaction moments.

Teachers: Teachers are the ones leading/orchestrating/guiding/coaching the interaction sessions.

Course builders: Course builders are the ones constructing the course material, in this case the preparatory material in particular, but potentially also material for the interaction sessions.

What are the questions they would like to have answered by Learning Analytics?

Students: (on top of the questions of the single interaction session)

- Related to own activity:
  - How did my preparation activities change over time?
- Related to the activity of others:
  - How did the preparation activities of others change over time?
- Related to comparison to others:
  - How do my preparation activities compare to others over time?
  - How do my preparation activities compare to past successful peers over time?
- Related to relation to others:
  - How did my interaction with others change over time?
  - How am I part of the social learning environment?

Teachers: (on top of the questions of the single interaction session)

- How does the preparation of students change over time? (time spent, activities done)
- Which students are at risk of dropping out?
- How did interactions between students and between myself and the students evolve over time? How was the social learning environment built? Was it successful?

Course builders: (on top of the questions of the single interaction session)

- Which preparatory assignments are students struggling with?
- When do students start dropping out and is this related to the material provided?
- Is the material supportive to the building of a social learning environment? How?

What are the pedagogical goals of the Learning Analytics Solution?

Students: (on top of the questions of the single interaction session)

- Provide students with **feedback** on how their preparatory activities develop over time.
- Trigger **reflection** of students on their growth regarding preparatory activities for flipped teaching.
- Cause **change in their learning behaviour,** in particular enhance a continued, effective and efficient preparation for a flipped teaching setup, supported by a social learning environment where the student can interact with peers and with the teacher.

Teachers: (on top of the questions of the single interaction session)

- Get a **better view** on how the interaction with the preparatory material changes over time.
- Trigger **reflection** on how the continued, effective, and efficient preparation could be stimulated.
- Cause **change in their teaching behaviour,** e.g. by adapting how the flipped teaching is organized (what is preparation - what is interaction), the timing of the sessions, how interaction between peers and between peers and teacher(s) is stimulated.

Course builders: (on top of the questions of the single interaction session)

- Get **feedback** on the use of preparatory material over the entire duration of the course.

- Trigger **reflection** on how the preparatory material is connected to the (non-) continued activity of students
- Cause **adaptations to the preparatory material** by for instance changing the preparatory material to stimulate a continued, effective, and efficient preparation of students for the flipped teaching sessions, building triggers in the material that stimulate interaction between peers.

3.4. Q&A session connected to course material

Who are the users/stakeholders?

Students: Students are the target users of course material and are provided with the opportunity to ask questions directly on the course material using a digital platform, rather than asking questions on a separate forum or discussion board, disconnected from the actual course material.

Teachers: Teachers are the ones leading/orchestrating/guiding/coaching the Q&A session based on the questions asked by students.

What are the questions they would like to have answered by Learning Analytics?

Students:

- Related to own activity:
  - Which questions did I ask/answer?
  - How many questions did I ask/answer?
  - Which parts of the course material were most unclear to me?
- Related to the activity of others:
  - Which questions did other students ask/answer?
  - How many questions did others ask/answer?
  - On which parts of the course material are most questions asked?
- Related to comparison to others:
  - How do my (number of) questions compare to other students?
- Related to relation to others:
  - How did my interaction with others change over time?
  - How am I part of the social learning environment?

Teachers

- Which questions did students ask/answer?
- When did students ask/answer these questions?
- How many questions did students ask/answer? (in total and on average)
- Which students asked/answered questions?
- On what parts of the course material are most questions asked?
- What are the “new” questions?
- How do the questions cause interaction between students or between students and teacher?

What are the pedagogical goals of the Learning Analytics Solution?

Students:

- Provide students with **the opportunity to ask questions** and insights on how they ask questions.

- Trigger **reflection** on how they ask questions and if they use the opportunities provided.
- Cause **change in their help-seeking behaviour,** in particular stimulate the timely posing of questions. Cause **change in help-providing behavior**, by answering or adding to another student's question. Support being part of a social learning environment.

Teachers:

- Get a **better view** on the questions students have and which students are asking questions, when and on what material.
- Trigger **reflection** on the help-seeking behaviour of students.
- Cause **change in their teaching behaviour related to stimulating help-seeking and help-providing,** and supporting students if they have questions, and provide additional support for topics that are unclear for students. Help to strengthen the social learning environment.

3.5. Single self-reflection task

This pedagogical use case focuses on a single reflection task, which is a dedicated task provided to a student focusing on generating reflection on a particular topic. This reflection task could be part of a flipped teaching setup (see earlier), but here the focus is on reflection tasks that can be stand-alone and should not be followed by an interaction session as is the case for a flipped teaching task.

Who are the users/stakeholders?

Students: Students are the target users of the reflection task. They are expected to or invited to complete the reflection task.

Teachers: Teachers are the ones leading/orchestrating/guiding/coaching the learning of students and are the ones that made the reflection task part of their teaching approach.

Course builders: The course builders, in this case reflection task builders, are the ones that constructed the reflection tasks.

What are the questions they would like to have answered by Learning Analytics?

Students:

- Related to one's own reflection:
  - Which activities did I do during my reflection?
  - How much time did I spend on the reflection?
  - Which reflection activities did I spend my time on?
  - How is my reflection compared to the expectations of the teacher?
  - Is reflection important to be successful in the course?
  - What is the feedback based on my reflection? (e.g. particular measures that could be derived from the reflection)
- Related to the activity of others:
  - Did others do the reflection?
  - How much time did other students spend on the reflection?
  - How did others do during the reflection? (e.g. particular measures that could be derived from the reflection)
- Related to comparison to others:

- How does my reflection(time, activities, particular measures) compare to my current peers?
- How does my reflection (time, activities, particular measures) compare to past successful peers?

Teachers

- How many students completed the reflection task? (percentage of the ones that should have completed the task)
- Which students completed the reflection tasks (and which students did not)?
- How much time did they spend? Which activities did they do?
- When did students complete the reflection?
- Where did students spend most time/attention during their reflection?
- How did they perform on the reflection tasks?
- Which students are underperforming or overperforming on the reflection tasks?

Course builders:

- Which parts of the reflection are interacted with most?
- Which parts of the reflection are students struggling with?
- How do the reflection measures compare to later success in the course?
- How do the reflection measures compare to the time spent on the reflection task and the activities done in the reflection task?

What are the pedagogical goals of the Learning Analytics Solution?

Students:

- Provide students with **feedback** on their reflection task.
- Trigger **reflection** of students on their reflection task.
- Cause **change in their metacognition,** in particular enhance a better reflection.

Teachers:

- Get a **better view** on if and how students reflect.
- Trigger **reflection** on how reflection with students could be stimulated.
- Cause **change in their coaching behaviour,** e.g. by adapting how they stimulate students in the completion of the reflection tasks.

Course builders:

- Get **feedback** on how the reflection task is used.
- Trigger **reflection** on how the reflection task is used, how they relate to the outcome of students, on how the reflection tasks itself are designed, etc.
- Cause **adaptations to the reflection task itself** by for instance changing the reflection task to better fit the knowledge level of students, provide a better measurement of the reflection measures, etc.

3.6. Repeated self-reflection tasks

This pedagogical use focuses on repeated reflection tasks and are therefore an extension over time of the previous pedagogical use case of a single reflection task. We focus here on the additional aspects connected compared to the single reflection task (previous section).

Who are the users/stakeholders?

Students: Students are the target users of the reflection tasks. They are expected to or invited to complete the reflection tasks.

Teachers: Teachers are the ones leading/orchestrating/guiding/coaching the learning of students and are the ones that made the reflection tasks part of their teaching approach.

Course builders: The course builders, in this case reflection tasks builders, are the ones that constructed the reflection tasks.

What are the questions they would like to have answered by Learning Analytics?

Students: (on top of the questions of the single reflection task)

- Related to own activity:
  - How did my own reflection (reflections completed, time spent, reflection measures) change over time?
- Related to the activity of others:
  - How did the reflection of my peers (reflections completed, time spent, reflection measures) change over time?
- Related to comparison to others:
  - How does my reflection (reflections completed, time spent, reflection measures) compare to others over time?
  - How does my reflection (reflections completed, time spent, reflection measures) compare to past successful peers over time?

