Chapter 1

General introduction

Introduction

Changes in the workplace mean that now, more than ever before, technical students need a wide range of skills in addition to specialized knowledge (e.g., Christoffels & Baay, 2016a, 2016b; Onderwijsraad, 2014). In the literature, this is referred to as the “T-shaped professional” (Guest, 1991): besides specific technical expertise, secondary vocational technical students should also have a broader professional orientation. As future professionals, these students are expected to produce instead of reproduce, work on complex tasks in collaboration with others, make use of technology, and continually develop themselves (Christoffels & Baay, 2016b; Fazekas & Litjens, 2014). With regard to these requirements, it can be argued that students 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. These more general, trans-disciplinary skills are often recognized under the umbrella term “21st-century skills” (e.g., Larson & Miller, 2011; Trilling & Fadel, 2009).

To function well in a professional setting where collaboration with others and teamwork have become increasingly important, training of *interpersonal skills* is essential. Interpersonal skills facilitate interaction with others; such skills enable people who are collaborating with others to, among other things, show commitment, express themselves clearly, exchange relevant information, and align with other individuals involved (Christoffels & Baay, 2016b). Proper collaboration and communication skills are required in a wide range of settings, not only face-to-face, but also digitally. In the context of this dissertation, the focus will be on stimulating students’ collaboration skills, by promoting the development of communication activities that are seen as essential for effective collaboration.

Besides the importance of interpersonal skills, training students’ *intrapersonal skills* also is important given the need for students to continually develop themselves and their knowledge. In general, these are skills that enable people to take responsibility and adjust to various circumstances, which is particularly important when it comes to lifelong learning (Christoffels & Baay, 2016b). In this context, metacognitive skills are key. Broadly speaking, metacognition concerns cognition about cognition (Veenman, van Hout-Wolters, & Afflerbach, 2006). In the context of this dissertation, the focus will be specifically on fostering students’ knowledge monitoring skills, by stimulating students to externalize and evaluate their knowledge.

Though secondary vocational teachers demonstrate their own understanding of these skills, they often lack the tools to help their students develop these skills (de Bruijn, 2012; van der Meer, 2017). Hence, in this dissertation, tools were developed in response to the overarching question: How can students in secondary vocational technical education be enabled to develop the desired interpersonal and intrapersonal skills? More specifically, this dissertation focuses on the development and evaluation of tools that help students acquire skills related to collaboration and knowledge monitoring. The effectiveness of these tools was investigated in three studies. This chapter provides a brief description of the context in which the research was conducted (i.e., school system, student population, learning environment, and domain), before elaborating on the tools that were developed.

School system and student population

In this dissertation, the focus is on students from secondary vocational technical education. This type of education is where students are trained to become professional practitioners, such as technical engineers, electricians, installers, or mechatronics technicians. Secondary vocational education in the Netherlands is offered at four levels: (1) entry level, (2) basic vocational training, (3) full professional training, and (4) middle-management and specialist training. All levels have two different pathways: a school-based option (in Dutch: BOL) involving full-time education and a work-based option (in Dutch: BBL) involving a combination of work and education (de Bruijn, Billett, & Onstenk, 2017).

The students in the studies of this dissertation were enrolled in a level 4, school-based technical track (with a total duration of four years). Most of them had just finished a pre-vocational educational track and were 16-17 years old when entering secondary vocational education. This means that they had passed the age at which school attendance is compulsory in the Netherlands (i.e., for 5- to 16-year-olds). However, the majority of these students did have an “obligation to qualify” (in Dutch: kwalificatieplicht), which is a form of extended compulsory schooling for students aged 16 to 18, with the main difference that the focus of this extended compulsory schooling is more on obtaining a diploma instead of school attendance (i.e., rules regarding school attendance are less strict, and more the responsibility of the student; Onderwijsconsument, 2019). An exception to this extended compulsory schooling applies to (the minority of) students who hold a “start qualification” (in Dutch: startkwalificatie): a high school diploma at a higher level than pre-vocational education or a diploma from at least level 2 of secondary vocational education (Rijksoverheid, n.d.). In consequence, our participants were a mix of students who followed the program in an extended compulsory mode and students for whom the program basically was noncompulsory. This may have influenced attrition rates, as we will see later.

The data from all studies were collected at the same schools for secondary vocational education in the Netherlands: Aventus, Deltion College, Graafschap College, and ROC van Twente (Studies 1 and 3); and Aventus, Deltion College, and ROC van Twente (Study 2). The technical programs that our students were enrolled in are generally characterized by a practical approach: the acquisition and application of specialized knowledge has a central place. Students learn, among other things, about topics related to electrical and mechanical engineering, automation technology, and control technology; in turn, they must apply this learning in practical lessons in which they work – mostly in teams – on projects, where they create electrical circuits, develop and assemble small devices, or program particular systems, for example. This specialized and practical focus within this type of education also resonates with the students who go there. Most of them have deliberately chosen a track with a practical focus; in general, they have in common that they prefer to learn by doing, are not strong performers in language, and their main focus is learning the specialized content needed in order to become a professional practitioner.

