Centre for Education and Learning
Leiden-Delft-Erasmus Universities

RESEARCH FOR DIGITAL EDUCATION

RESEARCH PROJECTS OF THE LEIDEN-DELFT-ERASMUS CENTRE FOR EDUCATION AND LEARNING 2019-2024

Digital Education

The Leiden-Delft-Erasmus Centre for Education and Learning (LDE-CEL) was an interuniversity and inter-disciplinary research and innovation Centre that was established in 2014 by Leiden University, Delft University of Technology and Erasmus University Rotterdam, The Netherlands. Aim of the Centre was to combine the specific strengths of educational innovation and research within the three universities and align educational policies. The three universities wanted their education to be evidence-based and educational innovation should be accompanied by research. The centre was founded in 2014 by Professor Henk Dekker, building a network of educational innovators and teaching professionals at the three universities. In 2019 Professor Marcus Specht became Scientific Director of the Centre and developed a focus on educational research and innovation for the second period of LDE-CEL from 2019 to 2024. This report gives an overview of the research activities and the related research output for this second period.

Research in LDE-CEL was shaped in multidisciplinary teams and implemented a range of studies from comparative analyses, mixed methods research, large research populations and big data analysis. PhD students and post-doctoral researchers worked on the focus areas of the LDE-CEL research programme bringing together research on ICT based enhance-ments of teaching and learning, adaptation of educational settings and instructional designs. Several studies developed prototypes and researched the barriers and perceived opportunities of new technolo-gies for teaching and learning in Higher Education.

The advisory and steering board meetings in 2019 and 2020 helped to sharpen the focus of LDE-CEL onto "Research for Digital Education" as an umbrella term linking important mega-trends in educational transfor-mation. With the trends on Datafication, and Virtualisation of Higher Education also the challenge

to develop Digital Literacy for educators and learners became a leading topic of the Centre.

The formulated focus on research excellence for digital education allowed to interlink researchers, educators, innovators, and entrepreneurs and stressed the importance of evidence-informed innovation. It also formed a unique value proposition for LDE-CEL in the network of fast-developing professionalisation centres, educational innovation units, Edtech initiatives and start-ups in the LDE context. Overall the Centre worked with innovation and research units and over 20 faculties of the Leiden-Delft-Erasmus universities as well as medical centres to develop educational innovation and evaluation of these innovation projects.

Research for Digital Education

The research program in 2019-2024 developed research projects within three program lines connected to these mega-trends on Datafication, Virtualisation and Digital Literacy.

Connected to **Datafication** a new wave of AI applica-tions has developed in the last years. Higher Education of the future must understand the potential of AI to support personal reflection, higher order problem solving, retention and knowledge development as also taking responsibiltiy for personal learning and career development. Therefore LDE-CEL developed projects on Learning Analytics in classical university courses as also in lifelong learning settings as MOOCs. Within these settings the support of goal-setting and self-re-gulation skills of students, as also the support of lecturers for core study tasks as essay writing and computational problem solving has been researched. Furthermore projects on AI based assessment approaches and hybrid problem solving of learners with Generative AI models (GenAI) have been developed.

Connected to **Virtualisation** projects on Augmented and Virtual Reality enable new forms of learning support as embedding feedback and practice in real world situations and simulations. The technology also enables the systmatic design and variation of virtual

experiences and training environments. Hybrid and blended learning solutions form an essential component of future, more resilient higher education systems. Especially collaboration in virtual environ-ments as also deliberate practice in dedicated VR and AR environments will shape future blended learning designs in Higher Education. LDE-CEL developed pilots and research projects on individual training settings in VR/AR/XR as also group settings for exploring and interacting in complex simulated environments. Latest projects also highlighted the possibilities of holographic projection in real world settings for teaching and learning.

Digital Literacy includes the use of data and digital tools and redefines the new instrumentarium of education and job practice in nearly all disciplines. LDE-CEL shaped research projects for developing curricula on digital skills including data literacy, programming education, computational thinking, and algorithmic thinking. The importance of these skills becomes clear from an interdisciplinary perspective as different levels and type of skills are needed for different scientific disciplines. CEL supported research on the definition of Computational Thinking and it's assessment in Higher Education, the understanding of how teenagers develop essential understanding of core concepts of algorithmic thinking and programming, as also how gender stereotypes play an important role in the interest for STEM topics.

LDE-CEL disseminated it's research results in 6 Annual Meetings and 15 Innovation rooms with inspiration and handson sessions. A PhD and Education Research Network was formed with regular PhD intervision and a colloqium series highlighting ongoing research projects. The Centre organised 3 International Conferences on Mobile Learning, Technology Enhanced

Learning, and Computational Thinking with more than 500 participants and scholars. With more than 20 faculties, innovation centres and LDE institutes projects on Learning Analytics (LA) and Artificial Intelligence for Education (AIED), Digital Skills and Digital Literacy (DL), and Augmented and Virtual Reality (VRAR) for Education have been implemented.

In all these projects rigourous quantitative and qualitative research methods have been applied and the results led to more than 80 publications in peer-reviewed high impact journals and conferences. Furthermore the Centre developed professionalisation offers for educational innovators and researchers. A MOOC on "Research methods for multidisciplinary research" already had more than 1000 participants, Campus Courses helped to develop more than 50 student projects on Educational Technologies. With spearheading new approaches in digital education LDE-CEL produced a variety of research outcomes that can shape the foundation for extending the research networks within and beyond the three universities.

Acknowledgement

Marcus Specht

Scientific Director of LDE-CEL

Themes

1. **Learning Analytics and Artificial Intelligence for Education**

2. **Digital Literacy and Future Competences**

3. **Augmented, Virtual and Mixed Reality for Education**

4. **Educational Innovation, Leadership and Professionalisation**

1.
Learning Analytics and Artificial Intelligence for Education

Learning Analytics and AI for Education

Data and AI enhanced learning looks at the variety of digital traces collected in today's learning environments and helps learners and teachers to make use of these traces for more efficient, effective and joyful learning.

Projects include building Learning Analytics Dashboards for teacher and learner support, unit and sequence analysis of learner activities for intelligent support, as also multi-modal data analysis for personal and collaborative interactions. These types of technologies aim to support reflection, self-regulation, student support and teaching processes.

LDE-CEL projects within this theme:

- Conversational Agents to support Goal-Setting
- Support Student Self-Regulation
- Customizable learning analytics dashboards
- Understanding MOOC Activities with Learning Analytics
- JELAI: a Jupyter environment with LA and AI support
- Enhancing Essay Writing and Programming Education with LA
- Multimodal Learning Analytics for Attentive e-Reading

Conversational Agents to Support Goal-Setting

How can learning analytics be used to support self-regulated learning in higher education environments?

LEARNING ANALYTICS
SELF-REGULATED LEARNING
GOAL SETTING
META-COGNITIVE PROCESSES
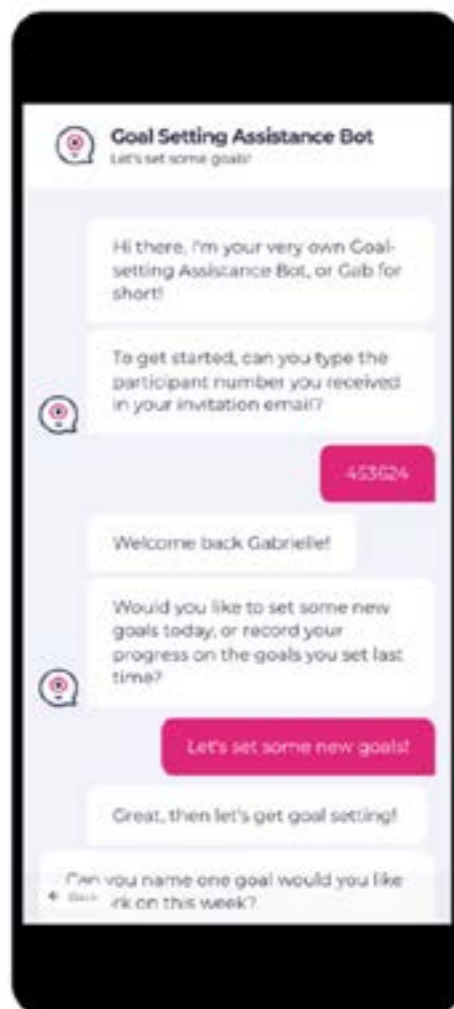
Problem
Self-regulated learning is a highly important skill for higher education students, with prior research finding that it plays a vital role in student learning and performance. This is especially true in technology enhanced learning environments. Goal setting interventions are a common approach to support self-regulated learning, however, there is little consensus in the field regarding how to design and implement effective goal setting interventions.

How can learning analytics be used to support self-regulated learning in higher education environments?

Approach
The increasing prevalence of technology in higher education has highlighted the importance of self-regulated learning skills for students in modern educational settings. The presence of this technology has also increased the ease with which large amounts of data can be collected about student behaviour and performance and used to offer them personalized support. Exploring how this data and technology can be leveraged to improve self-regulated learning is an important avenue of research with implications both for educational sciences research, as well as within educational practice.

Results
Throughout the course of this project we have designed, implemented, and tested a conversational agent, used to deliver a goal setting intervention to higher education students. In our first study we explored the effects of guidance and adaptive feedback on goal quality, and goal attainment. We found that guidance and feedback have a significant positive effect on goal quality, especially when combined, however they had no effect on goal attainment. To try and bridge the gap between goal quality and attainment we carried out a second study, exploring how monitoring and reflection support helped students transition from goal setting, into goal striving, thus increasing goal attainment. Our findings show that monitoring activities have a significant positive effect on goal attainment, while reflection had no significant effect.

With these findings we aim to inform both research on supporting self-regulated learning skills in higher education settings, as well as research on how to leverage conversational agents to deliver adaptive educational supports. Our focus is on doing research in real-life educational settings, to maximize the genera-lizability and potential impact of findings.

Recent Publications

Martins van Jaarsveld, G., Wong, J., Baars, M., Specht, M., & Paas, F. (2024). Goal setting in higher education: How, why, and when are students prompted to set goals? A systematic review. Frontiers in Education, 9. https://doi.org/10.3389/feduc.2024.1511605

Martins van Jaarsveld, G., Wong, J., Baars, M., Specht, M., & Paas, F. (2024). Scaling goal-setting interventions in higher education using a conversational agent: Examining the effectiveness of guidance and adaptive feedback. In The 15th International Learning Analytics and Knowledge Conference (LAK 2025). https://doi.org/10.1145/3706468.3706510

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Supporting Student Goal Setting and Self-Regulation

How do cognitive and metacognitive processes interact in the context of learning and in what ways does technology transform and facilitate these complex processes?

LEARNING ANALYTICS
SELF-REGULATED LEARNING?
GOAL SETTING
META-COGNITIVE PROCESSES

Problem
Self-regulated learning (SRL) stands as a crucial competency for learners in the 21st century. Research showed that equipped with strategies to regulate their learning and development, students demonstrated higher academic achievements and increased motivation. However, many students, across all age groups, often lack these essential SRL skills or struggle to effectively apply them. This challenge is exacerbated in digital and remote educational settings, where students operate autonomously without the traditional support provided in face-toface learning environments.

Approach
Grounded in Zimmerman's SRL model and the latest educational psychology research, we have developed an educational application, GoaLearn App, aimed at supporting students' SRL process. This application is designed to equip students with the necessary tools and guidance to take charge of their learning experience, set academic goals, manage tasks, and effectively monitor their progress.

One notable feature is its incorporation of SRL prompts and surveys to facilitate reflection at various learning stages, a component often absent in existing goal-setting apps or planners. Through the collection of real-world data, our goal is to refine and enhance GoaLearn, ultimately empowering students at different age groups to become active agents in their learning journey.

Results
Students serve as the primary users of the app. Their interaction with the app involves planning and setting personal goals, carrying out tasks aimed at achieving those goals, and regularly reflecting on their progress. This continuous engagement with the app is designed to support their development and help them stay focused on their objectives.

Teacher accounts are designed to offer a range of additional features that cater specifically to the needs of educators. Teachers can create classes within the app, complete with the unique enrollment codes that facilitate easy student registration and organization. Moreover, the app enables teachers to create goal templates, allowing for the standardized setting of goals across different classes or group of students.

Support accounts can be registered on a school-by-school basis, allowing each institution to manage its own teachers effectively.

