Teacher's assistant

Following on from her work developing the interactive tutoring feedback model, **Professor Susanne Narciss** is now applying it to designing and evaluating adaptation strategies for tutoring feedback in advance digital learning environments

What led you to develop an interest in tutoring feedback strategies?

I started my academic career by following a teacher education programme at the University of Heidelberg. In my second year, I started to work as a research assistant on teacher cognitions and how they influence teachers' behaviour in critical situations in physical education classes. I found the psychological concepts, models and methodological approaches applied in this project so interesting that I decided to study psychology and undertook an interdisciplinary PhD on the cognitive effects of mental training. My interest in the issues related to tutoring feedback strategies came, in part, through unsatisfactory experiences with the often rather incomprehensive feedback messages that computer-based systems provide when mistakes are made.

Can you explain the underlying theory of your latest research?

The idea behind tutoring feedback strategies is to provide learners with exactly the information they need in order to help them accomplish learning tasks successfully, even though they have encountered obstacles or made mistakes. If learners are given the information they need when they make errors or encounter obstacles, they have the chance to master the task, and can attribute this mastery experience internally.

Mastery experiences are important for promoting learners' motivation, which is a crucial prerequisite for keeping students engaged in learning tasks. If students do not actively engage in learning tasks they miss opportunities for progressing their competencies and skills. Thus, it is important that feedback messages convince learners to continue practicing even if they encounter difficulties.

However, developing tutoring feedback strategies is very complex, because the issue of what information is needed has to be answered differently depending on learner characteristics, task characteristics and instructional objectives.

Have you made any particularly interesting discoveries so far?

One striking finding of both study phases of the Adaptive tutoring Feedback (AtuF) project was that female students benefit more from tutoring feedback strategies than male students. Female students had a stronger learning gain and a weaker decline in their motivation than male students. Our logfile analyses indicate this difference might be partly explained by students' post-feedback behaviour. Boys skip more often to the next trial after they have received a feedback message than girls.

Has a collaborative approach proved important to the success of the AtuF project?

AtuF is a multidisciplinary project that addresses research issues from two different fields – instructional research/learning sciences and computer science. The Dresden team is collaborating with the Centre of e-Learning Technology of the German Centre of Artificial Intelligence.

At the end of the second phase, we also began collaborating with Professor Johan Jeuring and his colleague Dr Bastiaan Heeren from Open Universiteit Nederland. Jeuring and Heeren have developed a flexible architecture of domain reasoners that have been successfully used before in adaptive and intelligent educational systems, including ActiveMath, for automatic generation and assessment of interactive exercises.

We will also continue to collaborate with Dr Giorgi Goguadze from Leuphana Universität Lüneburg. He was involved in the previous phases of the project as part of the Saarbücken team. In his dissertation, he developed research and practical means for tuning the ActiveMath exercise system into a flexible experimental platform that allows the dynamic adjustment of exercise behaviour. As such, this multidisciplinary approach has been very valuable for the AtuF project.

What will be the applications and impact of the completed project?

In the AtuF project, we combine state-of-the-art instructional expertise with advanced technological implementation. Therefore, instructional research goes hand in hand with computer science research, which means it will have far-reaching implications. The findings of the project create an opportunity to improve feedback in educational technologies and advance the learning sciences. We plan to mainly disseminate the project results through publications and international conferences.

Do you have plans to extend or develop this research further?

We are now at the end of phase 2; an interim period between phase 2 and 3. The data from the second phase have been partly analysed, but given the richness of the dataset, further analyses are possible and will be conducted. We have published some of the results of the first phase and are currently preparing further publications. Moreover, we have concrete plans for phase 3, in which we aim to develop dynamic adaptation strategies for tutoring feedback. We applied for further funding, in order to be able to implement these plans.

Besides AtuF, my research team is applying and investigating the design principles derived from the interactive tutoring feedback model in further instructional contexts; for example, in collaboration with Professor Jan-Willem Strijbos from Ludwigs Maximilian University at Munich, we are conducting empirical research on the effects of formative peer feedback strategies for both the feedback sender and receiver.

Interactive tutoring feedback

An innovative project supported by some of Germany's key academic institutions is exploring how tutoring feedback can be adapted for rapidly evolving computer-based learning systems

THE EXPLOSION IN digital learning across the world is changing the face of how teachers and tutors provide feedback and advice to their students. A collaborative group of researchers based at Dresden University of Technology, Saarland University and the German Centre of Artificial Intelligence has been working on a project since 2007 which is looking at interactive tutoring feedback and how it can be applied to online learning environments.

Much of their work stems from the interactive tutoring feedback model (ITF-model) developed by one of the main project team members, Dr Susanne Narciss. She outlines how this model helps to describe the conditions and ways in which feedback messages from teachers, tutors or peer students can influence how learners evolve their own learning capabilities: "The ITF-model conceptualises feedback as a multi-dimensional instructional activity that aims at contributing to the regulation of a learning process in such a way that learners acquire the knowledge and competencies needed to master learning tasks". The advantage of using tutoring feedback is that it equips students with the ability to detect errors, overcome obstacles and apply more efficient strategies to solving learning tasks themselves. Thus, tutoring feedback strategies can be used to make (digital) education smart in order to empower students to be intelligent lifelong learners.

ADAPTIVE TUTORING FEEDBACK

According to Narciss, the ITF-model provides the theoretical basis for developing tutoring feedback components and strategies, and for designing studies to investigate the effects and conditions of optimal tutoring feedback: "The work in our latest project, Adaptive tutoring Feedback (AtuF), builds on the experiences my research team made when applying the ITF-model in further studies".

