# English summary

## Introduction

The research within this dissertation took place in the light of changes underway in secondary vocational technical education and the needs of schools and teachers that are related to these changes. This type of education is generally characterized by a practical, teacher-centered approach in which teaching specialized knowledge plays a prominent role. It is, however, clear that in future-proof secondary vocational education, there will be a shift from knowledge transfer from teacher to student over to more active knowledge construction and development by the student, with knowledge not mainly limited to specialized knowledge, but also including a broader set of knowledge and skills. It can be argued that besides their specialized knowledge, future professional practitioners need both interpersonal skills to successfully cooperate in increasingly complex, multifaceted teams, and intrapersonal skills to enable them to continually construct and develop their knowledge and extend their skillset. Although the importance of this broader focus is recognized, secondary vocational teachers often lack appropriate instructional means and tools to facilitate the development of these more generalized "21st-century skills".

More concretely, as a response to this need, the studies reported in this dissertation focused on the development and evaluation of digital tools that help secondary vocational technical students acquire skills related to collaboration and knowledge monitoring. The tools incorporated elements that could trigger students' reflective thinking, as reflection is a well-known and often employed means in various educational settings to promote knowledge acquisition and skill development: *comparative feedback* (i.e., comparison of student performance against a reference), *reflection prompts*, and *interaction with peers*. This dissertation is a compilation of three studies in which the effectiveness of different implementations of the tools, which were complemented with teacher-coordinated classroom activities, was investigated.

## Participants and learning context

Participants in all studies were first-year technical students from secondary vocational education in the Netherlands (2017, 2018, and 2019 cohorts). They were all following a full-time middle-management or specialist technical track (i.e., the highest level of secondary vocational education in the Netherlands), that has a total duration of four years. The data from all studies were collected at the same schools

for secondary vocational education (i.e., Aventus, Deltion College, Graafschap College, and ROC van Twente).

To embed the designed tools in a relevant context for these students, an online learning environment was developed (using the Go-Lab ecosystem and in co-design with teachers) in which students learned about topics connected to the curriculum of their program. The learning environment was designed so that students could work in it independently from the teacher, either together (Study 1) or individually (Studies 2 and 3). It contained a series of assignments, two online labs (i.e., the *Electricity Lab* and the *Electric Power Transmission Lab*), and instructive multimedia material. Through working in the environment, students were stimulated to find out principles related to electricity (e.g., concerning the topics of current, voltage, and resistance) and electric power transmission (e.g., concerning the topics of efficiency, transformers, and cable resistance).

The content of the learning environment was roughly the same for all studies, but the exact assignments differed slightly. For Study 1, assignments were designed so that they required collaboration for completion, and the learning environment was supplemented with a chat facility that students could use to communicate during their real-time virtual collaboration.

## Procedure

All sessions took place during scheduled classes within regular school hours. The three studies followed a similar procedure and utilized a pretest – intervention – posttest design. In the first session, which lasted about 60 to 90 minutes, the required instruction was provided and a paper-based pretest on domain knowledge was administered. The first session was followed by two or three intervention sessions in which students worked, depending on the study, either collaboratively or individually on their own laptops in the online learning environment that had been developed. The intervention sessions lasted about 90 minutes each. In the final session, which took a maximum of 60 minutes, a paper-based posttest was administered. In every study, all sessions took place within two weeks, with the last and next-to-last session being completed in the same week.

# Overview of studies

## Study 1

The first study concerned fostering students' collaboration skills by promoting the development of relevant communication activities (i.e., the RIDE rules: Respect, Intelligent collaboration, Deciding together, and Encouraging). The tool that intended to teach students about these communication activities incorporated *comparative feedback*, *reflection prompts* and *interaction with peers*. It first required students to assess their own and their group members' collaborative behavior based on the RIDE rules, after which these assessments were visually represented and displayed to all group members. It then prompted the students to jointly reflect upon their collaboration and set goals for improvement. The tool was complemented with classroom instruction on the RIDE rules.

In three intervention sessions, students worked in heterogeneous (with respect to their prior domain knowledge) triads on their own laptops. Three (within-class) experimental conditions were compared: (1) combination of classroom instruction before entering into collaboration and several iterations of using the tool during collaboration, (2) classroom instruction only, and (3) no instruction and no tool (control condition).

Results of analyses regarding students' collaborative behavior (based on the chat activities from 92 students, derived from chat logs) and their domain knowledge learning gains (based on the domain knowledge test results of 87 students) indicated that providing students only with instruction benefits neither their collaborative behavior nor their knowledge acquisition, compared to providing no instruction. However, instruction combined with the tool that stimulated students to connect their behavior with the instructed characteristics positively affected students' collaborative behavior (compared to both instruction alone and no instruction) and knowledge acquisition (compared to no instruction).