Teachers: (on top of the questions of the single reflection task)

- How does the reflection of students change over time? (reflections completed, time spent, reflection measures)
- Which students are at risk of dropping out of the reflection?
- How does the reflection of students relate to academic achievement in the course?

Course builders: (on top of the questions of the single reflection task)

- Which reflections are students struggling with?
- When do students start dropping out of the reflection and is this related to students dropping out of the course itself?

What are the pedagogical goals of the Learning Analytics Solution?

Students: (on top of the questions of the single reflection task)

- Provide students with **feedback** on how their reflection activities develop over time.
- Trigger **reflection** of students on their growth regarding reflection (in particular the reflection measures).
- Cause **change in their metacognitive behaviour,** in particular enhance a continued, effective and efficient reflection.

Teachers: (on top of the questions of the single reflection task)

- Get a **better view** on how the reflection of students changes over time.
- Trigger **reflection** on how the continued, effective, and efficient reflection could be stimulated.
- Cause **change in their coaching behaviour,** e.g. by adapting how to stimulate and support students in their reflection.

Course builders: (on top of the questions of the single reflection task)

- Get **feedback** on the use of the reflection tasks for the entire duration of the course.
- Trigger **reflection** on how the reflection tasks are connected to the (non-) continued activity of students
- Cause **adaptations to the reflection tasks itself** by for instance, changing the reflection material to stimulate a continued, effective, and efficient metacognition of students.

4. Learning Dashboard Solutions

This section focuses on how learning dashboards can provide answers to the questions that the stakeholders would like to have answered and help to realize the pedagogical goals for the different pedagogical use cases. The stakeholders identified from the pedagogical use cases are students, teachers, and course-builders.

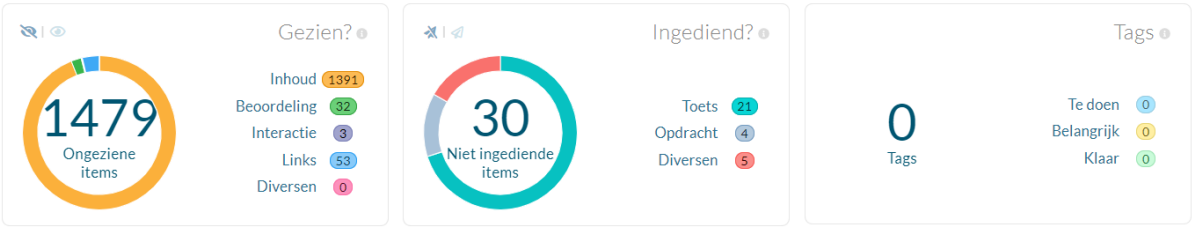
4.1. Student-facing dashboards

Student-facing dashboards are Learning Dashboards where students are the primary users. Below the different components of a student-facing dashboard for a dashboard for interactive courseware are elaborated.

Progress

A "progress" component would show how the student progressed in the course material provided. An example of a visualization is shown below.

Visualization showing the overall progress of a student

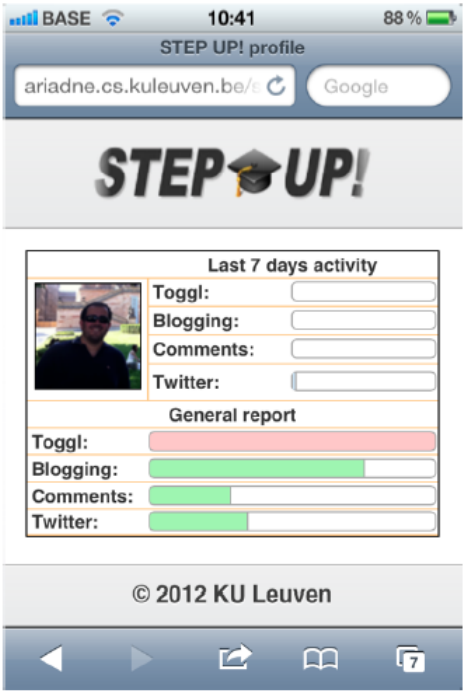


Visualization showing progress regarding items seen on a learning platform (left), assignments submitted (middle), and tags placed (right). Obtained from the Toledo Virtual Learning Platform (black-board based) of KU Leuven.

Dashboard showing the progress in a semester plan in an English course.

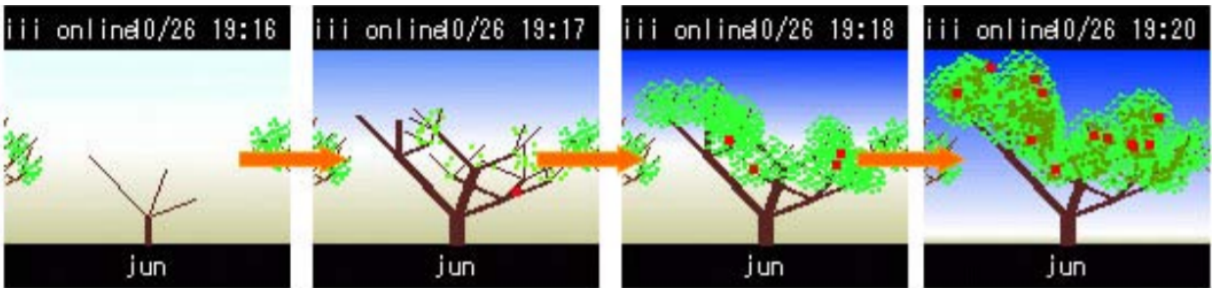
Individual activity

An "individual activity" component provides insight in the activity that a student has been doing. The bar chart below is an example of a visualization showing which activities have been done in a specific time period.



StepUp! dashboard providing an overview of the activity of a student in the last week and in the course overall, categorized over different activities [Santos et al, 2012]

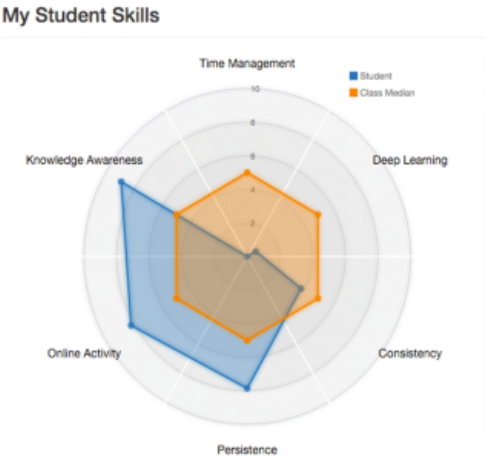
The evolution of the activity over time is another useful addition, as shown in the example visualization in the graph below.

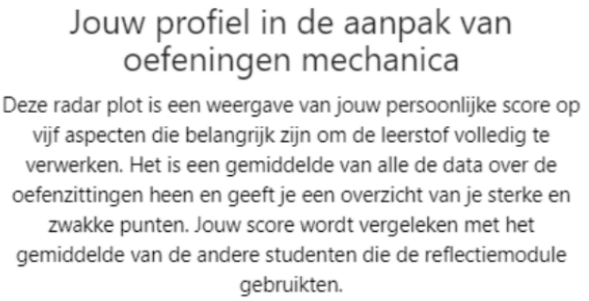


iTree, visualizing the activity of students on a course forum and connecting the metaphor of a growing tree, to the growth of discussion on a course forum [Nakahara et al. 2005]

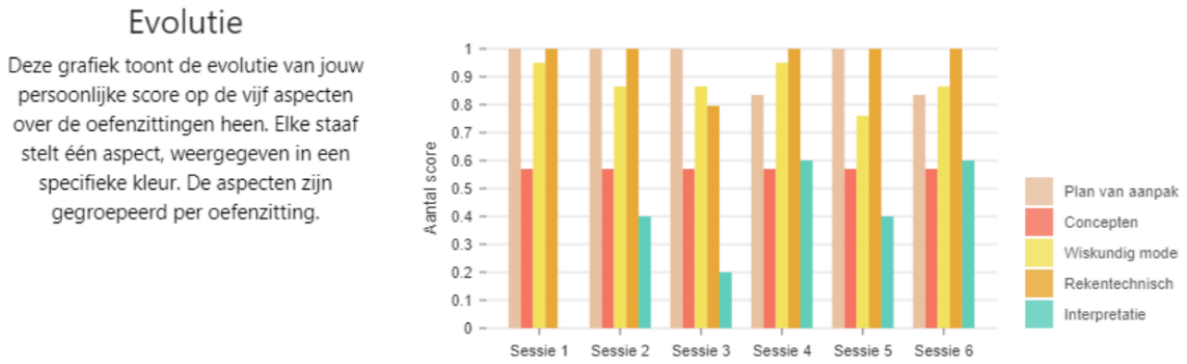
Individual "achievement"

An individual achievement component would show to a student how the personal achievement, as measured in the interactive courseware is at the current moment (see radar chart below), or how it evolves over time.





