eFiL Summary
e-**F**eedback for **i**nteractive **L**ecture

LP3C- MSHB - Université Rennes 2 (Eric Jamet, Nicolas Michinov, Estelle Michinov)
INTUIDOC - IRISA - INSA Rennes (Eric Anquetil, Nathalie Girard)
DUKE – LS2N - Université de Nantes (Yannick Prié, Julien Blanchard, Antoine Pigeau, Olivier Aubert)

2-year CominLabs education Project (2017-2019)

1. Introduction

The eFiL project is a 2 year project consisting of 80% engineering and 20% research. In line with the CominLabs call, we chose to recruit 3 engineers and concentrate on the development of artifacts and preliminary studies. This approach gave us a better understanding of the issues and leads to meaningful research questions.

The eFIL project focused on the design, development, and assessment of KASSIS, a new interactive digital notebook for active learning in higher education. KASSIS had been designed and developed over the previous 2 years at INSA Rennes, in collaboration with lecturers and IRISA laboratory's IntuiDoc team.

The main objectives of the eFiL project were to:

1) consolidate and improve the usability of the KASSIS solution (LP3C, IRISA-IntuiDoc) by applying a user-centered design (UCD) approach;

2) examine the uses of the KASSIS solution and its impact on active learning in higher education using, for example, innovative collaborative whiteboards, new types of graphic quizzes, and new visualization tools to deliver collective feedback such as heatmaps and clusters of thumbnails (LP3C);

3) enrich the solution by using student and teacher activity tracking (log) to design dashboards for the teacher and study appropriation and usage strategies for the students (LS2N + LP3C).

Summary of main achievements and research findings

Objective 1: Consolidate and improve the KASSIS solution

- Regular usability tests and surveys were conducted to consolidate and extend the KASSIS environment, applying a multidisciplinary UCD approach.
- KASSIS was extended by designing two innovative functionalities for the automatic graphic summary of collective feedback: an interactive saliency map (heatmap) and interactive graphic clustering.
- We conceived an automated generic clustering of handwritten graphics (Symbols, Mathematical equations, Drawings…) based on fuzzy C-Means approach with a dedicated feature selection using HBF49 features and t-SNE algorithm. The approach was validated using the "QuickDraw" dataset from Google.

Objective 2: Examine the uses of the KASSIS solution and its impact on active learning in higher education

- Many experimental studies were carried out to test KASSIS in various teaching situations (eg. peer instruction, collaborative drawing) and disciplines (e.g. computer science, ux design, psychology, physiotherapy).
- Together, these studies and tests involved more than 1,158 students and 14 different teachers (see Table 1).
- **Note taking** was faster with a keyboard, followed by paper and pen-based tablet; using a tablet with a pen may be particularly relevant for disciplines in which sketches or formulae are frequently used (studies 1 and 2).

- A very high level of interest for KASSIS **collaborative drawing** activity was demonstrated among both teachers and learners in medical education but this activity needs to be guided to be efficient (studies 3 and 4).
- **Regular quizzes** administered with KASSIS during the lecture improved learning outcomes more than quizzes administered at the end of the lecture (studies 5a and 5b).
- Peer Instruction may be extended to **graphic quizzes** (instead of multiple-choice questions), and a **collective feedback** to the whole class can be given in a heatmap format (instead of bar charts) with positive effects on learning outcomes when the teacher guided students about how to use the heatmap (study 6).
- Students using the KASSIS solution (**graphic quizzes**) were more satisfied, interested in the lesson, and understood better the concepts than those in traditional teaching (graphic quizzes on slides), but no difference was observed on academic performance (study 8).

Objective 3: Enrich Kassis with learning analytics dashboards

- Two types of dashboard (realtime for in-class monitoring, and post-class for more in-depth analysis of how the session unfolded) were iteratively designed and implemented in a UCD multidisciplinary approach, using prototyping and user studies to validate the dashboard proposals.
- The KASSIS environment was instrumented to capture interaction traces, thereby providing material for research activities and the design of teacher dashboards.
- Preliminary data analyses were carried out, yielding a number of ideas that could not, however, be properly validated, owing to a lack of data.
- The iterative methodology we used for trace modelling and dashboard design seems sound, and we want to use it again in other contexts to assess its relevance.
- There clearly is value in fine-grained analysis of course unfolding with new types of visualizations, for teachers and for researchers.
- Dashboards were recognized as helpful by teachers.