Publications

Zhang, S., Bryczkowski, J. M., & Specht, M. (2024). GoaLearn App: A Goal-Setting and Monitoring Application to Support Students' Self-regulated Learning. In R. Ferreira Mello, N. Rummel, I. Jivet, G. Pishtari, & J. A. Ruipérez Valiente (Eds.), Technology Enhanced Learning for Inclusive and Equitable Quality Education (pp. 267–272). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-72312-4_38

https://goalearn.learn.ewi.tudelft.nl/

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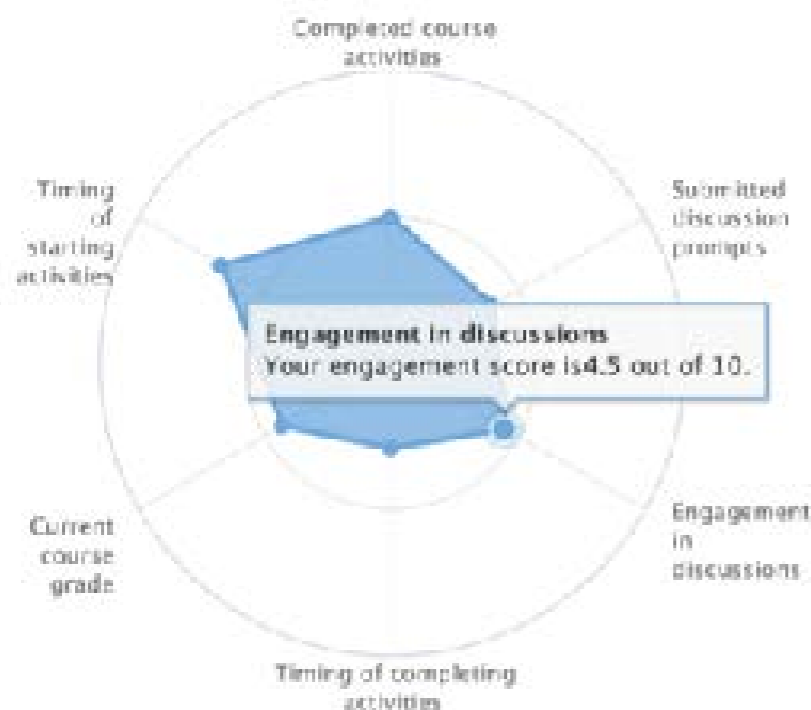MSc. Naomi Wahls - TU Delft
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Shirong Zhang

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Customizable Learning Analytics Dashboards

How do learners perceive and use dashboards so that we can build designs that fit learners' needs.

LEARNING ANALYTICS DASHBOARD

MASSIVE OPEN ONLINE COURSE (MOOC)

SELF-REGULATED LEARNING

FEEDBACK

Problem

As more and more teaching and learning moves online, students need to take more and more responsibility for their own learning and develop skills that allow them self-regulate their learning. An essential aspect of developing such skills is feedback, an educational support that requires significant efforts from instructors and TAs, especially in large courses. Learning analytics can support online learners by providing automated feedback based on the data traces they generate when interacting with the learning environment. To fully maximize the potential such tools have, we need to understand how learners read and interpret such information and the impact on their learning experience.

Approach

To research this topic, we built a learning analytics dashboard that allowed students to record their learning goals and to select the information they wish to receive as feedback. The assumption behind this study design is that students' dashboard configuration choices in an authentic learning setting will allow us to gain insight into learners' metacognitive and self-regulating processes by observing the decisions they make about their learning. The system was implemented and piloted in two massive open online courses (MOOCs) offered by Risbo, Erasmus University Rotterdam and ran for several months in 2020. By analysing the choices over 400 students made when configuring their dashboard, we gained insights into how learners' feedback needs are influenced by their goals and self-regulated learning skills.

Results

We found that learners primarily chose indicators related to completed activities, such as tracking course progress and completed assignments. This preference suggests an inclination toward measurable and task-

specific feedback over abstract or process-oriented feedback. However, self-regulated learning (SRL) skills like help-seeking and time management influenced preferences for specific indicators, such as engagement in discussions or procrastination metrics.

The findings underscore the need for dashboards that allow learners to tailor feedback tools to their individual needs. Since skilled learners are more likely to monitor behaviors associated with higher achievement, dashboards should include scaffolding features that help novice learners recognize the value of process-oriented feedback and more effective learning behaviors. Finally, Learning analytics dashboards should consider course-specific learning designs and demographics to maximize their relevance and effectiveness.

Publications

Jivet, I., Wong, J., Scheffel, M., Valle Torre, M., Specht, M., & Drachsler, H. (2021) Quantum of Choice: How learners' feedback monitoring decisions, goals and self-regulated learning skills are related. In LAK21: 11th International Learning Analytics and Knowledge Conference (LAK21), April

Jivet, I. (2021). The Dashboard That Loved Me: Designing adaptive learning analytics for self-regulated learning. [Doctoral Thesis, Open Universiteit: faculties and services]. Open Universiteit.

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Understanding MOOC Activities with Learning Analytics

How can Learning Analytics can support teachers by providing statistics based on the data traces that students generate when interacting with online learning environments.

LEARNING ANALYTICS

MOOC

ONLINE LEARNING

DATA LITERACY
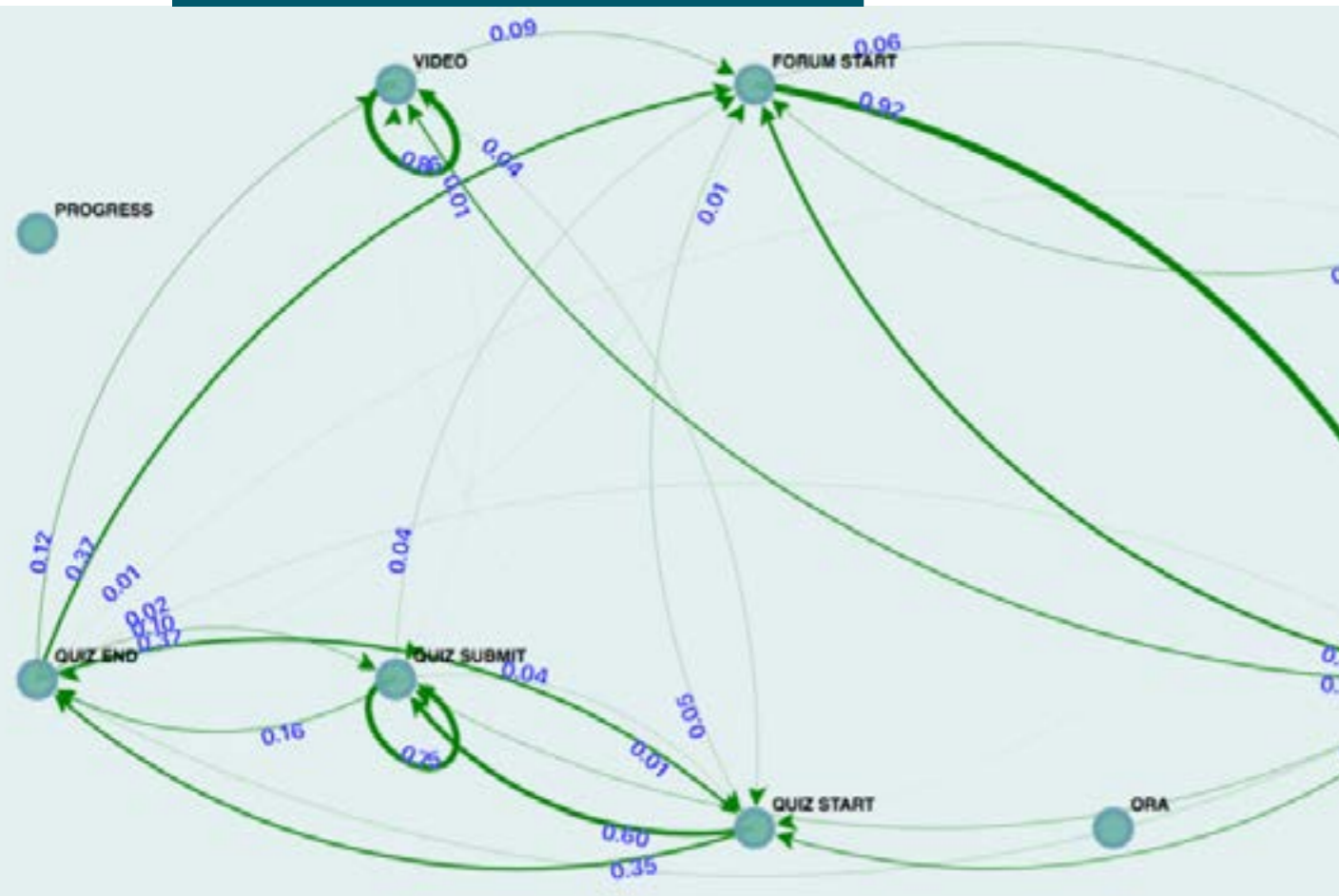
Problem
Understanding what is going on in large scale online courses and MOOCs is a challenge. ELAT was created to make Learning Analytics on edX data accessible for instructors and researchers regardless of their technical knowledge. It is an open-source, installation-free, privacy-aware analysis tool. The main challenge is to develop senseful indicators and reflect on measures that help to understand relevant student behaviour and predict related performance measures. Often for educators it is a key challenge do access and work with the available data in an educational setting.

Approach
ELAT (edX Log-data Analysis Tool) attempts to fulfil a need for simple processing of MOOC data for Learning Analytics, before its design, we reviewed existing solutions for this problem, and we found that most of the tools in published work are outdated and simply can not be used. Others require institution-wide efforts, both in IT-infrastructure and setup, while ELAT can be used in the browser by any instructor or researcher with access to edX data logs. In addition, the project is based on MOOCdb, which defines a session-based database schema to aggregate the list of isolated events into meaningful learner. ELAT generates an initial set of theory-based visualizations, as well as downloadable files for further analysis.

Results
The ELAT environment was used in several studies and research projects at the TU Delft. After a first publication at the LAK conference in 2020, projects on student activity analysis as also analysis of existing datasets have been performed. The research developed around questions of gender divide, linking value creation to course activities, and lifelong learning analytics.

Publications and Prototypes

Manuel Valle Torre, Esther Tan, and Claudia Hauff. 2020. EdX log data analysis made easy: introducing ELAT: An open-source, privacy-aware and browser-based edX log data analysis tool. In Proceedings of the Tenth International Conference on Learning Analytics & Knowledge (LAK '20). Association for Computing Machinery, New York, NY, USA, 502–511. https://doi.org/10.1145/3375462.3375510

Website: https://mvallet91.github.io/ELAT/

Tool: https://mvallet91.github.io/ELAT-Workbench/

NodeJS implementation for batch processing: https://github.com/mvallet91/ELAT-Node

MSc. Thesis: Debugging the Divide: Exploring Men's and Women's Motivations and Engagement in Computer Science MOOCs (2024), by Casper Hildebrand

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Social Network Analytics and Value Creation in Learning Networks

How can Social Network Analytics help to understand and faciliate the processes in Learning Networks.?

SOCIAL NETWORK ANALYTICS

LEARNING NETWORKS

VALUE CREATION

Problem
Often informal exchange in networks essentially contributes to the development of knowledge and expertise, but the faciliators and design parameters for successful networked learning are often complex to understand. To design an engaging and effective learning experience for a professional learning networks, we need to understand the values created by these experiences for learners and professionals.

Approach
The value creation framework (Wenger et al., 2011) provides a foundation for understanding networked learning. Our research aims to explore and identify effective pedagogical practices for designing engaging and impactful online learning experiences in networked environments. This includes investigating these networks' characteristics and evaluating them from value creation perspectives. Second, we need to explore the challenges and problems that professional learners face in everyday practice. Third we need to develop and validate robust assessment methods that can effectively evaluate the quality and impact of professional learning occurring within networked learning platforms.

Results
Our findings emphasize how these values contribute to professional development on an individual and collective level. Second we identify characteristics of successful learning networks on different value cycles. Third we designed interventions to demonstrate the potential of applying these characteristics in the design of new networks.

Publications

Soleymani, A., De Laat, M., Itard, L., & Specht, M. (2024). How Networked learning can facilitate professional development? In Proceedings of the International Conference on Networked Learning, 13. https://doi.org/10.54337/nlc.v13.8543

Soleymani, A., De Laat, M., & Specht, M. (2024). Evaluating Professional Learning Networks using Value Creation Framework; A literature study. SSRN. http://dx.doi.org/10.2139/ssrn.4870033

Soleymani, A., Itard, L., de Laat, M., Valle Torre, M., & Specht, M. (2022). Using Social Network Analysis to explore Learning networks in MOOCs discussion forums. CLIMA 2022 Conference. https://doi.org/10.34641/clima.2022.300

Soleymani, A., Van Den Brom, P., Ahmed, S., Konings, M., Sjoer, E., Itard, L., Zeiler, W., De Laat, M., & Specht, M. (2023). Learnings networks and professional development in building energy management systems industry. Education Sciences, 13(2), 215. https://doi.org/10.3390/educsci13020215

Soleymani, A., De Laat, M., & Specht, M. (2024). A Game-based Professional Development Network in Computer Science Education; Evaluating Value Creation, Motivation and Personal Experience. The Electronic Journal of e-Learning. [Submitted].