The two above visualizations use a radar chart to visualize the "achievement" of students as measured in a digital platform, developed in the context of the project.



Visualization showing how the outcome measures (here five) evolve over time (here six sessions), developed in the context of the project.

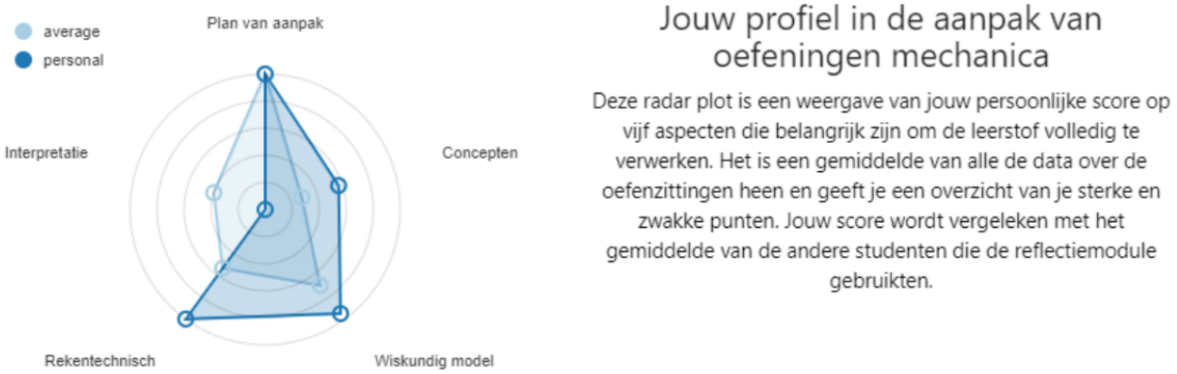
"What is hot"

A "What is hot" component would aim at pointing students to items or discussions that are currently "hot", i.e. worked a lot on by other students/teachers.

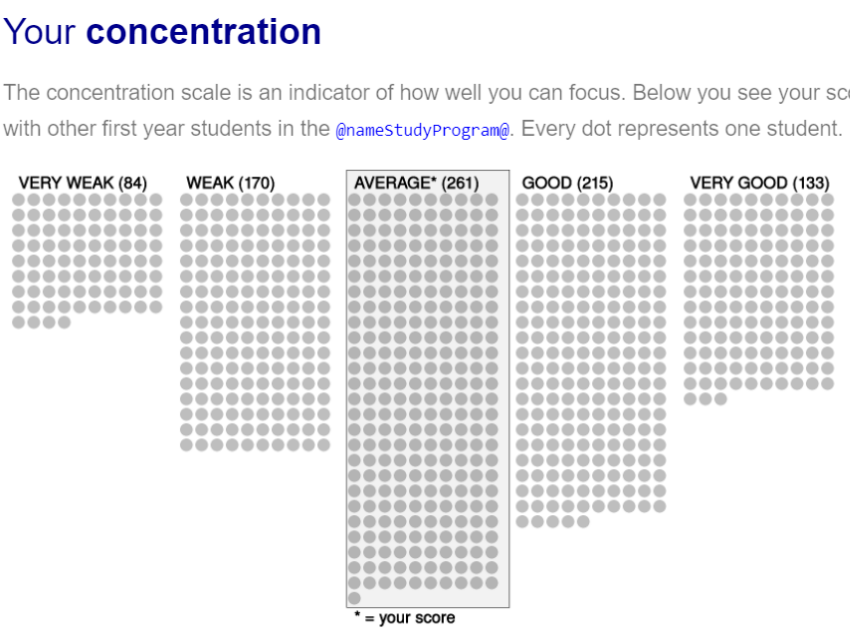
Word-cloud to visualize the "action" points that students defined form themselves after a reflection task, developed in the context of the project.

Positioning with respect to current peers or past successful peers

Learning dashboards often provide opportunities for students to position themselves with respect to their peers. This can be done for activity, progress, achievement, etc.

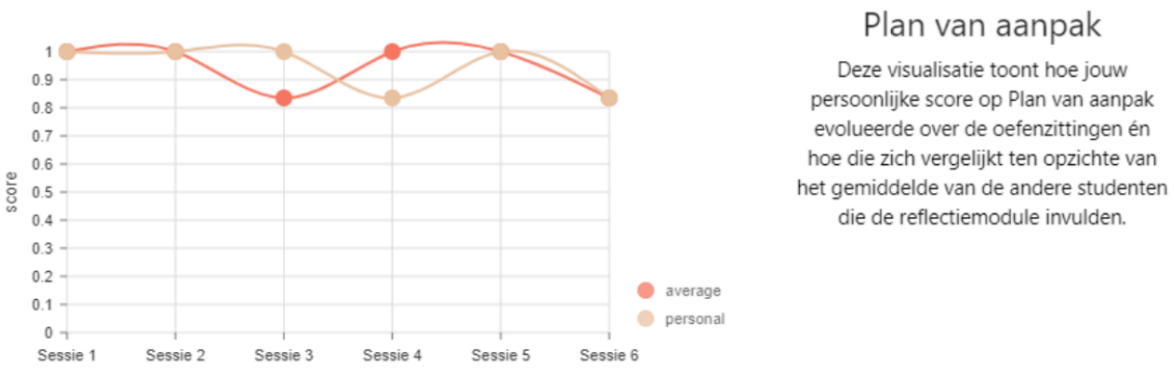


The above visualization allows students to compare their own skills to the average skills of their peers, developed in the context of the project.

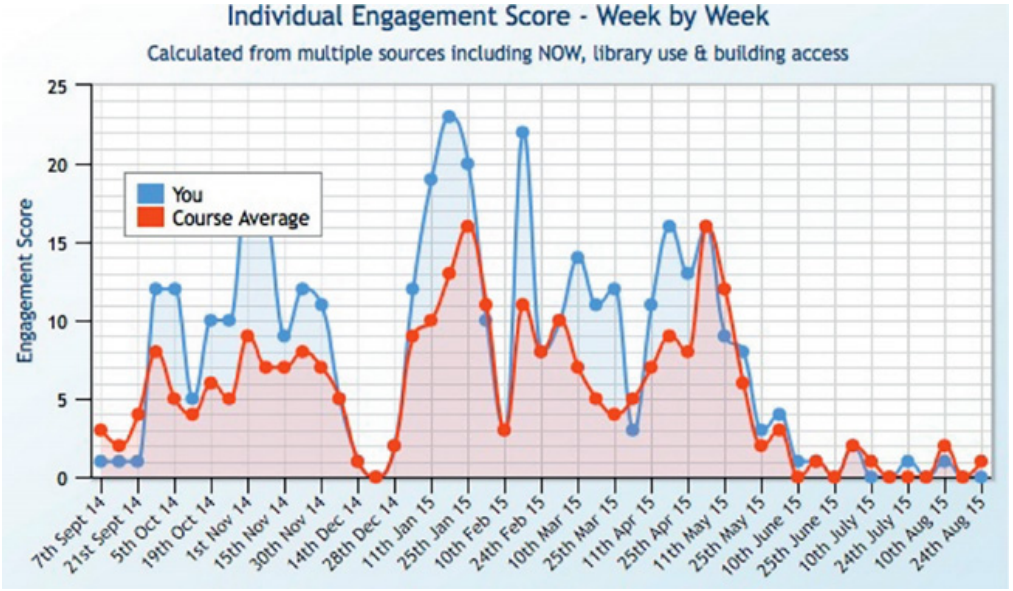


Visualization that allows students to compare the current status of their learning skill (in this case concentration) to their peers. The entire distribution is shown [Broos et al, 2017]

The comparison to peers could also be visualized over time, as shown in the graph below.