In contrast to the expectation that instruction would foster students' collaborative behavior and that the improved collaborative behavior would positively affect their knowledge acquisition, this study demonstrated that classroom instruction alone was not enough to induce an effect. However, in line with our expectations, we did find a positive effect on both students' collaborative behavior and their knowledge acquisition when instruction was complemented with support that included a combination of *comparative feedback*, *reflection prompts,* and *interaction with peers.*

## Study 2

The second study focused on stimulating skills related to students' knowledge monitoring. The tool was designed to elicit externalization and evaluation of knowledge and incorporated *comparative feedback* and *reflection prompts*: it enabled students to set out their (newly acquired) knowledge in a concept map, after which a combined concept map feature mapped the student's self-generated concept map onto an expert example concept map, and highlighted differences and commonalities between the two. The tool was complemented with a feature that prompted students to reflect upon the differences between the two concept maps.

Students worked individually for two intervention sessions on their own laptops; as part of the learning environment they all created a concept map of their knowledge at the end of both sessions. Three (within-class) conditions were compared in an experimental set-up: (1) tool use including both the combined concept map and the reflection prompt feature, (2) tool use with the combined concept map feature only, and (3) tool use *without* the combined concept map and the reflection prompt feature (control condition).

Results based on analyses of domain knowledge test results of 91 students indicated that all students, regardless of the support they received, did learn. Frequency of consulting the combined concept map (based on the log actions of 60 students) was found to be a significant predictor of learning gain. This, however, did not translate into significantly higher learning gains compared to students who did not receive the combined concept map. Adding reflection prompts did not result in higher learning gains.

In contrast to the expectation that a combined concept map containing *comparative feedback* would improve students' conception of what they (do not) know and therefore benefit their learning, this study demonstrated that providing students with *comparative feedback* in addition to creating their own concept map did not benefit their knowledge acquisition over providing no *comparative feedback*. Although access to the *comparative feedback* was found to be positively associated with learning, even the addition of *reflection prompts* did not guarantee effective use of the feedback, as, contrary to our expectations, this did not help secondary vocational students to further improve their learning.

## Study 3

Similarly to Study 2, the third study focused on stimulating students to externalize and evaluate their knowledge. Based on the findings in Study 2, we suggested some changes that were incorporated in the design of Study 3 (i.e., concept map training, a more restricted concept mapping facility, and more open-ended and positively phrased reflection prompts). In addition, the tool that had been developed was deployed in a hybrid setting: the digital tool was complemented with a teacher-guided classroom discussion. Consequently, the support included not only *comparative feedback* and *reflection prompts*, but also *interaction with peers*: reflection prompts were *jointly* discussed during the classroom discussion before students (individually) formulated their responses to the prompts.

Again, students worked individually for two intervention sessions at their own laptops, and as part of the learning environment they all created a concept map of their knowledge at the end of both sessions. Four partially quasi-experimental conditions were compared: (1) tool use including both the combined concept map feature and the reflection prompts, to which students responded after the teacher-guided classroom discussion, (2) tool use including both the combined concept map and the reflection prompt features, (3) tool use with the combined concept map feature only, (4) tool use without the combined concept map or the reflection prompt feature (control condition). The first condition concerned a between-class comparison, while the last three conditions were compared within-class.

Results based on analyses of domain knowledge test results of 144 students indicated that all students, regardless of the support they received, did learn. It was found that these learning gains were significantly higher for students in the classroom discussion condition compared to all other conditions, which can be explained by the quality of their reflections; results based on analysis of 74 students' responses to reflection prompts showed that students who participated in the classroom discussion provided more domain-related responses to the reflection prompts compared to the other prompts condition. Domain-related responses, in turn, were found to be a predictor of students' learning gain.

It was expected that *comparative feedback* as provided in the combined concept map would trigger students' reflection and benefit their learning accordingly, and that the addition of *reflection prompts* would further facilitate this activity. Contrary to this expectation, the current study demonstrated, similar to the results of Study 2, that merely adding *comparative feedback* and *reflection prompts* (to be *individually*

processed) did not add to the value of having students create their own concept map. However, in line with the expectation that students would benefit from discussing their answers, from the findings of this study it can be concluded that that *reflection prompts* do have added value when combined with a teacher-guided classroom discussion in which prompts are *jointly* discussed in *interaction with peers*.

## General conclusion

Based on the overall results, it is argued that support (i.e., *comparative feedback, reflection prompts*) that is found to be effective in many other educational contexts does not necessarily benefit secondary vocational technical students' behavior or learning. It stands out that these students benefited most when *interaction with peers* was part of the support (i.e., Studies 1 and 3). Based on this, social interaction is suggested as a promising element when designing instructional support for secondary vocational technical students. Future research can contribute to further improving the design of such support by providing additional insight into *how* interaction with peers is most beneficial for these students.