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JELAI: a Jupyter Environment with LA and AI support

What patterns of help-seeking behavior do learners use when they interact with Large Language Models (LLMs) during learning tasks? What are the effects of different patterns on the students' performance and learning gain? Can students be guided to use strategies with positive effects?

INTERACTION ANALYTICS

LLM-BASED TUTORING

FEEDBACK GENERATION

HELP SEEKING
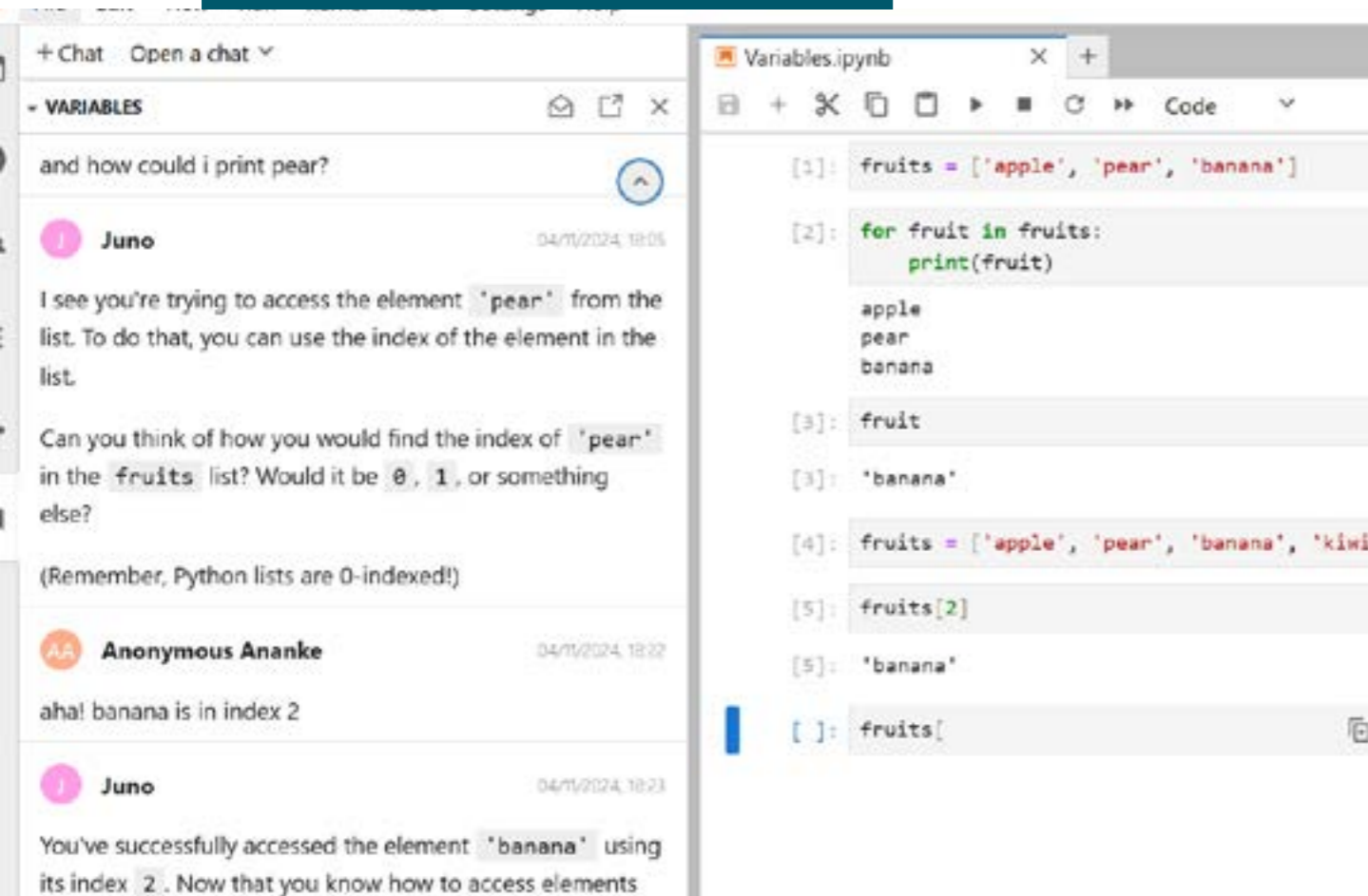
Problem
The increasing use of generative AI, particularly Large Language Models (LLMs), in education raises concerns about its impact on students' learning and skill acquisition, such as critical thinking, self-reflection, and help-seeking. While AI has the potential to enhance learning, it is essential to understand how students are using these tools to inform the design of educational systems and tasks that foster these key skills.

Approach
The Jupyter Environment with LA and AI support (JELAI) is an open-source, modular experimental environment designed to capture student interactions within the Jupyter notebook and with an embedded AI assistant. By integrating both data sources, JELAI enables realistic studies of student-LLM interactions, identifying comprehensive learning behaviors. Additionally, it facilitates real-time interventions via the assistant, adding contextual guidance for students and providing a responsive interface to address their learning needs as they work with LLM support for all ty0pes of tasks typically performend in Jupyter notebooks.

Results and impact
In first studies we could analyse the type of help seeking behaviour that students have in Jupyter based learning environments and how their behaviour impacts the learning outcomes and the reliance on assistance. The future research based on Jelai allows for two different types of study directions:

- Learning Analytics on hybrid problem solving: Detailed analysis of user behaviour based on logging while problem solving and working on complex problems. In these studies we will use different Jupyter environments from learning instroductionary programming to learning statistics and machine learning in higher education and can analyse the problem solving and help seeking behaviour of students for research purposes.

- Personalised Prompting of LLM based tutors: Based on the analysis of behaviour and problem solving we expect different effects on students learning outcomes, in a second series of studies we want to investigate the impact of pedagogical prompting of LLMs and the impact of these onto the learning outcomes.

Publications and Prototypes

Code Repository: Valle Torre, M. (2024). JELAI [Python]. https://github.com/mvallet91/JELAI (Original work published 2024)

Valle Torre, M. (in progress). Introducing JELAI, a Jupyter Environment for Learning Analytics and AI

In progress: Van der Velden, T. (2024) Using LLMs for support in high-school programming education [Master's thesis, Delft University of Technology]. Delft.

Valle Torre, M. (2023). Learning Sequence Analytics for Support in Learning Tasks. EC-TEL Doctoral Consortium (DCECTEL 2023) co-located with the 18th European Conference on Technology Enhanced Learning (EC-TEL 2023), Aveiro, Portugal, 4-8 September 2023, 57–62. https://ceur-ws.org/Vol-3539/paper9.pdf

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Enhancing Essay Writing and Programming Education with Learning Analytics

How can Learning Analytics help lectuers and learners? How can main activities as writing essays or learning software development be enhanced with dedicated Learning Analytics?

LEARNING ANALYTICS

ARTIFICIAL INTELLIGENCE

FEEDBACK

AUTOMATED ESSAY SCORING

PROGRAMMING EDUCATION

Essay

Censorship, @CAPS1 or @CAPS2? I can understand why libraries would decide to keep certain books off their shelves. Libraries are a place for learning and work. If you were sitting near someone at a public library who was reading smut you could feel awkward. Although some people @MONTH1 find certain items unoffensive, other @MONTH1 disagree. Imagine you are a mother with a young child who decided to wonder through the library. Your child finds a magazine. It's '@CAPS3'. Not something that you are going to want to explain to your child. If the library were to have not kept the magazine, it never would have happened. Libraries are a public place that should be taken seriously. If people really want to find something that is inappropriate they can find it somewhere else. The modern world today makes it easy for people to find just about anything without a large hassle. Therefore it should be fine to keep certain materials out of our libraries. How can people take libraries seriously if there are dirty books, or books with rude language, and scandalous themes. If you are trying to get work done or learn and there are distracting items on the shelves then it @MONTH1 make things more difficult. Libraries are serious places and should be treated as such.

Improve the Highlighted Sentence

You can improve the formality by rephrasing the sentence.

- **Formality**: Formality is defined as the word-use in text. We follow the definition of this paper.
- **Rephrasing**: Try to rephrase this sentence

If you were sitting near someone at a public library who was reading offensive material you could feel awkward.

✔ Check   Save Improvement   🗐 Suggestion   ↺ Undo

[13:00:48] You improved by 14%

Problem

Learning Analytics and AIED is a broad field of educational research. In the last 6 years different pilots have been established for enhancing programming education or essay writing as also enhancing teacher support for giving personalised feedback in these domains.

Essay Writing with Revision Coach

The rising number of students challenges the teacher's time-consuming task to provide consistent and high-quality feedback for all students. Therefore, this work proposes RevisionCoach – an automated writing feedback system that iteratively constructs educational, localized feedback to assist students to learn how to write. RevisionCoach's objective is to educate, and for that reason, the design considers learning by deliberate practice, differentiated learning, and self-regulated learning.

LLM-Based Learning Analytics and Interventions

Learning Analytics systems often fall short in offering detailed, actionable insights that educators can use to enhance their teaching. To address this, we propose a system leveraging Large Language Models to analyse programming submissions and generate actionable analytics. The study focused on two primary research questions regarding the accuracy of LLMs in classifying programming submissions and identifying common issues, and educators' perceptions of the usefulness of the system. Through a system evaluation and focus group, we found that LLMs can analyse SQL assignment submissions with reasonable accuracy and can identify common issues.

Learning Analytics for Introductory Programming

Due to the increase in student numbers, the amount of time teachers have for each individual decreases. This work makes use of WebLab data of the Introduction to Python course. To provide more useful information for teachers in introductory programming assignments, this work applies learning analytics to revision history of the student submissions of this course. The revision history provides more insight into the progression of the students throughout the assignment compared to only the final solutions. With these data, this work clusters and analyzes student submissions to provide instructors with information about the types of submitted solutions, students who struggled with the assignment, and the biggest hurdles for the students.

Publications

Oudsen, E. M. (2021). Learning Analytics of Beginner Programming Assignments for Teachers. https://repository.tudelft.nl/record/uuid:f282be68-6a17-441c-bc64-1eb21989ccb8

van der Laan, P. J. (2021). Automated Writing Feedback. https://repository.tudelft.nl/record/uuid:440cc75f-6695-4d4a-94d5-f79532ed0d63

Busropan, C. B. Z. (2024). Enhancing Programming Education Through LLM-Based Learning Analytics and Interventions. https://repository.tudelft.nl/record/uuid:caace3a4-c2ea-430b-a4e6-97976dca803a

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Multimodal Learning Analytics for Attentive e-Reading

What theoretical and technical approaches can be taken to recognize learners' attention regulation in e-reading for higher education?

How can automatic AI-based real-time feedback in e-reading assist attention management for higher education learners on their knowledge gain, perceptions, and interaction qualities with the system?

MULTIMODAL MACHINE LEARNING

MULTIMODAL LEARNING ANALYTICS

REAL-TIME FEEDBACK

COMPUTER-MEDIATED LEARNING

CONVERSATIONAL AGENTS AND ROBOTS

Problem

E-learning has shifted the traditional paradigms of knowledge gain in higher education, offering more flexible, ubiquitous, and personalized learning experiences. Though educators bring invaluable expertise, empathy, and contextual understanding of the educational experience, they are constrained by their capacity to interpret and respond to the myriad learner needs in real-time and at scale. On the other hand, information about the learning and learners can be captured through multiple data streams and processed based on multimodal reasoning.

Approach

This work adopts a holistic approach, intertwining Learning Analytics and feedback as an inherent loop, empowered by machine learning as a means of multimodal reasoning and feedback provision via the computer and peripheral agents, such as a humanoid robot. First, human attention and its indicators are investigated to capture learners' distractions during e-reading. Second, a real-time feedback approach is studied, aligning feedback interfaces, content, and timing in line with learning outcomes and learners' perceptions.

Results

The project led a) to several valueable datasets for future training and referencing of machine learning models, b) machine learning models for detecting and classifying attention regulation behaviour, and c) empirical data about interventions for attentive e-reading.

Publications

Lee, Yoon, and Marcus Specht. "Can We Empower Attentive E-Reading with a Social Robot? An Introductory Study with a Novel Multimodal Dataset and Deep Learning Approaches." LAK23: 13th International Learning Analytics and Knowledge Conference, 2023, pp. 520–30.

Lee, Yoon, et al. "Role of Multimodal Learning Systems in Technology-Enhanced Learning (TEL): A Scoping Review." European Conference on Technology Enhanced Learning, Springer Nature Switzerland Cham, 2023, pp. 164–82.