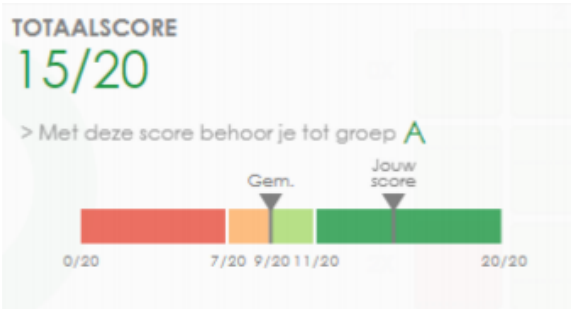
Visualization of how an outcome measure (here "Plan van aanpak") evolves over time, together with the evolution of the average of the peers over time, developed in the context of the project.



NTU student dashboard visualizing the overall engagement (from a multitude of sources) over time and in comparison to the course average.

Positioning with respect to expectation of teacher

A dashboard component could visualize the students progress or activities with respect to the expectation of the teacher.



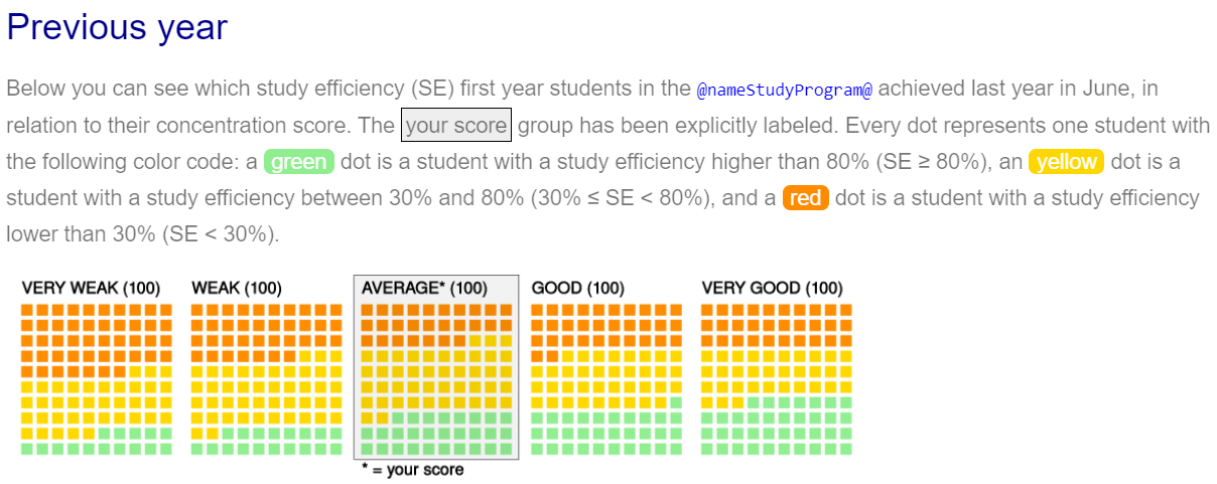
Visualization of the current status together with an expectation of the teacher, highlighted by the color, obtained from the feedback dashboard connected to the "ijkingstoets" of www.ijkingstoets.be offering feedback to prospective students after participating in a test in the transition from secondary to higher education.

For achievement measures, a positioning with respect to peers is also often made, as illustrated below for a "total score", where the expectation of the teacher is highlighted in the colors and the average is indicated with a grey bar.

Positioning with respect to past (successful) peers

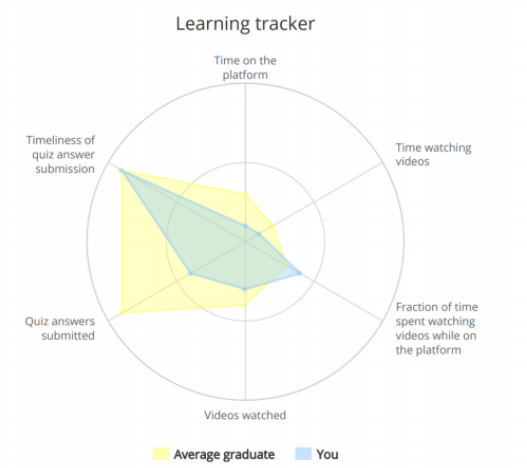
Another way to position a student with respect to a reference group is to position with respect to past peers.

This can also be achieved by visualizing the outcome measure (e.g. achievement in the course) of students from a previous cohort, depending on the measure currently under investigation (e.g. activity in the course so far). The visualization below provides an example for concentration (measure under investigation) and the outcome measure academic achievement (in June).



Visualization allowing students to assess the impact of the measure under investigation (here concentration) on an outcome measure (here academic achievement in June) for a past cohort (here students of the previous academic year) [Broos et al. 2018]

To prevent students from comparing themselves to peers that are underperforming, comparisons to past successful peers are often used, as illustrated below.



Learning tracker visualizing the students' own activity and comparing it to average (past) graduates. [Davis et al., 2017]

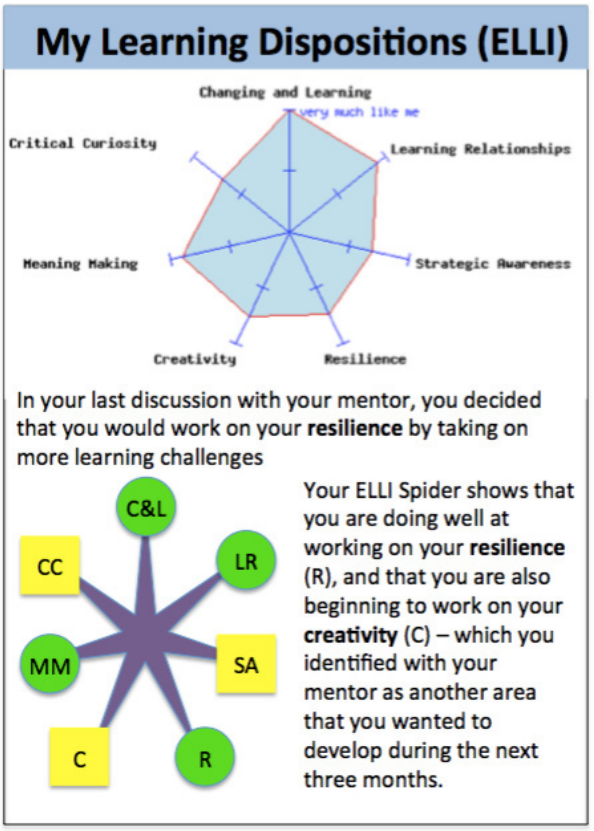
Social Learning Analytics

Learning Analytics can also focus on the social aspect of learning. So-called Social Learning Analytics explicitly focuses on the social aspect of learning, and is defined as "[Learning Analytics] focus[ing] attention on elements of learning that are relevant when learning in a participatory online culture" [Buckingham Shum and Ferguson, 2012]. Hereby social learning analytics focuses on learners and teachers as being part of a social learning environment where they do not operate solitary. Such social learning interactions can involve both direct interactions between peers or between teachers and students (messaging to each others, following peers in a discussion forum, etc.), or doing interactions on digital platforms that are perceived by others (replying to forum posts, tagging, rating, etc.). Five types of social learning analytics have been defined: network analyses, discourse analysis, content analysis, disposition analysis, and context analysis [Ferguson and Buckingham Shum, 2012]. The first two are seen as inherently social learning analytics and the last three as "socialized" learning analytics. These socialized learning analytics are seen as analytics also being meaningful to isolated learners, but can take new dimensions in the context of social learning [Ferguson and Buckingham Shum, 2012].