2. Main results

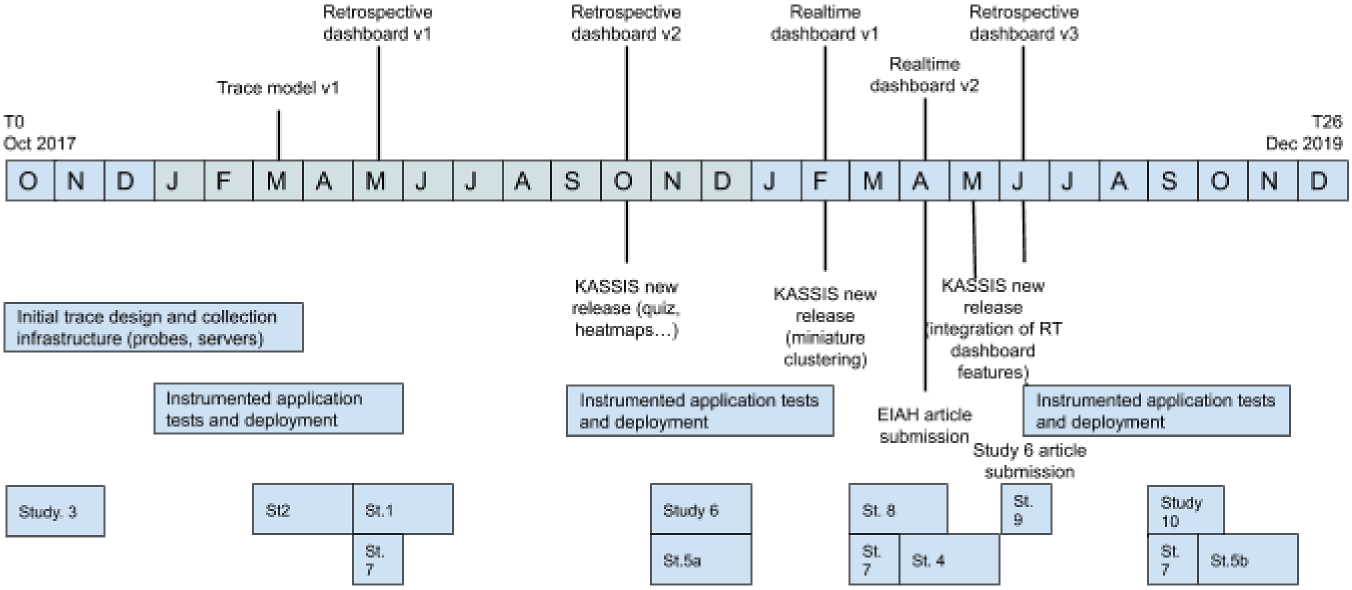
During this 2-year project, working in close collaboration with LS2N and INTUIDOC, the LP3C team conducted more than 10 studies (N = 1,158), surveys or usability tests to consolidate and extend the KASSIS solution. Some preliminary results have already been published, while others will be published in the near future.

The first objective of the studies summarized below was to improve KASSIS from a UCD perspective. When prototypes were designed, they were used to collect user feedback (from students and teachers) during and after the learning tasks. These user tests allowed us to assess whether usability objectives were met, but we also used the information we gathered to drive the design of subsequent prototypes for the INTUIDOC team. For example, this approach was used to analyze users' needs and habits (Study 1) and to evaluate and improve the usability of KASSIS in various teaching settings (Studies 2, 3, 4, 5a, 5b, 6, 8 and 10).

The second objective of these studies was to rigorously evaluate the impact of KASSIS on students' learning outcomes and motivation. To this end, we compared several functionalities of KASSIS with those of more traditional environments (Study 2 for note taking, and Study 8 for graphic quizzes), and assessed different ways of using KASSIS to assess their respective effects on learning (Studies 3 and 4 for dyads' collaborative learning, Studies 5a and 5b for distributed quizzes, and Study 7 for collective feedback in a heatmap format).

The third objective was to design teacher dashboards adopting a UCD approach. For example, we used this approach to analyze teachers' needs and habits (Study 7) and to improve dashboards (Study 10).

The timeline below presents an overview of the project unfolding, the detailed table describing the key features of the studies conducted in the course of the project can be found in the full report / website.



2.1 Objective 1: Consolidate and improve the KASSIS solution

Thanks to several specific user-centered design studies (1, 9 and 10) and seven experimental studies described below, the KASSIS application has been improved during this project, with some interface improvements and two major new functionalities to improve the automatic synthesis of the collective feedback. According to the type of the collected hand-drawn student responses, KASSIS offers two collective visual feedbacks:
- interactive saliency map (heatmap): aggregate drawing answers in the form of a visual heatmap displayed to the teacher. The teacher can then validate the 'correct' answer that can be displayed to the learners.
- interactive graphic clustering: clustered view of the graphic answers, by gathering similar graphic answers, displayed as either a flat view of the graphic clustering, or as an interactive 3d-view.