Narciss has applied the ITF-model to a range of different learning situations, including both individual and collaborative ones. Through her latest research Narciss, along with fellow team members Dr Erica Melis, Professor Jörg Siekmann and Dr Sergey Sosnovsky, has applied the model to digital learning situations. AtuF is made up of work phases which are designed to systematically develop and evaluate a range of different feedback options that can be used to enhance the way in which students learn and become motivated to improve. The results of AtuF provide the opportunity to advance feedback via several existing European projects developing web-based systems for mathematics education, such as ActiveMath and MathBridge.

BEYOND CURRENT KNOWLEDGE

The challenge for personalised tutoring feedback and implementing it into ICT-based learning systems is that whilst it can be a very powerful way to resolve problems and optimise learning, it involves a vast range of variables that can limit how effective the feedback is. However, many of today's interactive environments for teaching support knowledge-building in this area.

There are still many questions needing to be answered in the field of adaptive tutoring, such as which variables researchers should be addressing or in what ways these are influencing one another. In adaptive tutoring feedback strategies, the manner in which a learner responds to different

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tasks and feedback is evaluated and then used to tailor a system to that particular learner. Using the digital environment to achieve this type of adaptive tutoring feedback can be highly challenging, but also presents huge potential for developing smart learning environments with individual adaptation strategies in the future.

A THREE-PHASED PROGRAMME

AtuF involves three key stages running over eight years. The first phase saw the team using the ITF-model to build on the basis of the ActiveMath web-based learning tool. They conducted a number of psychological and empirical task and error analyses. Following this, Narciss and collaborators developed and applied a range of different exercises to support the adaptation of feedback. "Furthermore, an interactive interface for multi-trial fraction tasks was developed and tested," she explains. "Through the project we piloted students' comprehension of particular tasks as well as feedback messages, and then iteratively improved them." At the end of this phase, they ran a study on over 200 sixth and seventh graders to investigate how individual and task characteristics impact the effects of four successful tutoring feedback strategies.

The emphasis for the second phase of AtuF was developing and assessing static tutoring feedback strategies. Static adaptation strategies tailor feedback strategies to relatively stable learner characteristics. In order to identify the learner characteristics that warrant adaptation, the researchers used the data gathered in the first phase and conducted detailed logfile analyses, producing some interesting results: "These analyses revealed that female students benefit more from the tutoring feedback strategies than male students, and that the motivational variables, namely perceived competence and intrinsic motivation, are worth being considered for adaptation," Narciss highlights.

From their results, the team was then able to fine-tune the student model and create two static adaptation strategies, which were then tested on high school students. Results indicated that for girls the type of feedback strategy was important for knowledge gain but not for motivation. "Girls' knowledge gain was significantly higher with the procedural rather than the conceptual feedback strategy," explains Narciss. But boys' knowledge gain was not significantly impacted, although some motivational variables did worsen under the conceptual feedback strategy.

The design, implementation and evaluation of a set of dynamic adaptation strategies will make up the main efforts of the third phase. Narciss and her project partners hope to optimise the parameters of feedback messages to a wider degree and a deeper level than achieved before: "We want to realise this not only based on students' coarse-grained parameters, but also their fine-grained, dynamic and individual histories of learning interactions and the semantic relationships between exercises and core knowledge components in the domain".

INFORMING FUTURE RESEARCH OPPORTUNITIES

Now reaching the final stages of the second phase, the team is excited about the opportunities to move forward with further research. Their findings supported the ITF-model's prediction that the effects of a feedback message or strategy impact on people differently depending on some key variables, in particular gender. "In the domain of mathematics education, gender is an individual factor which has to be taken into account in further research on adaptive feedback," expounds Narciss. She believes that just why and how boys benefit less than girls from tutoring feedback warrants more research, which could ultimately produce some valuable knowledge about adaptive feedback in a digital learning environment.

The researchers are also keen to further explore the factors which influence if and how learners process and apply successfully tutoring information. "Our results indicate that a more fine-grained diagnosis of a student's state of competence is necessary, including variables interpreting the learner's behaviour in the system as an adaptation source, thus leading to dynamic feedback adaptation strategies," adds Narciss. Such research will require an interdisciplinary approach to build on a number of findings from AtuF's different work phases. Ultimately, the group is keen to see that, as a result of their work, digital educational programmes increasingly incorporate adaptive tutorial feedback strategies, rather than more simple but less effective strategies currently offered by many systems.

Further interesting issues for future feedback design and research are provided by the ITF-model: "Concerning computer-based or networked collaborative learning contexts, empirical research on the effects of formative peer feedback strategies for both the feedback sender and the feedback receiver would be valuable," Narciss highlights. "Moreover, with regard to technology-enhanced blended learning environments, special interest should be devoted to teacher education and instructional design issues such as how to combine human and technical sources of feedback in order to design and implement formative multi-source feedback strategies."

INTELLIGENCE

ADAPTIVE TUTORING FEEDBACK – ATUF

OBJECTIVES

To systematically develop and evaluate adaptation strategies that allow tailoring tutoring feedback components to task requirements and student characteristics, in order to promote students' acquisition of competencies and their motivation.

KEY COLLABORATORS

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PROFESSOR SUSANNE NARCISS is Associate Professor at the Department of Psychology at Technische Universität Dresden. She received her PhD from Heidelberg University, and then moved to Dresden University. Her current interests include research on the role of motivation and metacognition for technology-enhanced learning and instruction, and factors in and effects of informative tutoring feedback (ITF). Her work on ITF was considered cutting-edge by the American Association on Educational Communication and Technology (AECT). Narciss' AECT handbook chapter 'Feedback strategies for interactive learning tasks' received the AECT Distinguished Development Award 2007.