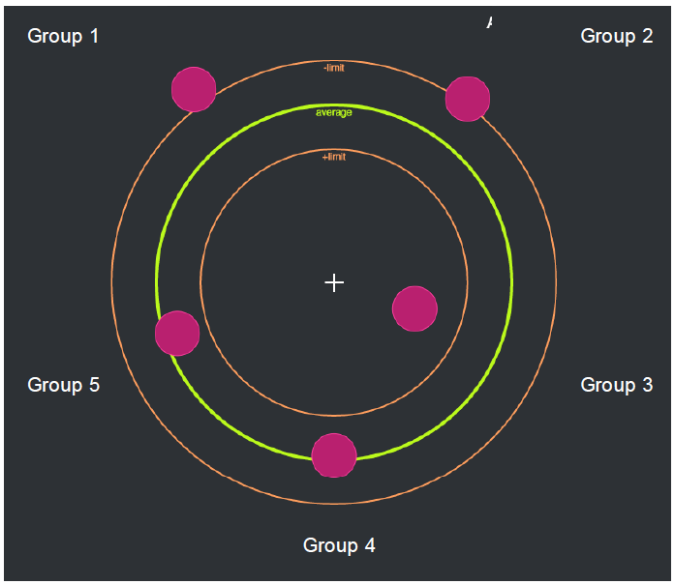
Dashboard CanvasNet focusing on the interactions between peers based on discussions on a forum in a virtual learning environment. The network visualization (social learning network analysis) allows students to explore with which peers they have been interacting, and some

summarizing metrics were available in the “Network Metrics” tab. The word cloud visualizes the most frequent words used in forum posts (social learning discourse analysis), and adds in text which have been covered by the current student [Chen et al., 2018].

Example of social learning discourse analysis, visualizing to what extent a student contributed to a forum discussion (number of posts) but also looking at what kind of contributions were done (reasoning, evaluating, extending, indicating challenges) [Ferguson and Buckingham Shum, 2012]



Example of social learning disposition analysis, visualizing outcome of a self-reported questionnaire on learning dispositions (top), and identified recent work on the learning dispositions (bottom) [Ferguson and Buckingham Shum, 2012]



Visualization showing “balance” in group discussions. Each purple dot represents one group. The more students engage in the discussion, the more their dot moves to the middle of the circle. Groups that engage less, move away from the middle. The average activity is indicated with the green circle [Charleer et al., 2017].

4.2. Teacher-facing and course-builder-facing dashboards

4.2.1. Overall progress

Learning Analytics can help to get an overview of the overall progress of the student. The progress is most measured using progress on tasks or “time spent”. We see the latter rather as an “overall activity” measure rather than actual progress. Progress should explicitly focus on how students progressed in the learning trajectory set up, not on the time they have spent.

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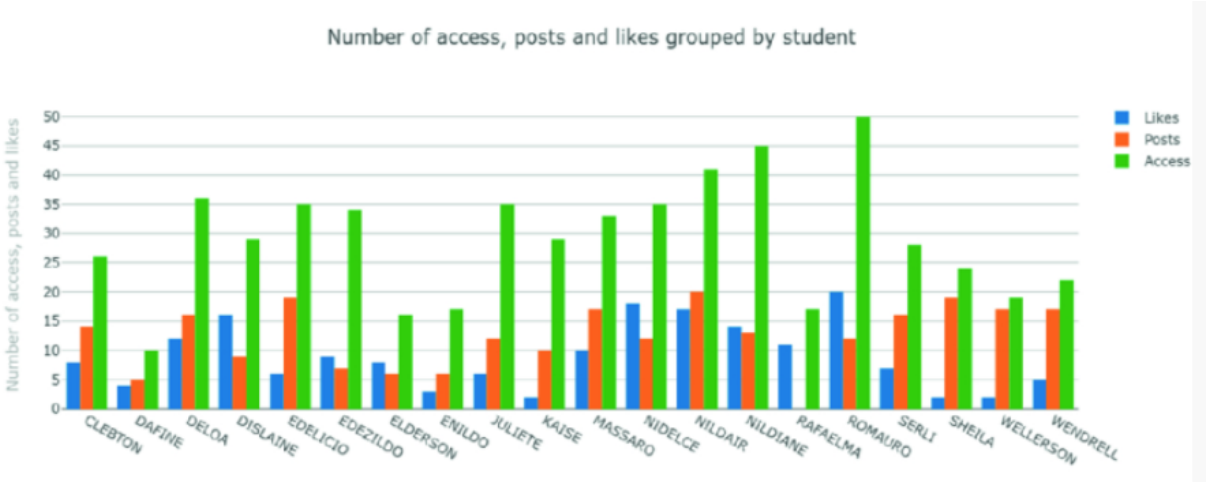
Class Progress	Unit 1 - Order of Operations	Unit 2 - Integers & Absolute Value	Unit 3 - Fraction Types	Unit 4 - Fraction Operations	Unit 5 - Decimal Operations	Unit 6 - Conversions	Unit 7 - Ratios & Proportions	Unit 8 - Statistics	Unit 9 - Probability
Completion	42%	42%	42%	17%	0%				
Performance	94%	94%	97%	97%	99%				
Unit Exam	88%	88%	90%	91%					

View of a simple google-doc based teacher dashboard providing an overview of the progress of students in the learning material in a course, obtained from https://practices.learningaccelerator.org/strategies/data-dashboard-for-progress-monitoring

4.2.2. Individual student progress

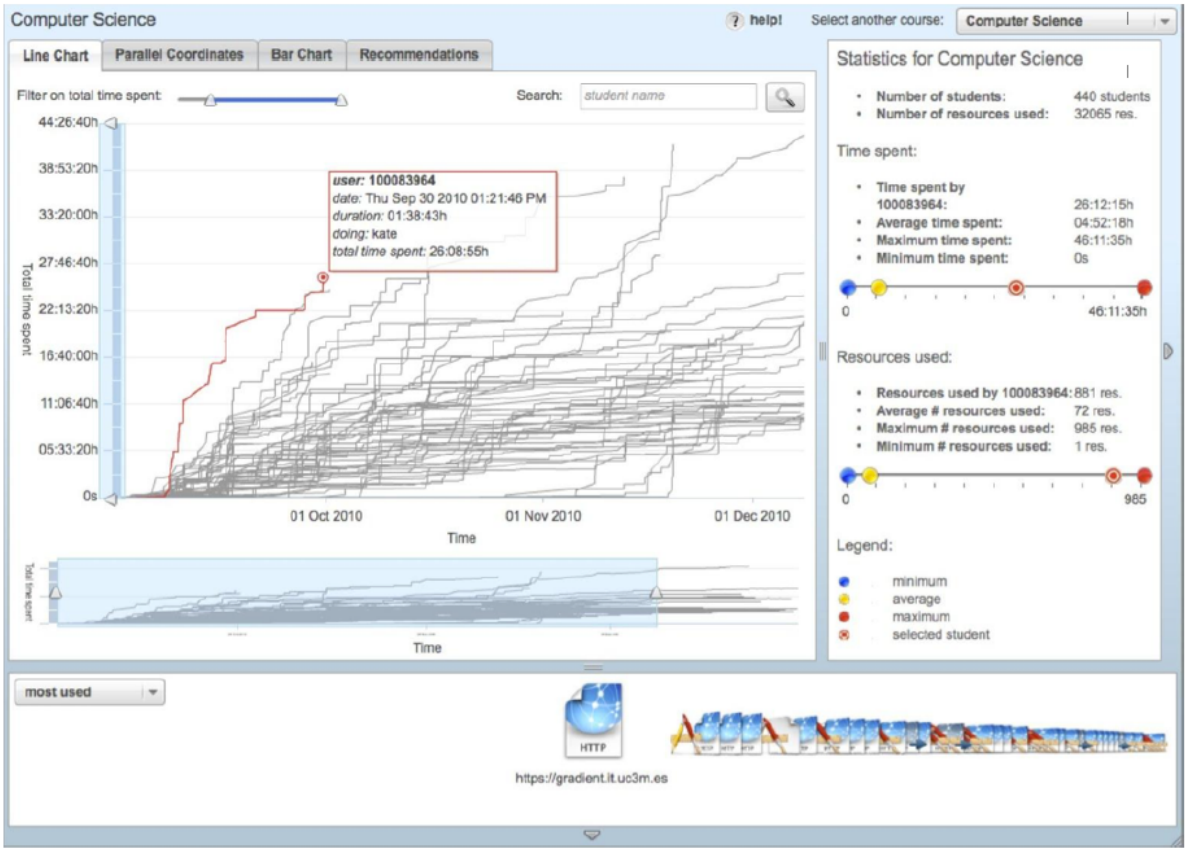
Teacher-facing dashboard showing the progress of individual students during a live teaching session [Molenaar and Knoop-Van Campen, 2019]