Lee, Yoon, et al. "Behavior-based Feedback Loop for Attentive E-reading (BFLAe): A Real-Time Computer Vision Approach." MiGA. 2023.

Lee, Yoon. "What Attention Regulation Behaviors Tell Us About Learning in E-reading?: Adaptive Data-driven Persona Development and Application based on Unsupervised Learning." IEEE. 2023.

Lee, Yoon, et al. "Multimodal WEDAR dataset for attention regulation behaviors, self-reported distrac-tions, reaction time, and knowledge gain in e-reading." 2023.

Lee, Yoon, et al. "Multimodal SKEP dataset for attention regulation behaviors, knowledge gain, perceived learning experience, and perceived social presence in e-learning with a conversational agent." 2023

Lee, Yoon, et al. "WEDAR: Webcam-Based Attention A nalysis via Attention Regulator Behavior Recognition with a Novel E-Reading Dataset." Proceedings of the 2022 International Conference on Multimodal Interaction, 2022, pp. 319–28.

Team

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2.
Digital Literacy and Future Competences

About digital literacy:

Digital literacy needed to study today is manifold, this ranges from having the skills to work with digital tools in general, the analysis and interpretation of data (data literacy) as also the skills to understand and work with computational tools in learning and teaching (computational thinking).

This research line brings together projects to understand and innovate learning and teaching with digital means including tools, data and algorithms as also research on how humans can be supported in developing the necessary skills. This led to publications that focus on defining literacy in the digital age, assessing and measuring computational thinking skills, as also on digital collaboration skills and learning programming and algorithmic thinking.

LDE-CEL projects within this theme:
- Learning from reading code.
- Formative assessment of computational thinking.
- Gender in Computer Science

Learning from reading code

My research approaches the learning and teaching of a programming language from a natural language perspective. In particular, it focuses on code-reading aspects of programming, such as reading exercises and the naming of variables.

PROGRAMMING EDUCATION
READING COMPREHENSION
FORMATIVE ASSESSMENT

Problem
Code reading and naming play a big role in understanding code, but while reading exercises are getting increasing attention in research, little work is known that covers if, and how, naming should be part of programming education. Occasional (reported) efforts to incorporate naming include the development of code quality rubrics that involve naming as one explicit aspect to review and give feedback to students on their assignments. It was found that feedback on naming practices, good and bad examples, and feedback on code quality, was highly valued and asked for by students. This suggests that topics such as readability, including naming, might not get enough dedicated attention in educational settings. My research is the first to conduct comprehensive investigations into this topic.

Since TU Delft offers programming courses to many different students across faculties, this research's outcomes are highly relevant. Outcomes are, for example, insights into how naming practices can be addressed in existing curricula. Ultimately, the research aimed to encourage the discussion among researchers and practitioners that focuses on how to include valuable training in reading code and code quality. I believe that a focus on these elements increases the accessibility of programming for both students and teachers and facilitates good programmer habits.

Results
As the research shows, developers are still choosing non-specific names that hinder code comprehension and remain affected by naming choices. This begs the question of how novices and learners are affected by naming practices that they encounter, especially if they also have not learned the meaning of certain single-letter names, which might be common and obvious to professionals. Although research has yet to investigate how. Furthermore results show that natural language affects novices' program comprehension and potential learning, and also that educators and teaching materials introduce naming practices inconsistently and they rarely address which, when, and why naming practices are (not) meaningful.

Publications
Van der Werf, Vivian, et al. "Teachers' Beliefs and Practices on the Naming of Variables in Introductory Python Programing Courses." 2024. -Upcoming Dec2024

Van der Werf, Vivian, et al. "Variables and Variable Naming in Popular Programming Textbooks for Children and Novices." 2024. - Upcoming Dec2024

Van der Werf, Vivian, et al. "Variables in Practice. An Observation of Variables in Introductory Programming MOOC's." ITiCSE 2023. 2023.

Van der Werf, Vivian. "Fostering a natural language approach in programming education." Koli 2023. (Doctoral Consortium), 2023.

Van der Werf, Vivian, et al. "(How) Should Variables and Their Naming Be Taught in Novice Programming Education?" Proceedings of the 2022 ACM Conference on International Computing Education Research-Volume 2, 2022, pp. 53–54.

Van der Werf, Vivian, et al. "What Does This Python Code Do? An Exploratory Analysis of Novice Students' Code Explanations." Proceedings of the 10th Computer Science Education Research Conference, 2021, pp. 94–107.

Team

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Vivian van der Werf

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Formative Assessment of Computational Thinking

This research project aims to explore the topic of assessment of computational thinking (CT) in higher education regarding what and how to assess CT skills to support student to learn CT skills.

FORMATIVE ASSESSMENT

COMPUTATIONAL THINKING

PROGRAMMING EDUCATION

HIGHER EDUCATION
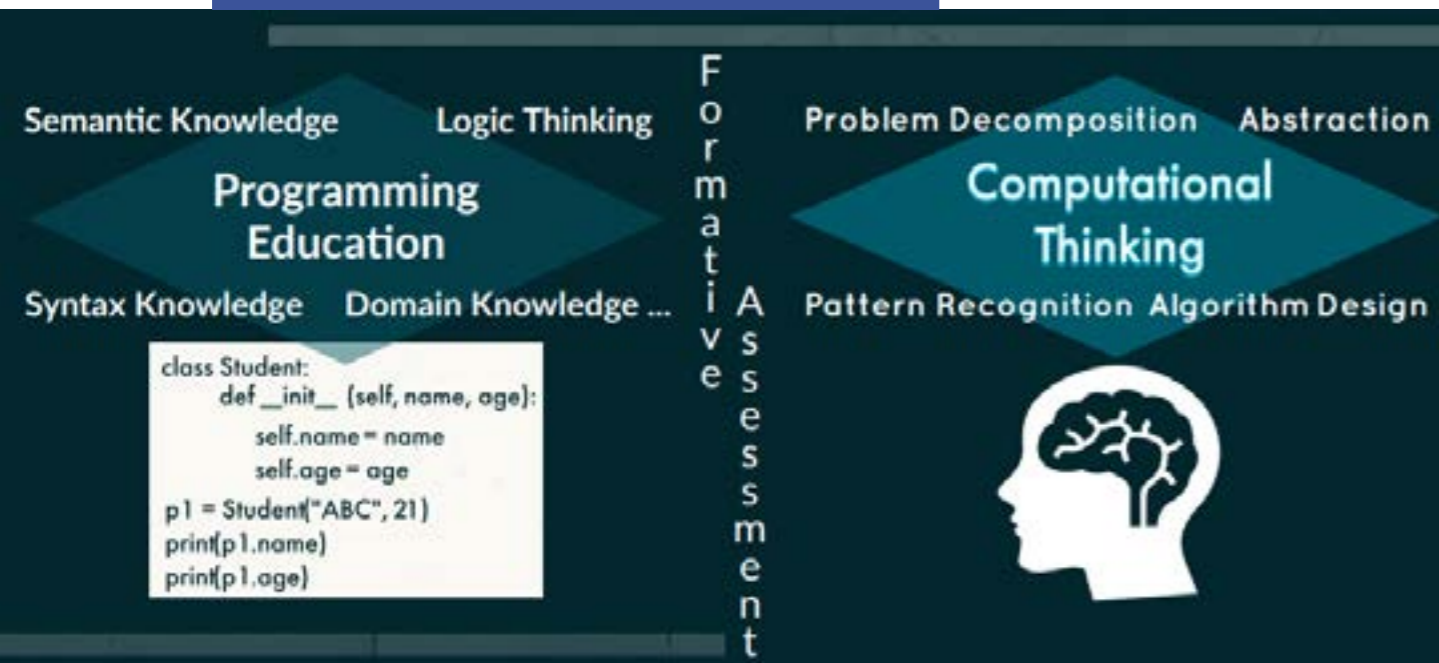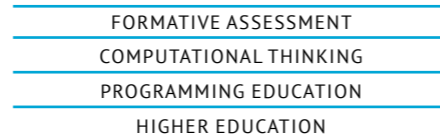
Problem

How can we thrive in an increasingly digital era? What should we teach to empower students to navigate their path in different scenarios? These questions prompt further exploration especially also in the field of programming education: Is coding essential for everyone, and is proficiency in coding alone sufficient for success? Many find the concept of Computational Thinking (CT) pivotal. Despite ongoing debates about its precise definition, efforts to integrate CT into educational programs are progressing globally.

However, there is little guidance on incorporating CT into higher education curricula as research often focuses on K-12 education. Experts have not reached a consensus on how CT should be taught, by whom, and how students, faculty, and staff should be held accountable for acquiring CT skills, knowledge, and attitudes.

Results

The findings from this dissertation underscore the critical need for targeted training programs to effectively promote CT across higher education. As CT becomes increasingly essential in our digital age, its integration into curricula requires comprehensive training for both educators and students. Our research reveals significant gaps in teachers' understanding of CT at a basic level, particularly in distinguishing it from traditional Computer Science concepts.

A survey of tertiary educators highlighted that many educators lack a clear grasp of CT's relevance across disciplines, compounded by limited formal training in CT. To address this, tailored training programs should be developed to deepen teachers' understanding of CT and provide strategies for incorporating it into their curricula. Such professional development would empower teachers and ensure consistent and effective CT education for students across various fields.

The need for student training is equally vital, particularly as CT becomes a foundational skill across disciplines. A study evaluating students' abstraction skills in sorting algorithms revealed significant proficiency gaps, especially among non-CS students. These students often struggle with the abstraction levels necessary for understanding and applying CT concepts, indicating a need for focused, discipline-specific training programs. Targeted educational interventions should be designed to build foundational CT skills, for example in algorithmic abstraction, tailored to the context of their specific fields. By addressing the training needs of both teachers and students, we can foster a more comprehensive and inclusive approach to CT education in higher education.

Recent Publications

Zhang, Xiaoling, et al. "Teachers' Intention to Integrate Computational Thinking Skills in Higher Education: A Survey Study in the Netherlands." 2024

Zhang, Xiaoling, et al. "A Systematic Umbrella Review on Computational Thinking Assessment in Higher Education." 2023

Zhang, Xiaoling, et al. "A systematic Review of Empirical Studies on Computational Thinking Assessment in Higher Education." 2023

Zhang, Xiaoling, and Marcus Specht. "Towards a Computer-Assisted Computational Thinking (CT) Assessment System in Higher Education." CEUR Workshop Proceedings, vol. 3292, CEUR-WS, 2022, pp. 12–21..

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Xiaoling Zhang

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Gender in Computer Science

We want to contribute to closing the gender gap in Computer Science, with a focus on girls and women. We aim to gain an understanding of the beliefs and interests children have related to Computer Science. Moreover, we are interested in how to make programming education for children in primary and secondary education gender inclusive.

