Irene-Angelica Chounta

Research Statement

My research focuses on studying and modeling user activities and interactions in various learning contexts. To that end, I follow an evidence-based approach: I engage in exploring data traces of user practice and in seeking patterns that provide valuable insights and are backed up by theoretical reasoning. Following this approach, my contributions are in the area of learning analytics and student modeling.

In academia, the term "*learning analytics*" is used to describe the activity of collecting and analyzing data of learners in order to understand and support learning [26]. The availability of big data, the multi-dimensionality of data (new types of data from social data to data provided by sensors and tangible artifacts) and the speed of acquiring data (data are available in real time and instantaneous process is feasible) call for data-driven analytical approaches [19,24]. Data-richness offers new opportunities for addressing fundamental challenges that remain open: the personalization and adaptation for providing feedback and support to learners (or "users" in general), developing and testing analytical methods using machine learning and data-mining techniques and, modeling human activities and processes in order to detect potential bottlenecks and to improve performance, efficiency and effectiveness. At the same time, we need to ensure solid foundations that derive from rigorous research and well-established pedagogical theories. This is an interdisciplinary problem. Research in educational technologies extends over multiple disciplines: from the learning sciences to data mining, machine learning and human-computer interaction. This suggests that educational technologies can benefit from the adoption of methods from related fields and vice versa; data-driven analytical approaches that are deep-rooted in established theories are central to developing a well-rounded understanding of user practice and engagement with technology.

My main research contributions in learning analytics involve the combined use of multiple analytical and data-mining methods (for example, social network analysis [13], activity metrics [16], logfile analysis [5,11], sequential pattern mining [25], time series analysis [6]) in various contexts (computer supported collaborative activities, MOOCs, online labs). In my PhD thesis I proposed the use of time-series to model collaborative learning activities and to assessing collaboration quality [2,7,9]. Additionally, I implemented an automatic rater of collaboration quality using Dynamic Time Warping and studied its use as part of a teacher dashboard [8]. I explored the use of analytics for scaffolding collaboration and communication [5,21,22]. I also studied the adaptation of Social Network Analytics and other modeling techniques to support communication and knowledge exchange in MOOCs [12,20] and small groups [13]. Furthermore, I have been exploring the use of learning analytics to explore motivation shifts among small groups [16] and to support making through learning activities in informal settings (for example, Dev Camps) [14]. Currently, I am working on designing an early warning system for addressing dropouts in Higher Education based on the synthesis of multiple data sources, such as the Study Information Systems (SIS) of academic institutions, the Learning Management Systems (LMS)

that facilitate courses and additional resources, such as specific purpose programming environments like Jupyter Notebooks, Intelligent Tutoring System activities and so on, if available. The early warning system is based on assessing the risk of a student dropping out the curriculum on three dimensions: academic background, performance and effort [26].

My main research contributions in student modeling involve machine-learning approaches to model students' knowledge state and to predict students' performance. To that end, I have proposed the "*Grey Area*" approach [4,15], that is the area a student model cannot predict with acceptable accuracy the outcome of a student's learning task with respect to correctness. This computational approach is used by Rimac[1] – a natural language-based intelligent tutoring system for Physics – to guide students through adaptive lines of reasoning [1,23]. I am also interested in exploring the relationship between response times and student performance. To that end, I proposed the concept of the *Zone of Interest* (ZOI) [3]. This line of research builds on the hypothesis that there is no linear relationship between step duration and correctness. On the one hand, a student needs a minimum amount of time in order to process the problem, retrieve appropriate information, and to construct a correct response. On the other hand, taking too long to carry out a step could indicate a lack of background knowledge, failure to retrieve critical information, and inability to address the step. Therefore, there is a time frame in which a student will likely provide the correct answer. Every step that lies outside this time frame will most likely be solved incorrectly or not solved. I identify this time frame as the Zone of Interest (ZOI) and I envision that this concept can be used to provide timely feedback to students and to improve the performance of computational student models [10].

For the next five years, I aim to extend my research into two main directions:

1. Providing personalized and adaptive feedback and support to learners.

From 2019 to 2021, I worked as the Principle Investigator on the research project (PSG286, funded by the Estonian Research Council, 2019-2022) that aimed to provide personalized guidance and feedback to students by adapting scaffolding to their background knowledge and cognitive state. To that end, I proposed the use of machine-learning based student models to assess students' knowledge and cognitive state with respect to prior practice. To monitor prior practice, I proposed the use of learning analytics. In order to maintain the most up-to-date representation of student's knowledge and cognitive state, the student models will be dynamically updated during students' practice. In order to provide guidance and feedback with respect to student's specific needs, I followed the Vygotskian construct of the Zone of Proximal Development (ZPD) and I adapted scaffolding with respect to the principles of Contingent Tutoring [4,15].

[1] https://sites.google.com/site/rimacsite/home

2. Designing computational learning analytics to monitor, model and evaluate aspects of creative processes.

My aim in this line of research is to explore and extend the use of learning analytics to other research domains, for example computer-supported cooperative work, online and maker communities, where humans work together in order to create digital or tangible artefacts as outcomes of creative processes. To that end, I have currently taken on a research line where I explore the use of learning analytics to analyze the collaborative construction of artefacts (such as, process models or programming code) and to provide feedback to facilitators who orchestrate modeling workshops or mentors in DevCamps [14,17]. My plan is to expand this work to study the creative processes developing in entrepreneurship and the active start-up scene in Estonia and Finland.

Currently, I lead the interdisciplinary research group "coLAps: Computational Methods in Modeling and Analysis of Learning Processes"[2] at the University of Duisburg-Essen – consisting of researchers, phD and master students – that aims to develop highly competitive research and to attract international visibility and funding.

During my research career, I gained experience in writing project proposals for both European and American funding agencies. While in the University of Tartu, I have authored and co-authored 5 research grants (1 funded, 2 rejected, 1 waiting for results and 1 work-in-progress) for major funding agencies (Estonian Research Council, Institute of Education Sciences, National Science Foundation, Erasmus+). Furthermore, I collaborate with outstanding researchers internationally, for example Sandra Katz, Patricia Albacete and Pamela Jordan (University of Pittsburgh, USA), Paulo Carvalho, Ken Koedinger and Bruce McLaren (Carnegie Mellon University, USA), Tobias Ley, Kairit Tammets, Maria Jesus Rodriguez-Triana (Tallinn University, Estonia), Agathe Merceron (Beuth Hochschule, Germany), Vanda Luengo (Sorbonne Université, France), Hiroaki Ogata (Kyoto University, Japan).

During the academic years 2018/2019 and 2019/2020, I fully developed and teach two master-level courses "Introduction to Learning Analytics" and "Research in Educational Technology". For both of these courses I offer formal lectures and hands-on workshops with the aim to bridging the gap between theory and practice with respect to teaching and to providing examples from real-life experiences that will better prepare students for their future endeavors.

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