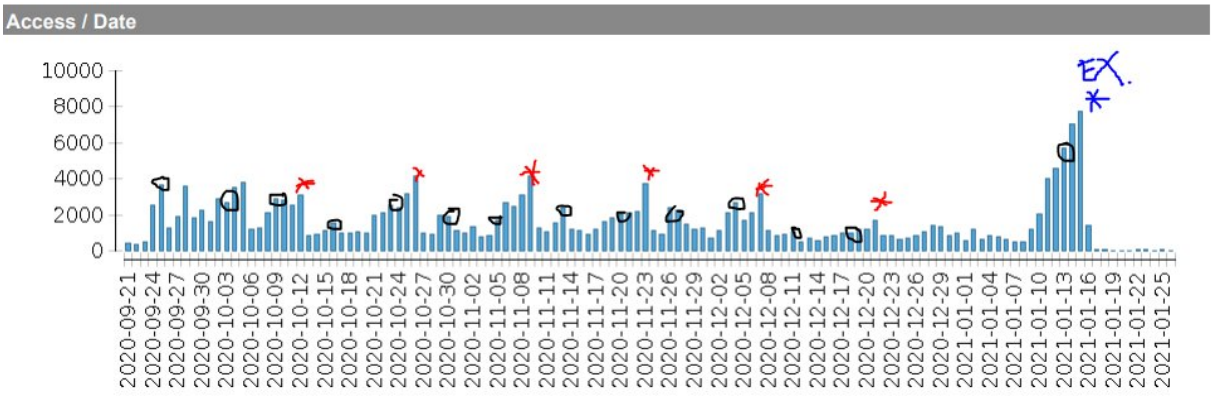
Visualization of individual student activity on a forum (likes, posts, access) [de Brandao, 2019]

4.2.3. Overall Activity

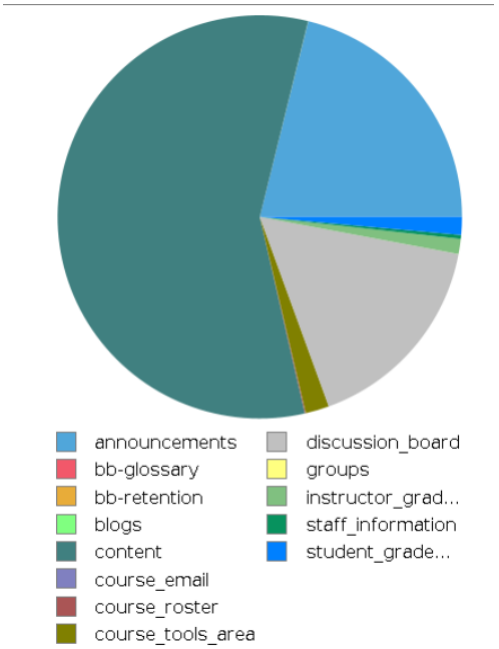
Learning Analytics can help to visualize if, to what extent, when and how students are active in a course.



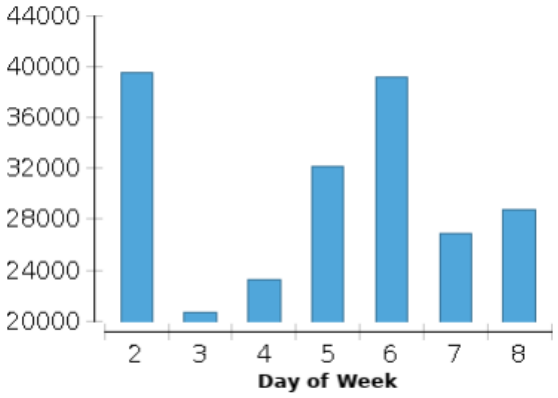
The student activity meter providing an overview of the time spent in the course (each line visualizes the time a student spends over the duration of the course) [Govaerts et al, 2012]



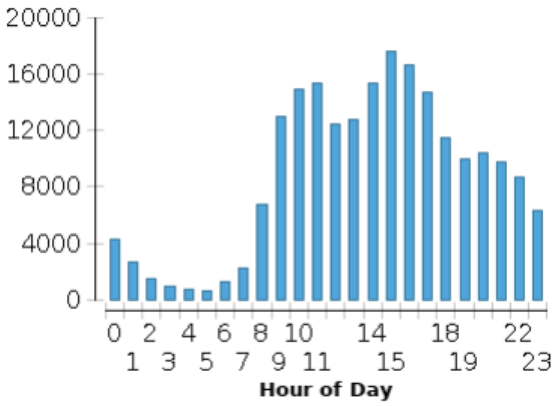
(Teacher annotated) Bar chart visualizing the overall activity of students in a Blackboard-based course over time. The annotations: black circle is weekly Q&A, red asterix are the bi-weekly assignments, and the blue asterix is the end-of-semester exam. Obtained from the Toledo Virtual Learning Platform (black-board based) of KU Leuven.



Pie chart visualizing what activities the students do in a Blackboard course. Obtained from the Toledo Virtual Learning Platform (black-board based) of KU Leuven.

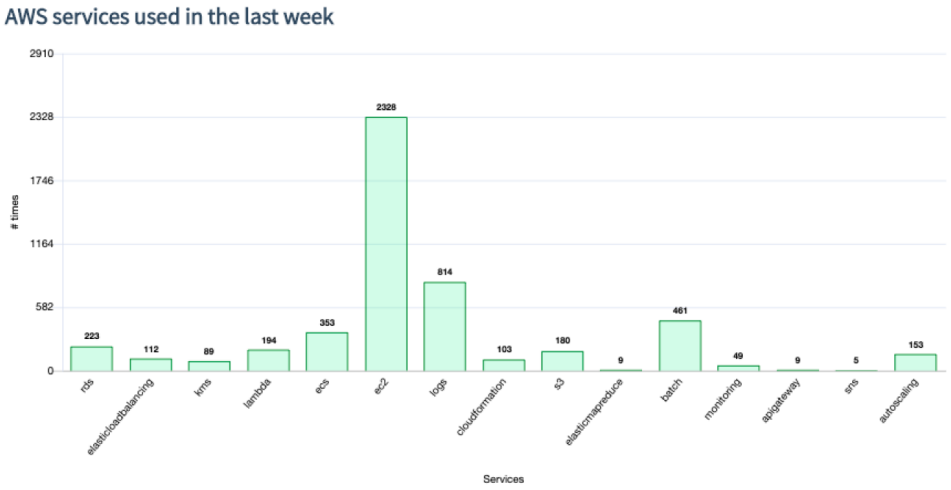


Bar chart visualizing the overall activity of students in a Blackboard-based course depending on the day of the week. Day 2 = Monday, Day 3 = Tuesday, …

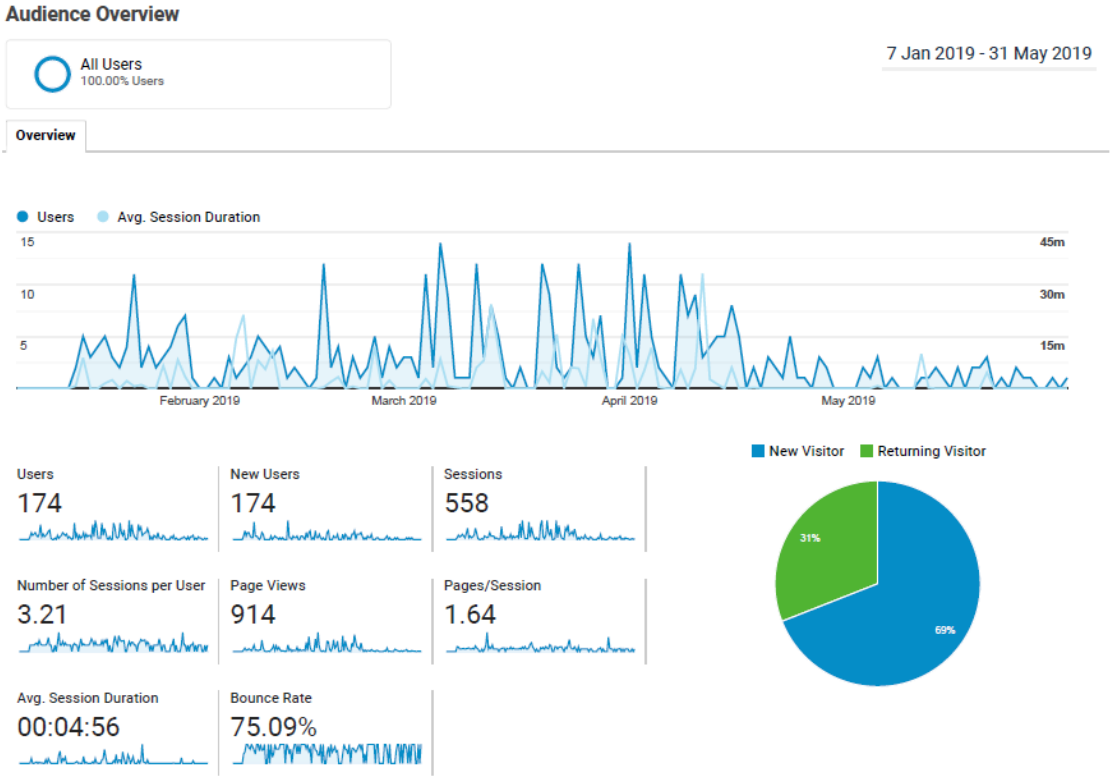


Bar chart visualizing the overall activity of students in a Blackboard-based course depending on the hour.