PRIMARY AND SECONDARY EDUCATION
INCLUSIVE EDUCATION
GENDER
STEREOTYPES
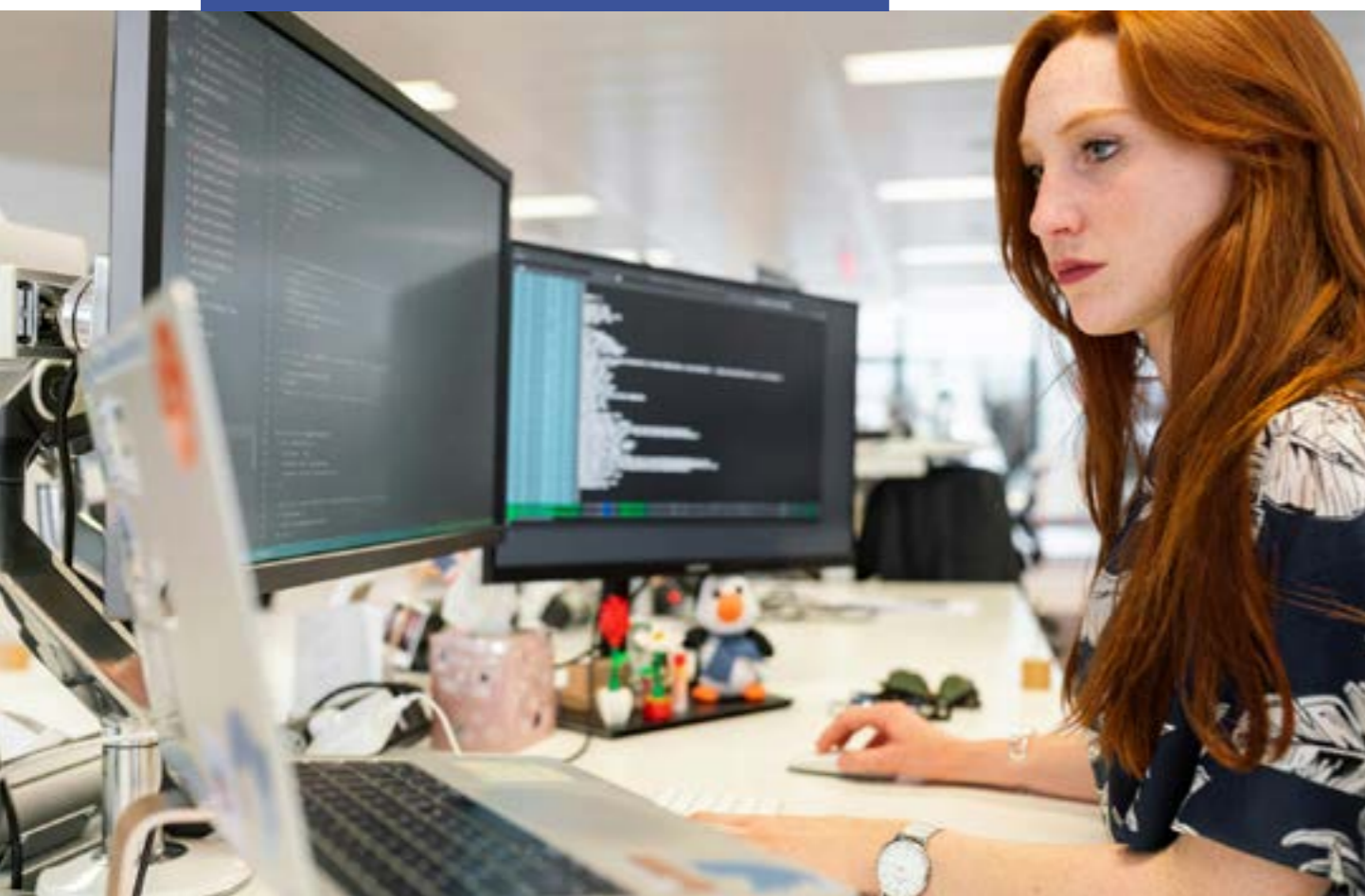
Problem
Women are underrepresented in the field of Computer Science (CS). In 2021, around 19% of ICT specialists in Europe are women. Increasing gender diversity in CS has multiple benefits, including more people who can fill the high amount of CS vacancies, women getting equal opportunities to enter a field with good perspectives, and more innovative ideas and outcomes. Moreover, since CS has a big impact on our society, we should enable everyone in our society to impact CS. However, a combination of factors causes girls and women to opt out of CS at different stages of their lives. In our work, we focus on children who are currently in primary or secondary school.

Beliefs and interests in Computer Science
To gain an understanding of children's beliefs and interests in CS in the Netherlands, we collected data at Science Live at NEMO Science Museum. We found that children believe programmers are male, like playing video games, and are likely to be social. Higher interest in a CS career is found in boys, children interested in computers or video gaming, children who gained programming experience at home or at an out-of-school activity, and children who believe programmers are social. This work is funded by VHTO, VSNU Digital Society and COMMIT/.

Gender-inclusive programming education
We analysed characters in programming books. Some books seem to target boys, some books are gender balanced, but no books seem to target girls. Furthermore, almost half of the characters are illustrated alone. We encourage authors, illustrators and publishers of these books to create a wider variety of books and emphasise the collaborative aspects of CS. We also explored gender differences in the programming language Hedy. We found that children, independent of their gender, worked the most on the

games. Some assignments did not have gender differences, indicating that programming assignments can be created in which children of different genders use similar commands and work on similar-sized programs. We believe that making our educational system and materials inclusive is part of the sustainable solution towards closing the gender gap in CS.

Publications
De Wit, Shirley, et al. "Children's Implicit and Explicit Stereotypes on the Gender, Social Skills, and Interests of a Computer Scientist". ICER 2021. 2021, pp. 239-251

De Wit, Shirley, et al. "Children's Interest in a CS Career: Exploring Age, Gender, Computer Interests, Programming Experience and Stereotypes". ICER 2023. 2023, pp. 245-255

De Wit, Shirley, et al. "Gender, Social Interactions and Interests of Characters Illustrated in Scratch and Python Programming Books for Children". SIGCSE 2024. 2024, pp. 262-268.

De Wit, Shirley, et al. "Gender Differences in Story, Game and Visual Adventures in Hedy". SPLASH-E 2024, pp. 1-11.

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3.
Augmented, Virtual and Mixed Reality for Education

About Augmented, Virtual and Mixed Reality for Education
Augmented and Virtual reality projects explore the possibilities of developing new learning materials with AR/VR, using game-based approaches for learning in virtual worlds as also individual and collaborative problem-solving in virtual environments.

New approaches also make use of 4d volumetric data and holographic projections to develop more immersive, authentic and engaging remote classroom interaction as also support joint teacher-learner experiences in virtual spaces.

LDE-CEL project within this theme
- Minecraft Virtual Campus
- Virtual reality and collaborative learning
- Holographic Projections for Augmented Classrooms
- Calligraphy Tutor for realtime feedback
- Virtual Reality for Vocational Education and Training

Minecraft Virtual Campus

Connecting students socially has never been more important. The goal of the Minecraft Virtual Campus is to boost social presence among TU Delft students and (re)familiarise them with their campus in a fun and engaging way. It is envisaged that social as well as pedagogical affordances of the virtual campus will be harnessed by both students and lecturers at TUD.

MINECRAFT
VIRTUAL CAMPUS
VIRTUAL IMMERSIVE ENVIRONMENT
SOCIAL PRESENCE

Problem
The implementation of the COVID19 restrictions has seen an unprecedented shift in the way we view education. Campuses became empty virtually overnight while lecturers strived to offer continued quality education remotely. Students have faced intense uncertainty, with many feeling isolation. During this period, a trend has emerged where many campuses (first occurring in the US) were being constructed in Minecraft with the goal to offer a place for students to both learn and connect.

TU Delft commenced its own virtual journey with the collaboration of TLS and LDE CEL. In early June 2020 the construction of a virtual campus to offer an immersive learning and fun environment for all of our students commenced. The campus features life like authenticity and has been constructed to scale. To date over 400 students have experienced the virtual campus and engaged in tours, game and social events. The objectives are to socially connect students, offer an engaging place to hang out, make contacts and discover the campus, host university events and, in time, facilitate education.

Approach
A collaborative approach to the construction and development of the campus was undertaken with TLS and LDECEL working together. Students across several faculties were recruited to construct the buildings and faculties while an external company, Shapescape was brought in to build and polish the interiors.

The official opening video of the Minecraft Campus of the TU Delft with introduction of Rector Prof. Dr, Rob Mudde can be found here.

Some background material for the different applications cases discussed in the workshops can be found in

Results
For the project different Minecraft application for education pruposes have been created. First of all joint workshops on how to use Minecraft in education have been organised, to understand the main potential and use cases.

As key use cases the following scenarios have been built and evaluated in informal piloting:

1. Welcome and guided tours on Campus for students, for this a guided tour has been implemented together with Education and Student Affairs and several students piloted the guided tour, on this tour also Non Player Characters have been integrated to tell about the history and function of Campus buildings.

2. Creative Space and Hangout: In the creativity space in which students could claim a space and present their own constructions to the Minecraft community. This piloting led to hundreds of students registering within the first week of opening the creative space of the TUD Campus.

3. Competitions for construction and modification of the Campus Space. For these dedicated instances of the Campus Model of TUd have been deployed and in open weeks students modified the existing model to present proposals for modification of the campus.

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Virtual Reality for Collaborative Learning

How do aspects of Virtual Reality affect dimensions of Collaborative Learning?

VIRTUAL REALITY

XR

COLLABORATIVE LEARNING

HIGHER EDUCATION

COMPUTER-SUPPORTED COLLABORATIVE LEARNING

Problem

While research on Virtual Reality's potential for education continues to advance, research on its support for Collaborative Learning is small in scope. With remote collaboration and distance learning becoming increasingly relevant for education (especially since the COVID-19 pandemic), an understanding of Virtual Reality's potential for Collaborative Learning is of importance. To establish how this immersive technology can support and enhance collaboration between learners, this systematic literature review analyses scientific research on Virtual Reality for Collaborative Learning with the intention to identify 1) skills and competences trained, 2) domains and disciplines addressed, 3) systems used and 4) empirical knowledge established.

By researching how different aspects of Virtual Reality can be used to support key dimensions of successful Collaborative Learning, Nesse's research aims to provide guidelines in regards to how these aspects can be implemented to facilitate and enhance collaboration between group members in educational settings. Within Nesse's research, three hyptheses will be tested:

1. Higher, more realistic representations of users lead to users having a higher motivation to engage with each other in the virtual, which in turn leads to higher quantity and heterogeneity in participation;
2. Enabling users to visualize their behavior and actions to other users leads to higher shared situational awareness between them, in turn allowing them to more effectively build upon each other's contributions;
3. When users have a higher control of the virtual environment (both visually and content-wise), the shared focus between users increases, leading to a higher on-task discourse in the group;

Approach

Based on the literature reviewed, skills and competences developed are divided into five categories. Systems primarily use monitor-based Virtual Reality and mouse-and-keyboard controls. A general optimism is visible regarding the use of Virtual Reality to support and enhance Collaborative Learning

Five distinct affordances of Virtual Reality for Collaborative Learning are identified: it 1) is an efficient tool to engage and motivate learners, 2) supports distance learning and remote collaboration, 3) provides multi- and interdisciplinary spaces for both learning and collaborating, 4) helps develop social skills and 5) suits Collaborative Learning-related paradigms and approaches.

Publications

Van der Meer, Nesse, et al. "Virtual Reality and Collaborative Learning: A Systematic Literature Review." Frontiers in Virtual Reality, vol. 4, 2023, p. 1159905.

Van der Meer, Nesse, et al. "Virtual Reality and Collaborative Learning in Higher Education: A Research Thesis Proposal." In Adjunct Proceedings of the ACM International Conference on Interactive Media Experiences: IMX 2021. New Jersey Institute of Technology. 2021.

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Holographic Projections for Augmented Classrooms

What are the implications of using Holographic medium for blended and distance learning?

HOLOGRAMS

MIXED REALITY

SOCIAL PRESENCE

DISTANCE LEARNING

Problem

With the increasing digitalization of education in TU Delft, the shift towards blended and distance learning as a dominant form of education is inevitable, and ongoing. This imposes a new set of educational requirements and demands from teachers and students. It is evident that the traditional method of delivering learning content in the form of recorded lectures such as videos, fails to meet these requirements.

This is more so in the context of teleconferencing tools currently used for synchronous collaboration in educational context. The HoloLearn project explores new media such as holograms, as the future of instructional medium in TU Delft. The project evaluates students and teacher requirements across various dimensions such as synchronous and asynchronous lectures, co-located and distributed collaborative settings etc. The findings of the project play a vital role in preparing TU Delft for the ongoing shift educational shift towards blended and distance settings. The project has build a prototype for so well presenting lecturers on a semi trasnparent glasswall as also an immersive environment which integrated VR models of a classroom and holograms from sensor scanning of participants.

Approach

The HoloLearn infrastructure makes it possible for teachers to provide synchronous lectures to both on-site and online students at the same time. This eliminates the need for teachers to always be physically present at a specific facility to give lectures. A depth camera captures, and uploads, color and depth video streams of a teacher to the HoloLearn server which is then stored and/or forwarded to students. The teacher is rendered as a hologram in the client side using indexed mesh construction and floating point cloud methods. During synchronous sessions, students can attend the lecture online in their desktop computers via a browser or Oculus GoTM virtual reality (VR) glasses.

In the remote classroom the project uses a semi-transparent screen onto which the teacher is projected after removing the background from the video stream which gives the illusion of the teacher being physically present in the classroom. Furthermore, the HoloLearn infrastructure stores lectures on the server to provide an asynchronous holographic experience to students. Students can remotely play back the recorded lecture in their desktop computers or VR glasses at their convenience.

Publications

Limbu, Bibeg, et al. "HoloLearn: Towards a Hologram Mediated Hybrid Education." Smart Learning Ecosystems as Engines of the Green and Digital Transition. (Springer Nature Singapore), 2023, pp. 117-132

Quin, Tristan, et al. "HoloLearn: Using Holograms to Support Naturalistic Interaction in Virtual Classrooms." Proceedings of the 1st International Workshop on Multimodal Immersive Learning Systems, MILeS, 2021.

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Post-doctoral researcher

Calligraphy Tutor for Real-Time Feedback on Handwriting

How do the affordances and potentialities of multimodal immersive learning environments facilitate deliberate practice and influence the mastery of complex skills with handwriting as a primary application domain?

