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Theoretical Contribution

Accelerating complex problem solving expertise: A self-regulated learning approach

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Complex problem solving (CPS) is a key competency in a strongly interconnected and fast moving world. Problem solvers need to deal with dynamic systems and novel situations, where experience alone is often not enough. Training so far, however, has been primarily focusing on practicing CPS with limited results. We introduce the concept of self-regulated learning (SRL) to explain how individuals learn during CPS. Additionally, SRL offers motivational and metacognitive strategies that could support the CPS process to develop problem solvers' competencies, and ultimately accelerate their expertise.

Keywords: complex problem solving, self-regulated learning, competency development, dynamic decision making

The Organization for Economic Co-Operation and Development (OECD) has included (complex) problem solving into their Program for International Student Assessment (PISA) and the International Assessment of Adult Competencies (PIAAC) as an important requirement to approach a rapidly changing world (OECD 2013, 2014). Additionally, accelerating technological advancements provide the opportunities to automate simple and well-defined problems shifting the remaining focus increasingly towards complex problems (Funke, Fischer & Holt, 2018). Thus, the relevance of CPS is going to increase further and further. Complex problems contain 1) a complex structure, 2) interconnectedness of elements, 3) a non-transparent information base, 4) a dynamic system, which is changing over time, and 5) competing goals (Dörner, 1975; Funke et al., 2018). Approaching these complex problems, requires CPS competency involving a bundle of knowledge (e.g., business management), skills (e.g., social skills), and abilities (e.g., deductive reasoning) (Fischer & Neubert 2015).

Depending on the complexity of the situation and novelty of the task it is important to learn beyond pre-existing knowledge and skills to prevent methodism (Dörner, 1996; Fust et al., 2018). Expert problem solvers apply iterative approaches and adjust strategies according to new information (Mishra, 2017). More research is needed, however, into how problem solvers learn and develop their expertise (Kretzschmar & Süß, 2015). Attempts of research to successfully foster CPS competency have not achieved the expected results yet (Greiff et al., 2013; Kluge, 2008; Kretzschmar & Süß, 2015). This is due to a predominant focus on task-specific scenarios in training, which often fail to equip solvers with transferable and adaptable skills necessary for new challenges (Kluge, 2008; Donovan et al., 2015). Training approaches have emphasized exposing solvers to a variety of problem situations without systematically teaching methods to approach these problems dynamically and flexibly. Effective methodologies require integrating strategies such as metacognitive reflection, iterative decision-making, and adaptive reasoning. Zimmerman and Campillo (2003) further suggest that the conceptualization of CPS may still be too narrow, as it has historically prioritized cognitive factors over motivational and emotional components. Recent advancements, however, propose a more integrative perspective (Funke et al., 2018; Fischer & Neubert, 2015).

Building on Bandura's (1986, 2015) social cognitive theory, we introduce the concept of self-regulated learning (SRL) to support the CPS process, improve CPS competency, and develop CPS expertise (Zimmerman, 2001; Winkler et al., 2023). Expertise denotes the final target in the development of domain specific knowledge, skills, or competencies (Funke, Fischer & Holt, 2018). SRL is about regulating one's emotions, motivation, and cognition while dealing with challenges including planning, monitoring, and evaluating one's learning process to achieve goals effectively (Zimmerman & Schunk, 2011). Prevailing perspectives of cognitive success factors of CPS are complemented by important metacognitive and motivational components. SRL is a supporting concept to CPS by making these motivational and metacognitive processes transparent and therefore manageable for the problem solver. Hence, we want to conceptually identify how SRL strategies can support problem solvers in developing CPS expertise.

We contribute to CPS research by introducing SRL to accelerate expertise and bundle existing argumentations for non-cognitive sources of CPS performance (e.g., Fischer & Neubert, 2015; Funke et al., 2018) in one holistic concept. Concrete SRL strategies are provided that can support and improve the CPS process. In addition, helpful implications are delivered of how SRL can be taught in complex problem situations requiring dynamic decision making (DDM).