Obtained from the Toledo Virtual Learning Platform (black-board based) of KU Leuven.

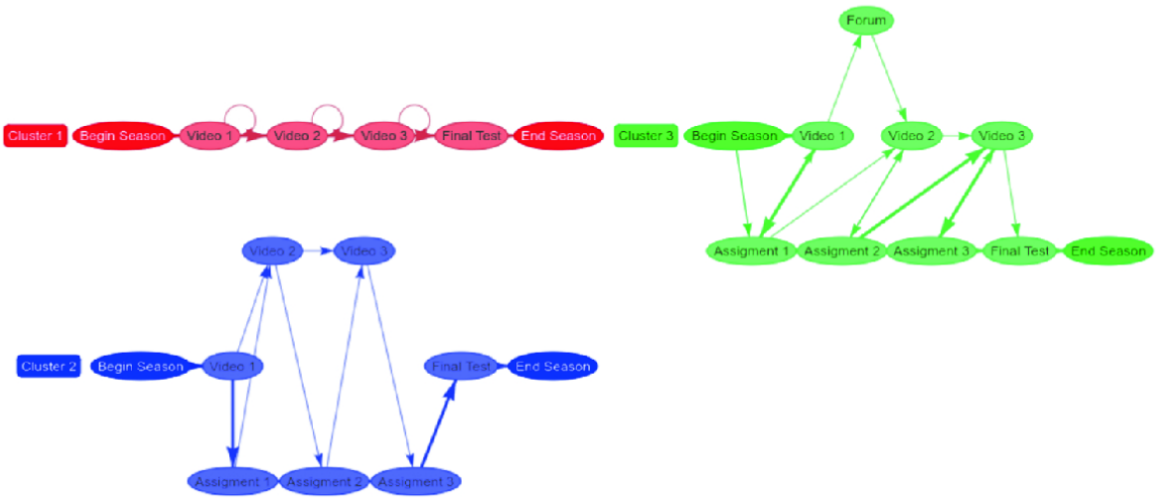


Overview of student activities categorized according to the nature of the activity [Naranjo et al, 2019]



Visualisation showing the overall activity of users. [Naranjo et al, 2019]

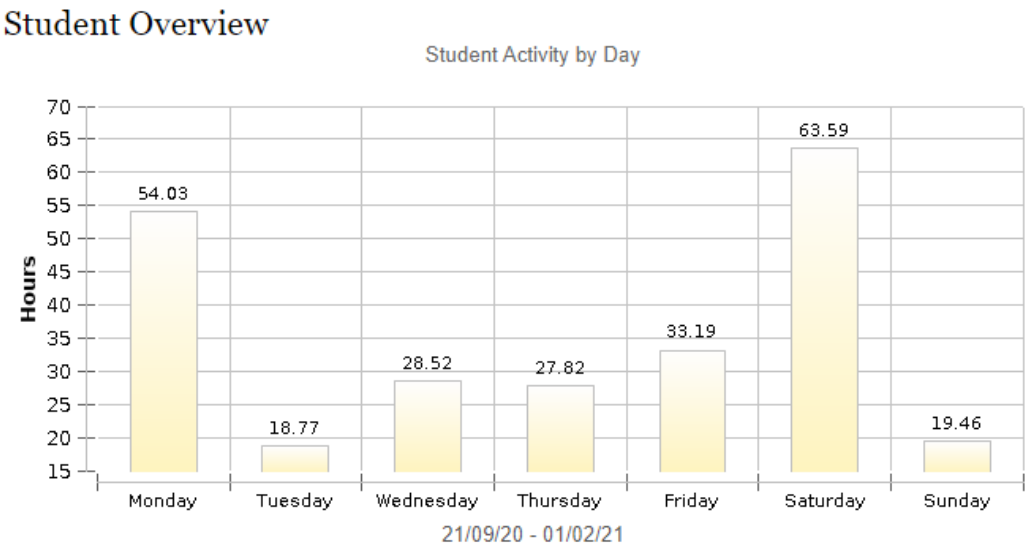
Learning Analytics can also help to discover h**ow students navigate through the course.**



Flow chart visualizing three typical navigation patterns (red, green, blue) in an online course [de Brandão Damasceno, 2019]

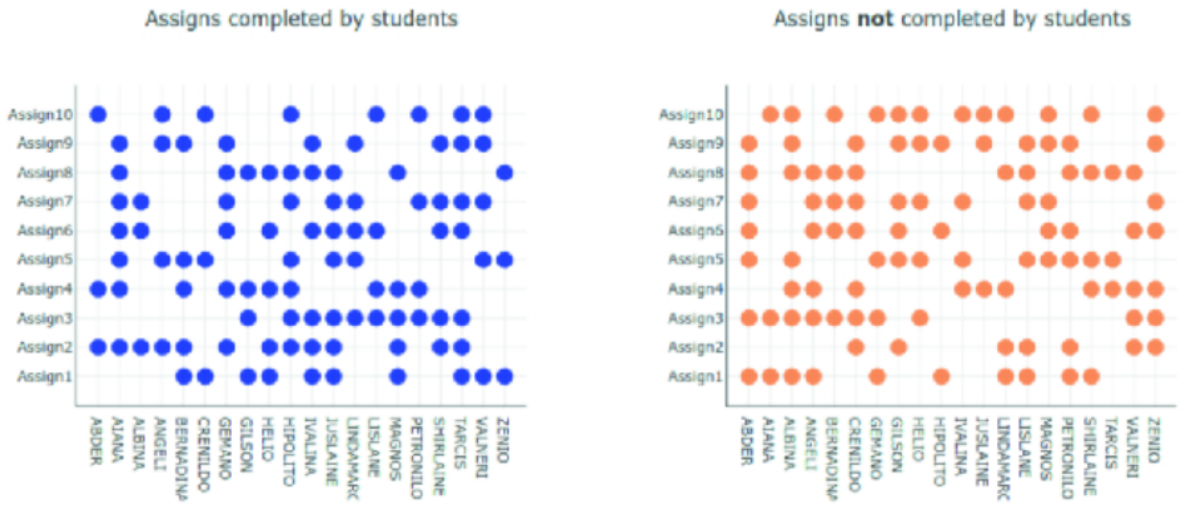
4.2.4. Individual student activity

Instead of only looking at the group level, other Learning Analytics looks at individual student activity. Learning Analytics can help to analyse if, to what extent, when and how an individual student is active in a course.



Bar chart visualizing the overall activity of an individual student in a Blackboard-based course depending on the day of the week. Obtained from the Toledo Virtual Learning Platform (black-board based) of KU Leuven.