PSYCHOMOTOR SKILLS

SENSORS

MULTIMODEL LEARNING

Problem

The number of students per teacher in universities is expected to grow in coming years. This can affect the quality of education as the achievable degree of personalization of learning under such circumstances is reduced drastically. The importance of one-to-one learning with a teacher has been further reinforced in recent years by the framework of "Deliberate practice". Multimodal technologies such as sensors and actuators can supplement data from digital educational platforms to build a rich data-driven learner model. This learner model can, along with a similarly generated teacher or expert model can provide personalized contextual feedback to the learner. The Calligraphy Trainer project explores these potentialities of multimodal technologies in order to exploit the rich learner data for personalization of learning.

Approach

Multimodal immersive technologies have improved the feasibility and accessibility of implementing authentic computer-supported learning environments to develop complex skills. However, mastering complex skills still requires copious amounts of deliberate practice in an authentic environment. One of the contributing factors associated with mastering complex skills is the contextually cohesive interaction between the cognitive, affective, and psychomotor aspects of learning. This can result in cognitively demanding and complex learning experiences, particularly for novices.

However, adding wearable technology and sensors often associated with multimodal immersive learning technologies introduces more complications that exaggerate the situation. While multimodal technologies undoubtedly offer new avenues for enhanced mastery of complex skills, their learning design must be conscious to reap the positive benefits. The "Calligraphy Tutor"

project explores the use of multimodal immersive learning environments for mastery of complex skills via deliberate practice in the context of handwriting. It aims to uncover the design principles and study the implications of such principles on learning, as well as their lasting long-term impact.

Publications

Limbu, B. H., Jarodzka, H., Klemke, R., & Specht, M. (2019). Can You Ink While You Blink? Assessing Mental Effort in a Sensor-Based Calligraphy Trainer. Sensors, 19(14), 3244. https://doi.org/10.3390/s19143244

Dikken, Olivier, et al. "Deliberate Practice of Handwriting: Supervision Under the Ghost of an Expert." European Conference on Technology Enhanced Learning, Springer International Publishing Cham, 2022, pp. 434–40.

Dikken, O., Limbu, B., & Specht, M. (2022). Deliberate Practice of Handwriting: Supervision Under the Ghost of an Expert. Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 13450 LNCS, 434–440. https://doi.org/10.1007/978-3-031-16290-9_33

Limbu, B., & Chounta, I. (2025). Can the mighty pen be mightier? Investigating the role of haptic senses in Multimodal Immersive Learning Environments. Manuscript under review

Team

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Bibeg Limbu

Post-doctoral Researcher

Virtual Reality for Vocational Education and Training (VR4VET)

Enabling an understanding and awareness for job-seekers is essential for becoming motivated and engaged in making career choices. In the VR4VET project we created realisitic simulation environments of jobs to enhance the opportunity to develop a realistic image of what a day on the job might look like.

CAREER CONCULTING AND CHOICE

JOB SIMULATIONS

VIRTUAL REALITY

Problem

Currently, 3.1 million young people in Europe aged 15-24 cannot find a job. The number of people not in education, employment, or training aged 15-29 is 9.6 million, and they often cannot contribute to society because of low self-esteem, low motivation, low level of developing working skills, and lack of mastery in school and in daily life. At the same time, youth already participating in education and training does not always receive adequate information about possible career choices. Innovative solutions are needed to include these groups in the working life or training programs. Research in digital career guidance emphasizes online communication, video, chat, and other tools. Immersive technologies have been used in vocational education in several contexts, but their use in career guidance is largely unexplored.

Approach

The project proposes a new approach to vocational education and career guidance by applying Virtual Reality to allow active and engaging exploration of professions and introductory training. This approach can give young job seekers a more realistic picture of different jobs and a vital learning experience that is needed for decision-making learning competence. The project contributes to developing innovative digital career guidance methods, including young people with mental health and other employability challenges, supported by studies. The project develops competence, and counselling techniques for vocational education trainers and career advisors, boosting their digital competences, and aligning with EU Youth Guarantee and Bridge to Jobs initiative.

Results

In the project a simulation of a cloud engneering workplace was developed as fully immersive VR environment. The workplace was modelled in joint developments with the Techniek College Rotterdam and the TU Delft New Media Centre.

The project delivers three scenarios implemented as immersive VR worlds one for Blue Sector, one for the Building Industry and one for Cloud Engineering. Furthermore sharable assets and instructional components for learning and exploring the workplace have been developed. The reusable components are shared in the source code repository and include task related components as tablets, and task guidance and scaffolding, instructional Non Player Characters, and also collaborative learning elements as expert demonstration and observation.

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Norwegian University of Science and Technology
Techniek College Rotterdam
Technology Arts Sciences TH Köln
BZB Bildungszentren des Baugewerbes

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Scientific Director of LDE-CEL

4.
Educational Innovation, Leadership and Professionalisation

Besides building a research community to explore new possibilities of digital teaching and learning, the documentation of best practices, training of higher education teachers, and the development of an active community for learning innovation was a core ambition of LDE-CEL.

At the heart of this development is the linking of innovative educators and research. Structuring teaching as an iterative learning process that makes use of research to validate and evaluate innovations in different contexts can be seen as the core loop of the learning engineering process.

As a first step LDE-CEL performed an analysis and mapping of the current educational innovation centres in The Netherlands and mapped the main centres, their vision on educational innovation and the current research projects. In a second step the Centre did qualitative research on the educational innovation policies of four dutch universities collecting data in interviews with the management of these universities and identified different leadership styles for faciliating educational innovation.

Based on these findings, annual meetings, innovation rooms, as well as professionalisation opportunities have been developed. Furthermore MOOCs and joint initiatives as the "100 days of" festival at Delft University of Technology have been launched with other educational units.

Mapping Educational Innovation: the NEXUS report

Understanding and faciliating educational innovation is a complex topic. In a first step LDE-CEL established an overview of the state of art from 2019-2022 based on interviews and desktop research. In a second step via automatic analysis of research databases a comprehensive overview of topics and stakeholders in educational innovation has been built. The results are published in the NEXUS report.

EDUCATIONAL INNOVATION

TEACHING AND LEARNING CENTRES

PRFOESSIONAL DEVELOPMENT

Problem
Currently the playing field for innovation in education is active, but scattered, with individuals working on projects within their own little groups. A common issue is that not everyone is privy to the activities and projects that are being done at their own institution, let alone outside the University.

This lack of overview creates a sphere where similar projects run in parallel or teachers feel like they have to reinvent the wheel due to the lack of cohesion in activities. The creation of 'Hubs', 'Centres', 'Labs', 'Communities' etcetera (from here on: Hubs) is a first step towards centralising ongoing initiatives as well as supporting and encouraging teachers to connect and share experiences with colleagues.

Each university has a different organisational structure, a different vision, and a completely different execution of the existing initiatives on educational innovations. Some Universities strongly pursue their vision and strategy as a compass to implement particular programmes from the top down. Other Universities allow faculties to develop their own initiatives on education and innovation, whereas others again rely more on independent organisations or partners to collaborate with the University on education related projects. Some universities have one clear Centre or Hub for Education Innovation, whereas others have several centers or departments, at a central level or per faculty. Some Universities do not have any centralised initiatives at all.

Approach
In the NEXUS project LDE-CEL has been building a database of Educational Innovation Hubs in the Netherlands. The project started with online research and interviews with the managers and coordinators of 25 Educational Innovation Centers at all 14

Universities. The project developed a comprehensive overview of all teaching and learning fellows appointed at these universities as also the main centre teams and research and innovation staff (about 2000). From this starting point an analysis of authored publications and databases has been performed and overlaps in topics as also co-authorship of research and innovation studies has been identified. Based on these analysis an online tool has been developed to explore specific topics and identify currently ongoing educational innovation and research projects as also to detect blind spots in the ongoing projects.

The main findings have been collected in an interactive report published open access and launched cooperation with ongoing national research activities as the National Regieorgan Onderwijs as also NPULS project. The report was updated in additional interviews in 2022.

Results

Specht, M., Walsarie-Wolff, S. Utama, C. (2021). Mapping Educational innovation in the Netherlands, the NEXUS Report. Whitepaper LDE-CEL. Delft. The Netherlands.

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Leadership Strategy and Educational Innovation

Establishing a culture for educational innovation and balancing top-down and bottom-up initiatives is a challenging task. The presented research projects help to understand educational innovation policies and characteristics of successful course innovations.

ENGINEERING EDUCATION

CHALLENGE BASED LEARNING

INNOVATION LEADERSHIP

EDUCATIONAL INNOVATION

Problem
Establishing a climate for educational innovation and managing innovations to be embraced and flourish in an educational setting is a challenging endavour. Educational innovation processes are influenced by many factors as policies, opportunities for experimentation, educators and learner agency and autonomy, as also expectations of stakeholders.

Leadership in higher can influence the structural embedding of educational technologies in higher education institutions. However, HEIs are complex pluralistic organizational environments with loosely coupled systems, diffused power and goal ambiguity which makes governance of educational innovations a wicked problem in which they have to balance dynamic complex interactions while also setting out a clear vision and enacting this vision towards organizational goals.

Approach
In this project we approached the challenge of educational leadership from interviewing leaders from four dutch universities and analysing their approaches considering complexity leadership to identify currently implemented educational innovation policies. We investigated the data through the lens of complexity leadership theory in which three types of leadership play an important role: administrative leadership (i.e. top-down oriented), adaptive leadership (i.e. bottom-up oriented) and enabling leadership that emerges as a leadership type between administrative and adaptive leadership and contributes to governing innovation in complex environments.

Results
This study sheds light on how, in the case of HEIs as complex environments, leaders made strategic choices and followed up on them to enable the innovative

potential of the organisation

In a follow-up PhD project by Erna Engelbrecht, funded by the 4TU.Centre for Engineering Education, we are developing a comprehensive framework for evaluating educational innovations at the course level. By placing the Engineering Educator at the core, this framework seeks to advance scholarly evaluation practices that integrate qualitative and quantitative data to assess the impact of educational transformations while uncovering deeper insights into the complex contextual and social dynamics of the classroom. Through this approach, we aim to provide meaningful guidance for educators and institutions striving to make research-based improvements in teaching and learning.

Publications and References

Schophuizen, M., Kelly, A., Utama, C., Specht, M., & Kalz, M. (2023). Enabling educational innovation through complexity leadership? Perspectives from four Dutch universities. Tertiary Education and Management, 29(4), 471-490.

Evaluating Innovation Project at the 4TU.CEE

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Massive Open Online Course: Multidisciplinary Research Methods for Engineers

The Leiden-Delft-Erasmus Centre for Education and Learning (LDE-CEL) has launched its MOOC on Multidisciplinary Research Methods for Engineers on edX. This MOOC aimed at engineers and other STEM related disciplines explains the fundamentals of planning and carrying out state-of-the-art qualitative and quantitative research in different phases of an innovation or research project.

MOOC
RESEARCH METHODS
ONLINE EDUCATION
MULTIDISCIPLINARY EDUCATION

Problem

The increasing use of data to understand phenomena and evaluate designs and interventions in different disciplines has become more and more evident. As a result, engineers and other applied scientists find themselves increasingly collaborating in multidisciplinary fields when carrying out research to remain innovative. These research methods tend to differ greatly from those used in engineering. This is why the interuniversity, interdisciplinary Leiden-Delft-Erasmus Center for Education and Learning decided to create this MOOC on Multidisciplinary Research Methods for Engineers and other STEM related fields.

This course helps learners to become successful multidisciplinary researchers in industry, non-profit, or academia. The course offers the fundamentals on how to plan and carry out state-of-the-art qualitative and quantitative research in different phases of an innovation or research project. The course has been designed by a team of experienced, multi-disciplinary researchers in education, engineering, and research methodologies and features experts in the field of research methodologies as guest lecturers. In the course, learners work towards creating a project plan for their research to give them a head-start in their research project.

Approach

The course consists of 6 modules, to cover the learning objectives:

Module 1: Introduction to Research
Module 2: Phases and Methods of Scientific Research
Module 3: Research Method Selection and Study Design
Module 4: Data Collection and Analysis
Module 5: Research Management, Documentation and Publishing
Module 6: Research Plan

Results

The MOOC ran for its first time in the spring of 2021and its fourth run started in the spring of 2024. To date, over 3,000 learners from more than 110 different countries have participated in the MOOC. The MOOC is popular among researchers with a STEM Master's degree who want to further develop their research skills in different domains. The course is also part of the course offerings of the TU Delft Graduate School. The MOOC will continue to run under the umbrella of Mechanical Engineering at Delft University of Technology. The MOOC has also been published as OpenCourseWare through TU Delft and as a result, is now being adapted for use in South Africa and Senegal through an Erasmus+ funded project.