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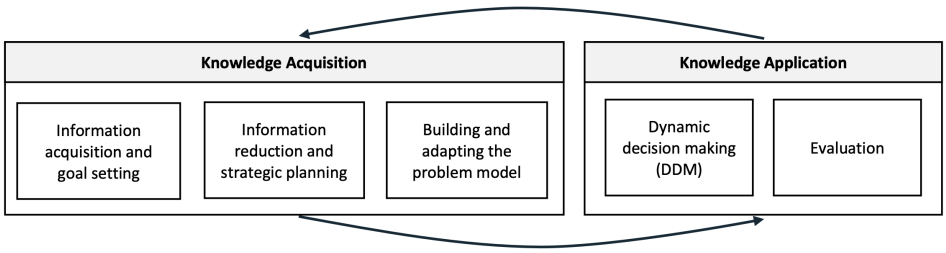

Figure 1. The iterative CPS process based on Fischer et al. (2012)

This article is structured as follows. First, we review CPS literature and existing training approaches. Second, the SRL cycle is introduced, consisting of forethought, performance, and self-reflection phase. Third, we illustrate how certain SRL strategies can support CPS and develop associated propositions. Finally, we conclude with a discussion, summarize implications for education, and offer the contributions.

The process of complex problem solving

CPS is an iterative cognitive and emotional process (Spering et al., 2005; Barth & Funke, 2010), strongly dependent on motivation (Hermes & Stelling, 2016). It consists of two phases: (1) knowledge acquisition, and (2) goal-oriented knowledge application (Leutner, Wirth, Klieme, & Funke, 2005).

Knowledge acquisition is about information generation and goal setting, information reduction and strategic planning, and problem model building. First, information must be generated due to the novelty and intransparency of the task, as initial assumptions about the problem structure are often incomplete and false (Dörner, 1989). Hence, solvers must systematically interact with the complex problem to acquire knowledge (cf. Funke, 2001). The root-cause and the main goal of the problem solving process are often not clear or given. Rule induction (Simon & Lea, 1974), generating and testing hypotheses (Klahr & Dunbar, 1988), and causal learning (Buehner & Cheng, 2005) can help to identify the relevant components of the problem and identify subgoals being important to address the main goal.

Second, the information generated must be reduced due to its complexity (Klauer, 1993). To be effective in the upcoming DDM situation, solvers must be selective in the use of the provided information by focusing on relevant problem features while ignoring irrelevant ones (Gonzalez & Lebiere, 2005). Excluding less relevant elements allows for more efficient planning and forecasting (Fischer et al., 2012). Therefore, when an entrepreneur wants to launch a new product, he should focus on the latest consumer preferences of the target groups, emerging market trends, and competitive positioning strategies and ignore irrelevant information like outdated market reports. By segmenting and breaking down complex information into smaller, more manageable chunks, individuals can better process, store, and retrieve the information (Halford et al., 1998).

Third, to develop a viable parsimonious model, hence, a simplified model of the problem, it is beneficial to use inductive, deductive, and abductive reasoning (Fischer et al., 2012; Güss, Ahmed, & Dörner, 2021). Inductive reasoning involves generalizing based on specific observations, while deductive reasoning starts with a general statement and examines the possibilities to reach a specific, logical conclusion. Abductive reasoning, on the other hand, generates hypotheses to explain observations or phenomena, which are particularly useful in complex, non-transparent systems.