Learning environment and domain

Although the skills addressed in this dissertation can be characterized as generalized and trans-disciplinary, this does not imply that they should be trained separately from the content. The literature has shown that such skills should not be taught in isolation, but are best acquired as part of the learning context (Hattie & Donoghue, 2016). The tools we developed were therefore integrated in a newly developed learning environment, which will be briefly introduced in this section. A more detailed description of the learning environment is provided in the Method section in Chapters 2, 3, and 4.

An online learning environment was developed with the Go-Lab ecosystem (de Jong et al., 2021), through co-design with teachers. The learning environment enabled students – either individually or together – to learn about topics that were connected to their curriculum (e.g., electrical circuits, electric power transmission). It contained a series of assignments, two online labs, and instructive multimedia material. Using an *online* learning environment not only facilitated the integration of the tools, it also aligns with current educational practice in which the use of ICT has a prominent role (Bijleveld & Heuzels, 2020). Furthermore, working on practical issues in the online labs as part of the learning environment stimulated students to actively engage in learning (de Jong, 2019).

Through working in the online learning environment, students were stimulated to figure out principles related to topics in electricity (e.g., current, voltage, and resistance) and electric power transmission (e.g., efficiency, transformers, and cable resistance). In the *Electricity Lab* students could create electrical circuits based on direct or alternating current, perform measurements on them, and view measurement outcomes. In the *Electric Power Transmission Lab* students could design a transmission network by choosing different power plants and cities, and could vary different components within the network (e.g., properties of the power line, number of power pylons, and the voltage) to find out the effects on, for example, network efficiency and costs.

To enable real-time virtual collaboration between students, a collaborative version of the learning environment was created in addition to the regular one: assignments were designed so that they required collaboration for completion and student actions within the assignment and the labs could be synchronized. In addition, the learning environment was supplemented with a chat facility that students could use to communicate during their collaboration.

Design

Two digital tools were developed to stimulate skills related to students' collaboration and knowledge monitoring. Though the tools were developed in co-design with teachers and the current context was kept in mind during the design, they have in common that the design is context- and content-independent, meaning that, in theory, implementation in other educational settings and with other educational content is possible.

The didactic design of the tools was driven by theories of reflection, since reflection is an essential component of the learning process and supporting reflection is a proven effective means to promote learning and foster awareness about one's knowledge and skills (e.g., Kori, Pedaste, Leijen, & Mäeots, 2014; Lin, Hmelo, Kinzer, & Secules, 1999; Rogers, 2001). The tools incorporate elements that, according to research, trigger and support reflective thinking: *comparative feedback*, *reflection prompts*, and *interaction with peers*. Beyond the more general definition of feedback, which particularly involves information regarding students' performance or understanding (Hattie & Timperley, 2007), *comparative feedback* as utilized in this dissertation is defined as feedback including a reference, such as performance of others or a particular norm, to which students can compare their own performance (Kluger & DeNisi, 1996). Pointing out differences between student performance and the respective reference ideally triggers students' reflections regarding their own performance. *Reflection prompts* are a widely used approach to support reflection, and are generally found to positively affect students' learning (e.g., Davis, 2003; Ge & Land, 2003; Kori et al., 2014). They typically intend to activate students to engage in particular processes or to focus on particular steps (Bannert, 2006; Bannert & Mengelkamp, 2013; Lin & Lehman, 1999). *Interaction with peers* can be facilitated in different ways and contexts; however, the main idea within the scope of the current dissertation lies in the premise that by interacting with peers, students can learn from various perspectives and input from others (e.g., Gabelica, van den Bossche, Segers, & Gijselaers, 2012; Lin et al., 1999). In addition, this interaction might enhance students' perceived ability to perform a particular action and/or their perceived value of completing the action and therefore their motivation to engage in the task at hand in a more effective manner (e.g., Wigfield & Eccles, 2000).

The tool design to support students' collaboration skills focused on behavior that is essential for effective collaboration. This behavior can be captured in a set of communication activities (i.e., based on the RIDE rules: Respect, Intelligent collaboration, Deciding together, and Encouraging; Saab, van Joolingen, & van Hout-Wolters, 2007). *Comparative feedback* (i.e., students received an overview of scores derived from self- and peer assessment), *reflection prompts*, and *interaction with peers* were used to trigger and support reflection and consequently stimulate students' awareness, development, and implementation of these communication activities.