Publications

MOOC on edX: https://www.edx.org/learn/engineering/delft-university-of-technology-multidisciplinary-research-methods-for-engineers?correlationId=a6fc87e2-a1c5-4962-9698-3197eba281e0

MOOC on OpenCourseWare: https://ocw.tudelft.nl/courses/multidisciplinary-research-methods-for-engineers/

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Community Building with Annual Meetings and Innovation Days

Linking educators and researchers around new topics and educational innovation and research has been the focus of the innovation days. The days included inspirational keynotes from international leaders, workshops to start handson activities as also a platform to link to other LDE community members.

COMMUNITY BUILDING
EDUCATIONAL INNOVATION
EDUCATIONAL RESEARCH

Relevance
From 2018 to 2024 LDE-CEL organised 6 Annual meetings with a dedicated focus on one of it's spearheaded topics. Additionally innovation days have been organised to develop a more hands on practice and stimulate the discussion around educational innovation.

Some highlights have been innovations days on virutal, augmented and extended reality, an innovation day on learning analytics, as also an international conference on digital skills linked to an innovation day.

Annual Meeting 2018 Curious, Explore, Learn and Share: The first LDE-CEL meeting 2018 was focused on bringing together educators, innovators, and researchers on digital education. With 6 EdTech startups presenting their developments, workshops on digital skills, serious games and mobile learning a rich program was discussed with 120 participants.

Annual Meeting 2020 Connecting an online world for learning: In 2020 the Annual meeting of CEL had to be done online presenting a rich variety of possibilies for online events as a virtual online space, an online exhibiiton in VR, as also the opening of the TUD Minecraft Campus. This event attracted 140 particpants also with keynotes from Prof. Justin Reich, Director MIT Teaching Lab on the topic of "Why Technology Alone Can't Transform Education". All session recordings can be found here.

Annual Meeting 2022 Developing a Culture of Learning Analytics: In 2022 a real international event with the focus on developing Learning Analytics in organisa-tions has been launched with highlights as a keynote by Simon Buckingham Shum from the University of Technology Sydney, Hendrik Drachsler from the Leibniz Institute for Research and Information in Education, as

also from Alyssa Wyse from the Learning Innovation Incubator from Vanderbilt University a tour de monde has been given on LA practices world wide. An event to which 130 participants contributed.

Annual Meeting 2024 Artificial Intelligence, Digital Education Research and Evidence: In 2024 the annual meeting was focused on the digital transformation of higher education driven by Artificial Intelligence. With keynotes by Prof Mutlu Cukurova from University College London, and Prof. Pierre Dillenbourg from EPFL the event brought together 120 participants to discuss the perspectives on teaching and learning in a world of AI and the role of research.

Beside these annual meetings a series of 15 innovation rooms with dedicated topics have been organised which hosted hands on workshops, inspiration talks with external experts as also exchange and community building on educational practices in the LDE context and beyond.

Resources

LDE-CEL Youtube channel with Recordings of Keynotes, Workshops https://www.youtube.com/@ldecel3092

Marcus Specht
Scientific Director of LDE-CEL

Publications

Ahmed, M. S., van der Velden, J., Soleymani, A., van den Brom, P., Konings, M., Itard, L., Specht, M., Sjoer, E., & Zeiler, W. (2022). Learning and Knowledge Transfer of Professionals within the Building Services Sector. CLIMA 2022 Conference.

Bermans, B., Tan, E., & Specht, M. (2021). Functionalities of Mobile Learning Apps and Potential for Data Integration in the Context of Higher Education: A Systematic Review.

Cambaz, D., & Zhang, X. (2024). Use of AI-driven Code Generation Models in Teaching and Learning Programming: A Systematic Literature Review. Proceedings of the 55th ACM Technical Symposium on Computer Science Education V. 1, 172–178. https://doi.org/10.1145/3626252.3630958

Chen, H., Tan, E., Lee, Y., Praharaj, S., Specht, M., & Zhao, G. (2020). Developing AI into explanatory supporting models: An explanation-visualized deep learning prototype. 14th International Conference of the Learning Sciences, 1133–1140. https://research.tudelft.nl/en/publications/developing-ai-into-explanatory-supporting-models-an-explanation-v

de Wit, S., Hermans, F., & Aivaloglou, E. (2021). Children's Implicit and Explicit Stereotypes on the Gender, Social Skills, and Interests of a Computer Scientist. Proceedings of the 17th ACM Conference on International Computing Education Research, 239–251. https://doi.org/10.1145/3446871.3469753

de Wit, S., Hermans, F., Specht, M., & Aivaloglou, E. (2023a). Children's Interest in a CS Career: Exploring Age, Gender, Computer Interests, Programming Experience and Stereotypes. Proceedings of the 2023 ACM Conference on International Computing Education Research - Volume 1, 1, 245–255. https://doi.org/10.1145/3568813.3600131

de Wit, S., Hermans, F., Specht, M., & Aivaloglou, E. (2023b). Exploring the Effects of the Hedy User Interface on the Development of CS Interest in Girls.

de Wit, S., Hermans, F., Specht, M., & Aivaloglou, E. (2024a). Gender Differences in Story, Game and Visual Adventures in Hedy. Proceedings of the 2024 ACM SIGPLAN International Symposium on SPLASH-E, 1–11. https://doi.org/10.1145/3689493.3689983

de Wit, S., Hermans, F., Specht, M., & Aivaloglou, E. (2024b). Gender, Social Interactions and Interests of Characters Illustrated in Scratch and Python Programming Books for Children. Proceedings of the 55th ACM Technical Symposium on Computer Science Education V. 1, 262–268. https://doi.org/10.1145/3626252.3630862

Di Mitri, D., Schneider, J., Limbu, B., Mat Sanusi, K. A., & Klemke, R. (2022). Multimodal Learning Experience for Deliberate Practice. In M. Giannakos, D. Spikol, D. Di Mitri, K. Sharma, X. Ochoa, & R. Hammad (Eds.), The Multimodal Learning Analytics Handbook (pp. 183–204). Springer International Publishing. https://doi.org/10.1007/978-3-031-08076-0_8

Dikken, O., Limbu, B., & Specht, M. (2021). Expert distribution similarity model: Feedback methodology for non-imitation based handwriting practice. CEUR Workshop Proceedings, 2979, 46–52.

Dikken, O., Limbu, B., & Specht, M. (2022). Deliberate Practice of Handwriting: Supervision Under the Ghost of an Expert. European Conference on Technology Enhanced Learning, 434–440.

Engelbrecht, E., Rooij, R. M., & Specht, M. M. (2022). Towards a multi-faceted framework for planning and evaluating innovation in Engineering Education. Education, 6, 18.

Facey-Shaw, L., Specht, M., Rosmalen, P. van, & Bartley-Bryan, J. (2020). Do Badges Affect Intrinsic Motivation in Introductory Programming Students? Simulation & Gaming, 51(1), 33–54. https://doi.org/10.1177/1046878119884996

Fanchamps, N. L., Slangen, L., Hennissen, P., & Specht, M. (2021). The influence of SRA programming on algorithmic thinking and self-efficacy using Lego robotics in two types of instruction. International Journal of Technology and Design Education, 31, 203–222.

Fanchamps, N. L., Slangen, L., Specht, M., & Hennissen, P. (2021). The impact of SRA-programming on computational thinking in a visual oriented programming environment. Education and Information Technologies, 26, 6479–6498.

Fanchamps, N., Slangen, L., Specht, M., & Hennissen, P. (2022). The Effect on Computational Thinking Using SRA-Programming: Anticipating Changes in a Dynamic Problem Environment. IEEE Transactions on Learning Technologies, 15(2), 213–222.

Fanchamps, N., Slangen, L., Specht, M., & Hennissen, P. (2023). Effect of SRA-programming on computational thinking through different output modalities. Journal of Computers in Education, 10(2), 433–462.

Jansen, M., Fanchamps, N., Milrad, M., Specht, M., & Hamidi, A. (2022). The TACTIDE EU STEM project: TeAching Computational Thinking with Digital dEvices. APSCE CTE-STEM 2022.

Jivet, I. (2021). The dashboard that loved me: Designing adaptive learning analytics for self-regulated learning. PhD Thesis. https://research.ou.nl/en/publications/the-dashboard-that-loved-me-designing-adaptive-learning-analytics

Jivet, I., & Saunders-Smits, G. (2021). The effect of the covid-19 pandemic on a mooc in aerospace structures and materials. In SEFI 49th Annual Conference (pp. 258-267).

Jivet, I., Viberg, O., & Scheffel, M. (2022). Culturally aware learning analytics. Companion Proceedings of the 12th International Conference on Learning Analytics and Knowledge, 186–188. https://www.researchgate.net/profile/Sanaz-Nazari/publication/360208122_Controlling_for_Speededness_in_PANCE_Examinees'_Responses_Using_Change-Point_Analysis/links/626842a98cb84a40ac8cc609/Controlling-for-Speededness-in-PANCE-Examinees-Responses-Using-Change-Point-Analysis.pdf#page=197

Jivet, I., Wong, J., Scheffel, M., Valle Torre, M., Specht, M., & Drachsler, H. (2021). Quantum of Choice: How learners' feedback monitoring decisions, goals and self-regulated learning skills are related. LAK21: 11th International Learning Analytics and Knowledge Conference, 416–427.

Kollom, K., Tammets, K., Scheffel, M., Tsai, Y.-S., Jivet, I., Muñoz-Merino, P. J., Moreno-Marcos, P. M., Whitelock-Wainwright, A., Calleja, A. R., & Gasevic, D. (2021). A four-country cross-case analysis of academic staff expectations about learning analytics in higher education. The Internet and Higher Education, 49, 100788.

Lee, Y., Chen, H., Tan, E., Praharaj, S., & Specht, M. (2020). Flower: Feedback loop for group work supporter. The International Learning Analytics and Knowledge Conference (LAK Demo Session). https://sambitpraharaj.com/documents/publications/LAK20_Demo_paper_Final.pdf

Lee, Y., Chen, H., Zhao, G., & Specht, M. (2022). WEDAR: Webcam-based Attention Analysis via Attention Regulator Behavior Recognition with a Novel E-reading Dataset. Proceedings of the 2022 International Conference on Multimodal Interaction, 319–328.

Lee, Y., Limbu, B., Rusak, Z., & Specht, M. (2023). Role of Multimodal Learning Systems in Technology-Enhanced Learning: A Scoping Review. European Conference on Technology Enhanced Learning, 164–182.

Lee, Y., Migut, G., & Specht, M. (2023a). Behavior-based Feedback Loop for Attentive E-reading (BFLAe): A Real-Time Computer Vision Approach. MiGA@ IJCAI. https://research.tudelft.nl/files/166552348/paper_6.pdf

Lee, Y., Migut, G., & Specht, M. (2023b). What attention regulation behaviors tell us about learners in e-reading?: Adaptive data-driven persona development and application based on unsupervised learning. IEEE Access. https://ieeexplore.ieee.org/abstract/document/10295465/

Lee, Y., & Specht, M. (2023a). Can We Empower Attentive E-reading with a Social Robot? An Introductory Study with a Novel Multimodal Dataset and Deep Learning Approaches. LAK23: 13th International Learning Analytics and Knowledge Conference, 520–530.

Lee, Y., & Specht, M. (2023b). Multimodal SKEP dataset for attention regulation behaviors, knowledge gain, perceived learning experience, and perceived social presence in e-learning with a conversational agent. https://scholar.google.com/scholar?cluster=1724927413889618355&hl=en&oi=scholarr

Limbu, B., Fominykh, M., Klemke, R., & Specht, M. (2019). A Conceptual Framework for Supporting Expertise Development with Augmented Reality and Wearable Sensors. In I. Buchem, R. Klamma, & F. Wild (Eds.), Perspectives on Wearable Enhanced Learning (WELL) (pp. 213–228). Springer International Publishing. https://doi.org/10.1007/978-3-319-64301-4_10

Limbu, B., Schneider, J., Klemke, R., & Specht, M. (2018). Augmentation of practice with expert performance data: Presenting a calligraphy use case. Proceedings of the 3rd International Conference on Smart Learning Ecosystem and Regional Development—The Interplay of Data, Technology, Place and People, Aalborg, Denmark, 22–24. https://scholar.google.com/scholar?cluster=16014075105894348155&hl=en&oi=scholarr

Limbu, B. H., van Helden, G., Barnes, J. S., & Specht, M. M. (2022). We can teach more than we can tell: combining Deliberate Practice, Embodied Cognition, and Multimodal Learning. In Multimodal Immersive Learning systems (pp. 15-21). CEUR-WS.