4.2.5. Student achievement



Bubble chart to visualize which tasks were completed by each student (left) or not completed (right) [de Brandão Damasceno, 2019]

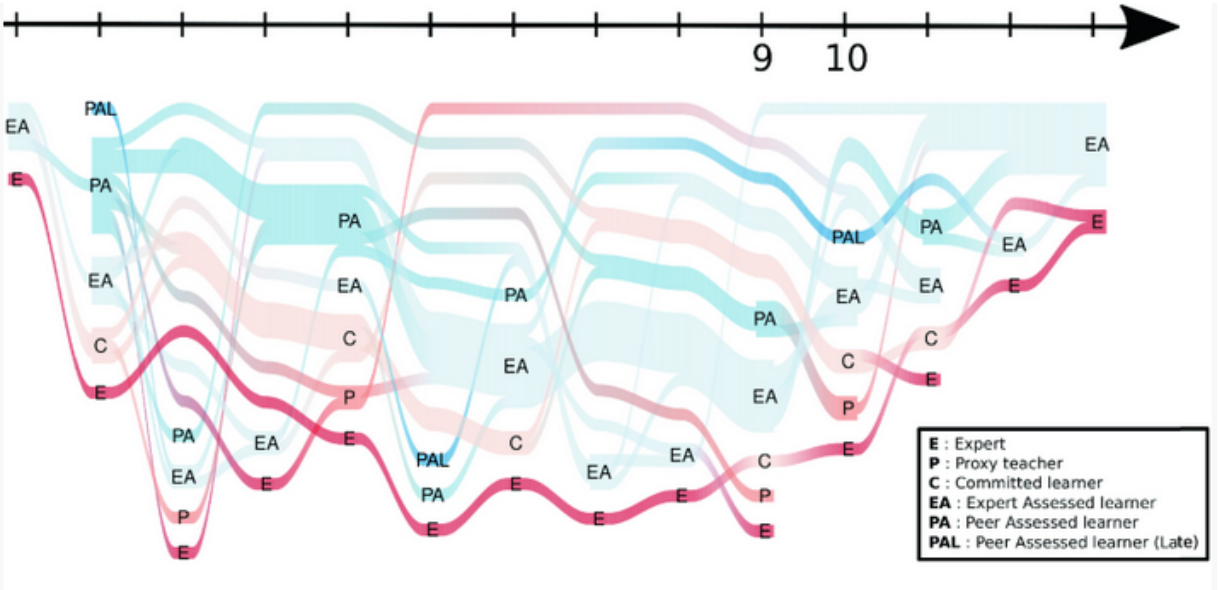
4.2.6. "What is hot/difficult?"

Learning Analytics can focus on discovering the parts that students find hard.

Classroom Salon [Barr and Gunawardena, 2021], which also has a view where the teacher or course builder can find the most-commented or most-discussed parts of the material.

Social Learning Analytics

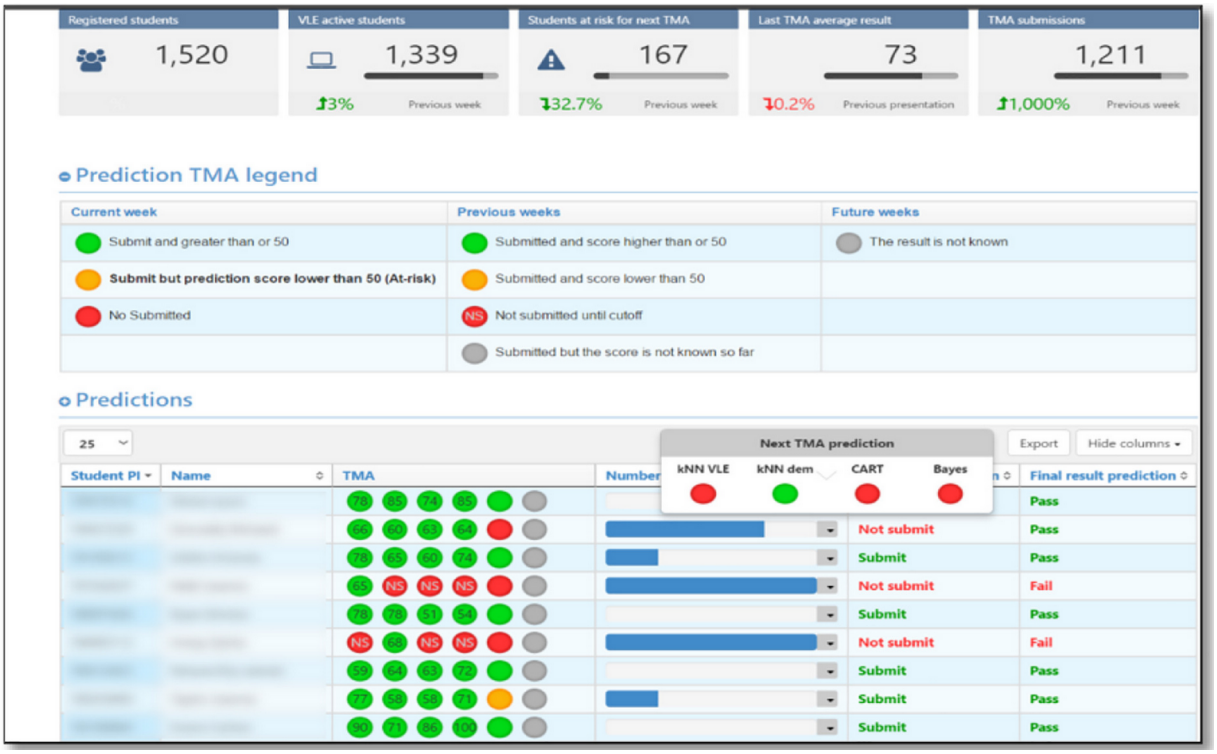
We first refer to the paragraph of social learning analytics in the student-facing dashboards section as most often the functionality is made available to both students and teachers. The use of social learning analytics to detect at-risk students is elaborated in the next section. One particular example that is of interest to teachers and course-builders from social learning analytics is the analysis of roles learners take over the duration of the course, as illustrated below. This is a unique teacher view presenting details on how student roles evolve over time at the group level.



Sankey diagram showing how the roles of learners change over time (14 phases of the course). [Charbey et al. 2020]

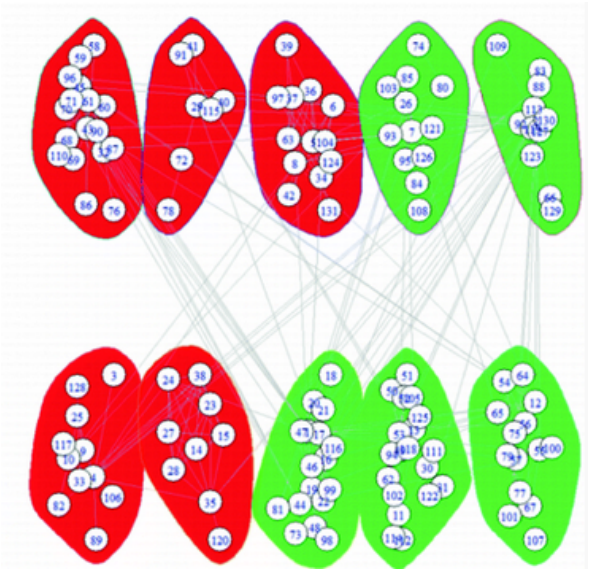
Identification of non-engaging or at-risk learners

Learning analytics can help to identify non-engaging and at-risk learners using different approaches. Below we highlight a selection.



OpenUniversityAnalyse (OUA) is a teacher-facing dashboard that visualizes the predictions of an underlying algorithm regarding whether students will submit their assignment or not using a traffic light system (red students are at-risk, orange are moderately at risk, and green are not at risk) [Herodotou et al., 2020]

One that is particularly interesting in the context of interactive courseware and co-creation is the view of social learning analytics.



Combination of social network analysis and identification of at-risk students. Based on the network analysis, student groups are identified. For each student group the color indicates whether the group is at risk (red) or not (green) [Adraoui et al., 2019]

5. Conclusion

This output serves as a starting point for the development of Learning Analytics solutions and dashboards in particular to support the interactive courseware and co-creation in the learning and teaching process. While the use of a technological platform for interactive courseware and co-creation will create digital traces, one has to be careful to interpret these as actual learning traces and to attach meaning to the traces. Using the technological platform in a well-designed pedagogical scenario, will support the interpretation of the digital traces and will make it easier to attach meaning to the digital trace in the context of the envisioned learning process. To this end different pedagogical scenarios for interactive courseware were described in this document. Learning Analytics should serve the learning and teaching process and aim at answering particular questions learners or teachers have in the context of the pedagogical scenario used. Therefore, this document highlighted the typical questions students, teachers, and course builders might have in the different pedagogical scenarios. Finally, different learning analytics visualizations and dashboards were explored that could provide answers to the questions stakeholders' questions.

This document will support the process of the actual design process of a learning analytics solution for the nextbook interactive courseware and co-creation platform.

6. References

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