In an entrepreneurial context, inductive reasoning might involve observing trends in customer behavior and formulating a business strategy based on these observations. Deductive reasoning would then test this strategy by applying it to new market segments to see if it holds true. Abductive reasoning would contribute by hypothesizing the reasons behind unexpected shifts in customer behavior, enabling proactive adjustments to the strategy. Due to the interconnectedness of the variables the problem model needs to be questioned and adapted continuously. Ohlsson's (1992) theory of representational change explains how individuals can modify their understanding of a problem to overcome obstacles and discover novel solutions. If a startup team, for instance, encounters a significant decline in sales, they might change their approach by reassessing their target market or modifying their product features to better meet customer needs. Simon and Lea (1974) expanded on Newell and Simon's (1972) concept of the problem space. This framework divides the problem space into two main areas: the rule-space and the instance-space. The rule-space includes all the possible rules that could apply to the problem, while the instance-space includes all the possible states or situations the problem could present. For example, in a chess game, the rule-space would encompass the rules governing how each piece can move, and the instance-space would include the various positions the pieces can occupy on the board. Information from the rule-space helps to navigate the instance-space and vice versa, making the search for a solution more efficient and comprehensive. By employing inductive, deductive, and abductive reasoning while being open to changing one's problem representation, individuals can develop and refine models that address complex

problems more effectively. These approaches allow for a more dynamic and responsive understanding, which is crucial for tackling the interconnected variables typical of many real-world issues.

Goal-oriented knowledge application contains DDM and evaluation. Both are important to approach the dynamics of complex problems (Fischer et al., 2012). First, problem solvers must specify the often imprecise and overarching goals they want to accomplish. If some of these goals turn out to be contradictory, they must find suitable trade-offs or accept only partially reaching their goals (Fischer et al., 2012). To achieve their goals, problem solvers must decide on decision making strategies and information to build on. If one strategy does not contribute to goal achievement another strategy should be applied, and the problem may be reformulated. In summary, there are three strategies to rely on during knowledge application (Schoppek, 2002; cf. Leutner et al., 2005). First, if the right solution to a subtask is known automatically, instance knowledge is applied. For example, an entrepreneur might have a proven method for conducting market research that reliably predicts customer preferences. When launching a new product, he can apply this existing market research strategy without needing to develop a new approach. Second, structural knowledge is needed when the search for a solution based on the viable parsimonious model is necessary. For example, if a startup is struggling financially, the entrepreneur might need to apply structural knowledge by using financial modeling and analysis to figure out the best strategy for cutting costs and increasing revenue. This might require making precise cash flow forecasts and budget changes based on a deep understanding of the business's financial structure, revenues, and costs. Third, new information is generated through system interaction or search strategies like seeking help from industry experts. Finally, due to the interfering goals, solvers evaluate their problem representation by monitoring their progress towards a solution and by including feedback from the environment. If the problem representation is not viable for reaching the specified goals in time, solvers return to knowledge acquisition and might adapt their goals (Fischer et al., 2012).

A thorough understanding of the CPS process is crucial to foster CPS competency. CPS competency encompasses the appropriate management of this CPS process, whereby specific skills, abilities, and knowledge are essential to achieve the desired problem solving performance (Fischer & Neubert, 2015).

Training of complex problem solving

Findings about how to enhance CPS competency are still rare and without concrete conceptual frameworks or instructional methodologies (Baggen, 2017; cf. Greiff et al., 2013; Kluge 2008; Kretzschmar & Süß, 2015; Schoppek, 2004; Schoppek & Fischer, 2017). To train and measure CPS competency, most studies use microworlds or complex dynamic systems. Table 1 provides an overview of training approaches, their objectives, and their effects.

The reviewed training sessions focus on direct instruction, guided exploration, and learning from experience to increase CPS performance in one or more microworlds. Only Donovan et al. (2015) provided training on self-reflection going beyond a direct instruction and Güss and Hermida (2024) demonstrated the effectiveness of error management training addressing key biases like the status-quo bias.

Greiff et al. (2013) and Schoppek and Fischer (2017) focused on learning by experience in MicroDYN, a multiple-item approach, identified an increase in use of VOTAT, an exploration strategy meaning "vary one thing at a time". Schoppek and Fischer (2017) were focusing on the performance transfer from MicroDYN to Dynamics2, another microworld, and the other way round. They identified the successful application of the PULSE strategy, which is about setting all input variables to zero and waiting for some time to observe the dynamics of the system. Unfortunately, the tasks to be solved in the MicroDYN are very similar (Greiff at al., 2013). Dörner and Funke (2017) argue that linear systems like MicroDYN fail to meet the requirements of complexity in most cases as all tasks can be solved with one strategy like VOTAT or PULSE.