Limbu, B., Van Roijen, R., Beerens, M., & Specht, M. (2023). HoloLearn: Towards a Hologram Mediated Hybrid Education. In M. Dascalu, Ó. Mealha, & S. Virkus (Eds.), Smart Learning Ecosystems as Engines of the Green and Digital Transition (pp. 117–132). Springer Nature Singapore. https://doi.org/10.1007/978-981-99-5540-4_7

Limbu, B., Vovk, A., Jarodzka, H., Klemke, R., Wild, F., & Specht, M. (2019). WEKIT.One: A Sensor-Based Augmented Reality System for Experience Capture and Re-enactment. In M. Scheffel, J. Broisin, V. Pammer-Schindler, A. Ioannou, & J. Schneider (Eds.), Transforming Learning with Meaningful Technologies (Vol. 11722, pp. 158–171). Springer International Publishing. https://doi.org/10.1007/978-3-030-29736-7_12

Loh, H. S., Martins van Jaarsveld, G., Mesutoglu, C., & Baars, M. (2024). Supporting social interactions to improve MOOC participants' learning outcomes: A literature review. Frontiers in Education, 9, 1345205. https://www.frontiersin.org/articles/10.3389/feduc.2024.1345205/full

Martins van Jaarsveld, G. M., Wong, J., Baars, M., Paas, F., & Specht, M. (2021). Learning analytics supported goal setting in online learning environments. In EC-TEL (Doctoral Consortium) (pp. 4-14).

Martins van Jaarsveld, G., Wong, J., Baars, M., Specht, M., & Paas, F. (2024). Goal setting in higher education: How, why, and when are students prompted to set goals? A systematic review. Frontiers in Education, 9. https://doi.org/10.3389/feduc.2024.1511605

Martins van Jaarsveld, G., Wong, J., Baars, M., Specht, M., & Paas, F. (2024). Scaling goal-setting interventions in higher education using a conversational agent: Examining the effectiveness of guidance and adaptive feedback. In The 15th International Learning Analytics and Knowledge Conference (LAK 2025). https://doi.org/10.1145/3706468.3706510

Meulen, A. van der, Hermans, F., Aivaloglou, E., Aldewereld, M., Heemskerk, B., Smit, M., Swidan, A.,

Thepass, C., & Wit, S. de. (2021). Who participates in computer science education studies? A literature review on K-12 subjects. PeerJ Computer Science, 7, e807. https://doi.org/10.7717/peerj-cs.807

Al Owayyed, M., Tielman, M., Hartholt, A., Specht, M., & Brinkman, W. P. (2024). Agent-based social skills training systems: the ARTES architecture, interaction characteristics, learning theories and future outlooks. Behaviour & Information Technology, 1-28.

Praharaj, S., Scheffel, M., Drachsler, H., & Specht, M. (2021). Literature review on co-located collaboration modeling using multimodal learning analytics—Can we go the whole nine yards? IEEE Transactions on Learning Technologies, 14(3), 367–385.

Praharaj, S., Scheffel, M., Schmitz, M., Specht, M., & Drachsler, H. (2021). Towards automatic collaboration analytics for group speech data using learning analytics. Sensors, 21(9), 3156.

Praharaj, S., Scheffel, M., Schmitz, M., Specht, M., & Drachsler, H. (2022). Towards collaborative convergence: Quantifying collaboration quality with automated co-located collaboration analytics. Lak22: 12th International Learning Analytics and Knowledge Conference, 358–369.

Praharaj, S., Scheffel, M., Specht, M., & Drachsler, H. (2023). Measuring Collaboration Quality Through Audio Data and Learning Analytics. In Unobtrusive Observations of Learning in Digital Environments: Examining Behavior, Cognition, Emotion, Metacognition and Social Processes Using Learning Analytics (pp. 91–110). Springer International Publishing Cham.

Quin, T., Limbu, B., Beerens, M., & Specht, M. (2021). HoloLearn: Using holograms to support naturalistic interaction in virtual classrooms. Proceedings of the 1st International Workshop on Multimodal Immersive Learning Systems, MILeS.

Rienties, B., Divjak, B., Eichhorn, M., Iniesto, F., Saunders-Smits, G., Svetec, B., Tillmann, A., & Zizak, M. (2023). Online professional development across institutions and borders. International Journal of

Educational Technology in Higher Education, 20(1), 30. https://doi.org/10.1186/s41239-023-00399-1

Saunders, G. (2022). The future of women aerospace engineers in academia—A numbers game. 692–701. https://doi.org/10.5821/conference-9788412322262.1205

Saunders Smits, G., Van Helden, G., Van der Werf, V., & Specht, M. (2022). Using peer assessment in inclusive digital education. In Towards a new future in engineering education, new scenarios that european alliances of tech universities open up (pp. 2305-2308). Universitat Politècnica de Catalunya.

Schophuizen, M. (2022). Educational innovation towards organizational development: The art of governing open and online education in dutch higher education institutions. https://research.ou.nl/en/publications/educational-innovation-towards-organizational-development-the-art

Schophuizen, M., & Kalz, M. (2020). Educational innovation projects in Dutch higher education: Bottom-up contextual coping to deal with organizational challenges. International Journal of Educational Technology in Higher Education, 17(1), 36. https://doi.org/10.1186/s41239-020-00197-z

Schophuizen, M., Kelly, A., Utama, C., Specht, M., & Kalz, M. (2022). Enabling educational innovation through complexity leadership? Perspectives from four Dutch universities. Tertiary Education and Management, 1–20.

Schophuizen, M., Kreijns, K., Stoyanov, S., Rosas, S., & Kalz, M. (2021). Does project focus influence challenges and opportunities of open online education? A sub-group analysis of group-concept mapping data. Journal of Computing in Higher Education, 33(2), 255–280. https://doi.org/10.1007/s12528-020-09264-w

Soleymani, A., Aerts, T., De Laat, M., & Specht, M. (2024). Gamified Networked Learning Environments in Higher Education: A Study on Student Engagement and Value Creation in Computer Science. European Conference on

Games Based Learning, 18(1), 755–765. https://papers.academic-conferences.org/index.php/ecgbl/article/view/2660

Soleymani, A., De Laat, M., Itard, L., & Specht, M. (2022). How Networked learning can facilitate professional development?. In Proceedings of the International Conference on Networked Learning (Vol. 13).

Soleymani, A., De Laat, M., & Specht, M. (2024). Exploring Personal Experience and Value Creation in Postdigital Education: Insights from a Large-Scale MOOC Survey. https://www.researchsquare.com/article/rs-5043440/latest

Soleymani, A., Itard, L., de Laat, M., Torre, M. V., & Specht, M. (2022). Using Social Network Analysis to explore Learning networks in MOOCs discussion forums. CLIMA 2022 Conference.

Soleymani, A., Specht, M., & De Laat, M. (2024). Evaluating Professional Learning Networks Using Value Creation Framework; A Literature Study. A Literature Study (June 16, 2024). https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4870033

Soleymani, A., van den Brom, P., Ahmed, S., Konings, M., Sjoer, E., Itard, L., Zeiler, W., De Laat, M., & Specht, M. (2023). Learnings Networks and Professional Development in Building Energy Management Systems Industry. Education Sciences, 13(2), 215.

Specht, M., Hang, L. B., & Barnes, J. S. (2019). Sensors for Seamless Learning. In C.-K. Looi, L.-H. Wong, C. Glahn, & S. Cai (Eds.), Seamless Learning (pp. 141–152). Springer Singapore. https://doi.org/10.1007/978-981-13-3071-1_7

Tan, E., Glahn, C., & Specht, M. (2019). Designing Mobile Inquiry-Based Learning Activities: Learners'agency And Technological Affordances. In Proceedings of the 15th International Conference on Mobile Learning (Vol. 1050).

Tsai, Y.-S., Rates, D., Moreno-Marcos, P. M., Munoz-Merino, P. J., Jivet, I., Scheffel, M., Drachsler, H., Kloos, C. D., & Gašević, D. (2020). Learning analytics in European higher education—Trends and barriers. Computers & Education, 155, 103933.

Valle Torre, M., Oertel, C., & Specht, M. (2024). The Sequence Matters in Learning—A Systematic Literature Review. Proceedings of the 14th Learning Analytics and Knowledge Conference, 263–272. https://doi.org/10.1145/3636555.3636880

van der Laan, P. J. (2021). Automated Writing Feedback. https://repository.tudelft.nl/record/uuid:440cc75f-6695-4d4a-94d5-f79532ed0d63

van der Meer, N., Brinkman, W., & Specht, M. (2021). Virtual Reality and Collaborative Learning in Higher Education: A Research Thesis Proposal. Adjunct Proceedings of the ACM International Conference on Interactive Media Experiences: IMX 2021.

van der Meer, N., van der Werf, V., Brinkman, W.-P., & Specht, M. (2023). Virtual reality and collaborative learning: A systematic literature review. Frontiers in Virtual Reality, 4, 1159905.

van Der Werf, V. (2023). Fostering a natural language approach in programming education (Doctoral Consortium). Proceedings of the 23rd Koli Calling International Conference on Computing Education Research, 1–2. https://doi.org/10.1145/3631802.3631838

van der Werf, V., Aivaloglou, E., Hermans, F., & Specht, M. (2021). What does this Python code do? An exploratory analysis of novice students' code explanations. Proceedings of the 10th Computer Science Education Research Conference, 94–107.

van der Werf, V., Aivaloglou, E., Hermans, F., & Specht, M. (2022). (How) Should Variables and Their Naming Be Taught in Novice Programming Education? Proceedings of the 2022 ACM Conference on International Computing Education Research-Volume 2, 53–54.

van Der Werf, V., Swidan, A., Hermans, F., Specht, M., & Aivaloglou, E. (2024). Teachers' Beliefs and Practices on the Naming of Variables in Introductory Python Programming Courses. Proceedings of the 46th International Conference on Software Engineering: Software Engineering Education and Training, 368–379. https://doi.org/10.1145/3639474.3640069

van Der Werf, V., Van Helden, G. V., Sch, J., & Saunders Smits, G. N. (2023). A Framework For Investigating The Application Of Educational Theories In Engineering Education Research. Research Papers. https://doi.org/10.21427/PM7V-MD26

van Der Werf, V., Zhang, M. Y., Aivaloglou, E., Hermans, F., & Specht, M. (2023). Variables in Practice. An Observation of Teaching Variables in Introductory Programming MOOCs. Proceedings of the 2023 Conference on Innovation and Technology in Computer Science Education V. 1, 208–214.

van Helden, G., Van Der Werf, V., Saunders-Smits, G. N., & Specht, M. M. (2023). The Use of Digital Peer Assessment in Higher Education–an Umbrella Review of Literature. IEEE Access.

van Helden, G., Zandbergen, B., Specht, M., & Gill, E. (2022). Student perceptions on a collaborative engineering design course. Towards a New Future in Engineering Education, New Scenarios That European Alliances of Tech Universities Open Up, 782–796.

van Helden, G., Zandbergen, B. T., Specht, M. M., & Gill, E. K. (2023). Collaborative Learning in Engineering Design Education: A Systematic Literature Review. IEEE Transactions on Education.

Zhang, S., Bryczkowski, J. M., & Specht, M. (2024). GoaLearn App: A Goal-Setting and Monitoring Application to Support Students' Self-regulated Learning. In R. Ferreira Mello, N. Rummel, I. Jivet, G. Pishtari, & J. A. Ruipérez Valiente (Eds.), Technology Enhanced Learning for Inclusive and Equitable Quality Education (pp. 267–272). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-72312-4_38

Zhang, X., Aivaloglou, E., & Specht, M. (2024a). Teachers' Intention to Integrate Computational Thinking Skills in Higher Education: A Survey Study in the Netherlands. 2024 IEEE Global Engineering Education Conference (EDUCON), 1–9. https://doi.org/10.1109/EDUCON60312.2024.10578887

Zhang, X., Aivaloglou, F., & Specht, M. (2024b). A Systematic Umbrella Review on Computational Thinking Assessment in Higher Education. European Journal of STEM Education, 9(1). https://eric.ed.gov/?id=EJ1414629

Zhang, X., Glahn, C., Fanchamps, L., & Specht, M. (2022). CTE-STEM 2022| Proceedings of Sixth APSCE International Conference on Computational Thinking and STEM Education 2022. 6th APSCE International Conference on Computational Thinking and Stem Education.

Zhang, X., & Specht, M. (2022a). A Review of Reviews on Computational Thinking Assessment in Higher Education. CTE-STEM 2022 Conference.

Zhang, X., & Specht, M. (2022b). Towards a computer-assisted Computational Thinking (CT) assessment system in higher education. CEUR Workshop Proceedings, 3292, 12–21.

Zhang, X., Specht, M., & Valle Torre, M. (2022). An investigation on integration of computational thinking into engineering curriculum at delft university of technology. Towards a New Future in Engineering Education, New Scenarios That European Alliances of Tech Universities Open Up, 890–901.

Xiao, J., Tan, E., Li, X., Cao, M., & Specht, M. (2020). Using social media in mobile MOOC for teacher professional development. International Journal of Mobile Learning and Organisation, 14(4), 492-510.

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