The tool design to support students' knowledge monitoring skills focused on students' ability to externalize and evaluate their knowledge. This can be fostered using concept maps and reference maps (e.g., Cimolino, Kay, & Miller, 2003; Ifenthaler, 2010; Novak & Cañas, 2008). *Comparative feedback* (i.e., a combined concept map feature, which mapped students' self-generated concept map onto an expert example and highlighted differences and commonalities between the two) and *reflection prompts* were used to trigger and support reflection and consequently to improve its quality and students' effective use of their knowledge representation.

The digital tools were complemented with teacher-coordinated classroom activities (i.e., specific instruction and plenary classroom discussion) to create a hybrid learning situation. The impacts of these activities are addressed in the different studies.

Problem statement and dissertation outline

Responding to the broader need for tools to equip secondary vocational technical students with relevant generalized and trans-disciplinary skills, the general aim of this dissertation is to understand how such students can be stimulated to develop skills related to effective collaboration and knowledge monitoring. More concretely, in three studies, two tools were developed and evaluated to explore how support for these skills can be designed. Study 1 concerned supporting students' collaboration skills by fostering the development of relevant communication activities, whereas Studies 2 and 3 addressed supporting students' knowledge monitoring skills by stimulating students to externalize and evaluate their knowledge (see Figure 1.1).

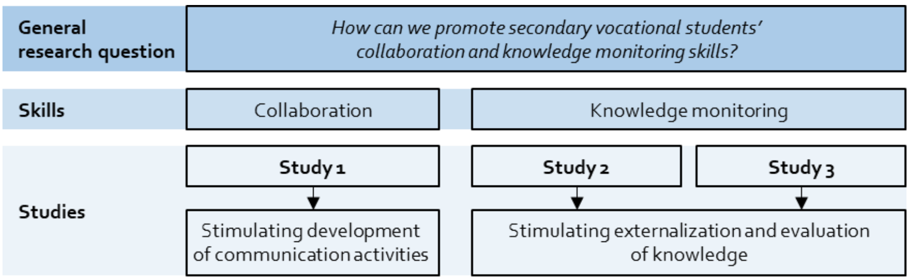

Figure 1.1. Overview of studies.

Study 1

To foster the development of relevant communication activities, the tool that we designed first requires students to assess their own and their group members' collaborative behavior based on the RIDE rules (i.e., Respect, Intelligent Collaboration, Deciding together, and Encouraging; Saab et al., 2007), after which these assessments are visually represented and displayed to all group members (i.e., *comparative feedback*). It then prompts the students to jointly reflect upon their collaboration and set goals for improvement (i.e., *reflection prompts* and *interaction with peers*). As a supplement to the tool, a classroom instruction was designed to teach students about the RIDE rules.

This first (experimental) study examined the effect of the combination of instruction and tool use and compared this to a situation in which only instruction was provided. For that purpose, three (within-class) conditions were compared regarding students' collaborative behavior and knowledge acquisition: (1) combination of classroom instruction before entering into collaboration with several iterations of using the tool during collaboration, (2) classroom instruction only, and (3) no instruction and no tool (control condition).

Study 2

The tool that intended to stimulate externalization and evaluation of knowledge enables students to set out their (newly acquired) knowledge in a concept map, after which a combined concept map feature maps the student's self-generated concept map onto an example concept map and highlights differences and commonalities between the two (i.e., *comparative feedback*). The tool was complemented with a feature that prompts students to reflect upon the differences between the two concept maps (i.e., *reflection prompts*).

This second (experimental) study examined the effect of different modes of the tool on students' knowledge acquisition. For that purpose, three (within-class) conditions were compared: (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 either the combined concept map or the reflection prompt feature (control condition).

Study 3

To further prompt students to externalize and evaluate their knowledge, the tool used in Study 2 was additionally deployed in a hybrid setting: the digital tool was complemented with a teacher-guided classroom discussion. Reflection prompts were jointly discussed (i.e., *interaction with peers*) before students (individually) formulated their answers to the prompts.

This third (partially quasi-experimental) study examined the effect of different modes of the tool on students' knowledge acquisition. Additionally, the added value of joint versus individual processing of prompts was explored for the quality of students' reflections. For that purpose, four conditions were compared: (1) tool use including both the combined concept map feature and the reflection prompts that students responded to after the teacher-guided classroom discussion, (2) tool use including both the combined concept map and the reflection prompt feature,

(3) tool use with the combined concept map feature only, (4) tool use without either 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.

Studies 1 to 3 are presented in Chapters 2 to 4. Chapter 5 provides a general discussion, in which findings of all studies are summarized and discussed.