Kluge (2008), Kretzschmar and Süß(2015), Schoppek (2004), and Donovan et al. (2015) applied more complex microworlds consisting of many interconnected variables. Kluge (2008) and Kretzschmar and Süß(2015) were able to improve knowledge acquisition but not knowledge application, which is the actual process of solving the problem. Schoppek (2004), however, successfully stimulated knowledge application by focusing the instruction on the dependency of the dependent variables. Donovan et al. (2015) were able to promote CPS performance with self-reflection. Similarly, Güss and Hermida (2024) demonstrated that targeted error management training can enhance CPS performance by addressing common errors and biases. Their training focused on frequently encountered decision-making errors and enabled participants to adapt dynamically to evolving task demands.

This creates the impression that the promotion of CPS competency may need more than training based on confronting solvers with complex problem situations.

Studies so far have primarily focused on instruction and practice (see Table 3), although recent research highlights alternative approaches, such as reflection training (Donovan et al., 2015) and error management training (Güss & Hermida, 2024), which go beyond traditional instruction by fostering adaptability during DDM. Thus, more approaches are needed which address the dynamic nature of complex problem solving.

Complex problem solvers are often confronted with situations where prior knowledge is not applicable, and no instruction is provided. Additionally, previous knowledge and schemas can even lead to bad decisions

Table 1. Overview of CPS trainings

Author	Training	Goal/Objectives	Effects
Schoppek (2004)	Direct instruction, guided exploration, and rehearsal exercises	Improving CPS performance in the microworld Dynamis2.	The focus of direct instruction and guided exploration on dependencies of dependent variables was superior to the focus on effects of independent variables. Both had a positive effect on performance. Rehearsal exercises had an adverse effect.
Kluge (2008)	Direct instruction (DI), guided exploration search (GES), a combination of both (DI+GES)	Improving CPS performance in the microworld ColorSim.	Direct instruction outperformed guided information search in knowledge acquisition. No training method improved knowledge application.
Greiff et al. (2013)	Learning from experience in MicroDYN	Improving CPS performance in the multiple item approach MicroDYN.	Increase in use of VOTAT, an exploration strategy meaning "vary one thing at a time".
Donovan, Güss, and Naslund (2015)	Short self-reflection training on DDM, supportive handout with self-reflective questions	Improving DDM skills and therefore performance in the microworld CHOCO FINE.	DDM training and high self-reflection relate to better performance in CHOCO FINE.
Kretzschmar and Süß(2015)	Learning by experience in different microworlds	Developing general problem solving knowledge (GPSK) to increase CPS performance in unknown microworlds.	Treatment group only performed better in knowledge acquisition but not in knowledge application.
Schoppek and Fischer (2017)	Training in MicroDYN and Dynamics2	Positive performance transfer from MicroDYN to the microworld Dynamics2 and vice versa.	Positive effect of performance in MicroDYN and on performance in Dynamics2 but not vice versa. Not VOTAT but PULSE strategy explained the transfer.
Güss and Hermida (2024)	Training in Error Management	Enhancing CPS performance by addressing common errors and biases, including status-quo bias.	Improved performance in dynamic simulations (ChocoFine, WinFire); reduced error rates; mitigated cognitive biases.

as behavior is not adjusted despite the availability of new information (Fust et al., 2018). Therefore, training should enable solvers to deal with such unknown problem situations. Recent approaches, such as reflection training (Donovan et al., 2015) and error management training (Güss & Hermida, 2024), highlight the importance of fostering adaptability and equipping solvers to manage uncertainty by addressing cognitive biases and encouraging critical self-assessment.