2.2 Objective 2: Examine the uses and impact of the KASSIS solution on active pedagogy in higher education

Seven experimental studies were carried out to examine to achieve this goal. Main findings of each study were summarized in the *Summary of main achievements and research findings* section above.

2.3 Objective 3: Enrich Kassis with Learning Analytics dashboards

The general goal is to capture and exploit interaction traces, so that they can be used by researchers and instructors through visualisations mainly in the form of dashboards, presenting in a synthetic view relevant and actionable indicators. Three types of dashboards have been envisioned and implemented: a research dashboard, aimed at scientists ; a real-time dashboard ; a retrospective dashboard, meant to be used after a lecture.
The main outputs of the project, related to Learning Analytics, are :

- a trace model adapted to the application 53 types of events (combinations of 15 action verbs and 37 object types) and an architecture consisting in an instrumented application and a trace server
- multiple dashboards (research, real-time, retrospective) conceived iteratively
- work-in-progress in trace mining for identifying relevant events or behaviours and profile users.

3. Conclusions and perspectives

We achieved our goals, which were to 1: Consolidate and improve the KASSIS solution; 2: Examine the uses and impact of the KASSIS solution on active learning in higher education; 3: Enrich Kassis with learning analytics dashboards.

The project's main outputs are an enhanced and more robust version of KASSIS, along with multiple studies (some of them still pending analysis) evaluating the uses of KASSIS and its impact on active learning, and providing guidelines for future application deployments. The KASSIS application is now instrumented to capture interaction traces, which can then be provided to teachers (and analysts) through dashboards, thereby opening up enhanced opportunities for reflective teaching. These assets were obtained through the work of a genuinely interdisciplinary consortium, with good relations and high levels of mutual understanding (interdisciplinarity is always risky).

We could not test the dashboards as thoroughly as we would have liked, owing to the unavoidable amount of time needed for modelling/designing/implementation, as well as the need to have real traces for prototyping. Time is needed for bootstrapping before the anticipated indicators can be contrasted with the reality of actual traces. On the bright side, we now have an instrumented version of the application, that will shorten the amount of time required for further developments and experiments.

Some results are still pending. For instance, we are working on a cross-team article on the creation and usage of dashboards, and investigating the automation of some forms of learning analytics through trace mining, in order to gain a deeper (self)understanding of how the sessions unfold.

Regarding future prospects, the KASSIS application could be more widely deployed in higher education, to build on its existing features and allow larger-scale collection of learning analytics. It could also be deployed in other settings (high school, college, etc.) and/or in other disciplines.

The same interdisciplinary consortium has submitted a proposal for the new Cominlabs call, entitled GUIDE, which is aimed at providing tools and assistance for the drawing of figures in the context of medical studies-a field that we identified during the eFiL project. This would give teachers more sophisticated tools, and also allow for the continued capture of activity traces, in order to capitalize on this asset.

4. Publications

a. Volumes of the experiments: 1,181 students and 14 different teachers were involved in the eFil project (see Table 1).

b. Volumes of logs already collected: the collected traces represent globally more than 800 000 events, but we made a selection of 31 representative sessions, that produced 400 000 events on 50 hours. This allowed us to elaborate and validate the dashboard and do some exploratory analysis, but we do not have enough data yet to do a proper mining work.

c. List of publications submitted and accepted

- Aubert O., Blanchard J., Pigeau A., Prié Y. Retours sur une conception de tableau de bord. In EIAH'2019 - Atelier IHM pour l'éducation, juin 2019, Paris, France. https://hal.archives-ouvertes.fr/hal-02121416
- Jamet E. (2019). Apprendre à partir de tablettes avec stylet : quelques résultats issus de projets de recherche collaboratifs. Journée d'études Tablettes tactiles et éducation, Apprentissage, pédagogie, acceptabilité. Toulouse, 24 et 25 juin 2019.
- Jamet E. (2019). Apprentissages actifs avec le numérique. Journée d'études Technologies éducatives et formation, Rennes, Novembre 2018.
- Michinov, N., Anquetil, E., & Michinov, E. (submitted paper). Guiding the use of collective feedback in a heatmap format to reduce group conformity and improve learning in Peer Instruction using graphic quizzes. *Computers and Education*.
- Michinov, N., Anquetil, E., & Michinov, E. (2019). Réduire l'effet de conformité au groupe pour améliorer l'apprentissage dans l'enseignement par les pairs. *Poster présenté aux Journées thématiques de l'ADRIPS: éducation et psychologie sociale*, Grenoble, 3-5 sept.