Successful solvers continuously evaluate whether their assumptions about current situations are correct (Donovan et al., 2015; cf. Mishra 2017). They develop and adapt strategies in accordance with new information and environmental changes. To successfully deal with complex problems, people need to learn beyond their pre-existing knowledge (cf. Fust et al., 2018). Yet, the processes of how individuals develop CPS competencies, and attain expertise in complex problem solving are still poorly understood. SRL is a methodology that enables solvers to take agency over their learning in complex problem situations (cf. Zimmerman, Schunk, & DiBenedetto, 2015) and to offer insights of how CPS competency can be fostered. Hence, we introduce the concept of SRL to enable individuals to improve their CPS process and develop CPS competencies over time.

Self-regulated learning

The concept of SRL and its components are outlined first, followed by an explanation of how SRL can support the CPS process and how it facilitates the acceleration of CPS expertise. SRL is the process where learners take agency over their own learning process, including the regulation of their emotions, motivation, metacognition, and cognitive strategies while dealing with complexity and advancing towards expertise (Zimmerman, 1989; Winkler et al, 2023). Rather than simply happening as an event, learning is an activity problem solvers follow proactively (Zimmerman, 2002). Zimmerman's social cognitive model of SRL consists of three cyclical phases: forethought, performance, and self-reflection (Bandura, 1991; Boekarts, 1999; Puustinen & Pulkkinen, 2001; Zimmerman, 2002; Winkler et. al., 2023).

The forethought phase sets the stage for learning and can be categorized into task analysis and self-motivation beliefs. Key components of task analysis are goal setting and strategic planning (Zimmerman, 2002; Zimmerman & Campillo, 2003; Winkler et al., 2023). Goal setting is the specification of intended actions and outcomes (Locke & Latham, 1990, 2002). Highly self-regulated individuals set proximal learning goals that address more distant outcome goals (Bandura, 1991). The second component of task analysis is strategic planning. Learners select adequate strategies to approach the challenge ahead. During planning,

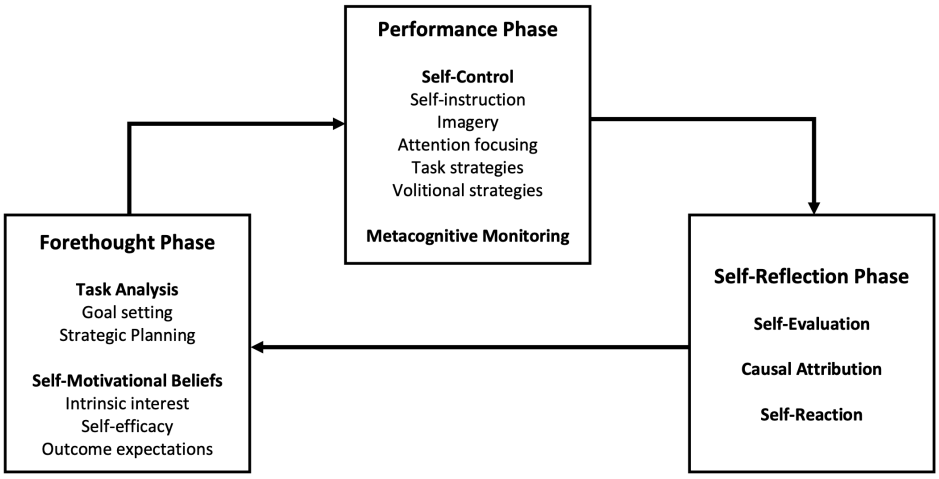

Figure 2. SRL model based on Zimmerman (2002)

self-regulated learners align their cognition, affect, and actions towards goal attainment to prepare for the performance phase (Pressley, Woloshyn et al., 1995; Winkler et al., 2023). Goal setting and strategic planning are supported by self-motivational beliefs like intrinsic interest, self-efficacy, and outcome expectations (Zimmerman, 2006, 2011). Intrinsically interested learners value a task for its own merits instead of its potential beneficial outcomes. Self-efficacy is the personal belief in one's capability to learn and perform a task effectively (Bandura, 1997). To activate personal resources, people need to be self-assured (Zimmerman & Campillo, 2003). Outcome expectations are an additional form of motivation. Learners make themselves aware of the expected benefits of their learning efforts e.g., increased CPS competency (Bandura, 1997; Wigfield & Eccles, 2000).

During the performance phase, self-regulated learners execute their planned learning activities (Zimmerman, 2000, 2011). There are two sets of subprocesses: self-control and metacognitive monitoring (Winkler et al., 2023; Zimmerman, 2002). Strategies that support self-control are self-instruction, imagery, attention focusing, task and volitional strategies (cf. Zimmerman & Campillo, 2003). Self-instruction refers to the ability to articulate or describe the steps needed to address and solve a problem (Schunk & Rice, 1985). Imagery is the creation of vivid mental visualizations and helps maintain motivation during learning and decision making (Ruvolo & Markus, 1992). In sports, psychologists have taught professionals to visualize successful executions of planned routines to stimulate their learning and performance efforts (Garfield & Bennett, 1985; Loehr, 1991). Attention focusing improves concentration by ignoring distractions influencing goal achievement (Zimmerman, 2011). Task strategies help learners to reduce complex tasks into their core elements and reorganize them in a meaningful manner (Zimmerman, 2007). Volitional strategies support avoiding frustrations about earlier mistakes (Kuhl, 1985). The second set is metacognitive monitoring. It is about observing one's performance and learning activities, the conditions one is surrounded by, and the outcomes being generated (Zimmerman & Paulsen, 1995). Especially the application of metacognitive monitoring is connected to proactive learning processes and clear goal structures (Zimmerman, 2007).

The self-reflection phase consists of self-evaluation, causal attribution, and self-reaction (Zimmerman, 2002; Winkler et al., 2023). Individuals evaluate their achievements concerning learning and outcome goals set during forethought phase. These self-evaluative judgements are directly linked to causal attributions (Zimmerman & Campillo, 2003). Causal attributions are beliefs about the reasons for one's errors or successes. Individuals that attribute failure to uncontrollable variables like low ability end up in discourage. Self-regulated learners tend to relate failure to controllable sources like poor strategy use (Zimmerman & Kitsantas, 1999). Consequently, they can sustain motivation and learn more effectively (Ucbasaran, Shepherd, Lockett, & Lyon, 2013). Self-reaction involves conclusions about the extent future actions need to be adapted to achieve desired goals (Winkler et. al., 2023, Zimmerman, 2002). This influences motivation, goal setting, and the definition of task strategies in subsequent SRL cycles (Zimmerman, 2011). Self-reflection is central to generating learning insights that gradually build up expertise (Winkler et al., 2023).

Supporting complex problem solving with self-regulated learning

Zimmerman and Campillo (2003) provide insights of how SRL can improve problem-solving efforts and results. Studies have addressed how SRL strategies impact problem solving, for example in mathematics (Fuchs et al., 2003). Given the characteristics of SRL with its focus on the learning process and adaptability to the learning situations, SRL also gives insights to support problem solvers in improving CPS competency. SRL offers personal agency over one's learning which involves how information acquisition and goal

setting, information reduction and strategic planning, problem model building and adaptation can be shaped (Bandura, 1991; Schunk, 2001; Zimmerman, 2000). Thus, it offers insights into how CPS competency can be built up.

We formulate ten propositions on how SRL and its components support the development of CPS competency to accelerate CPS expertise and provide an overview of the proposed influences in figure 3. We base our arguments on how SRL affects the distinct elements of the CPS process.

Proposition 1: SRL enables problem solvers to accelerate CPS expertise.

Information acquisition and goal setting

The main goal concerning the problem situation, such as making maximum profit, is often apparent. To achieve this overarching goal, however, solvers must develop subgoals (Donovan et al., 2015). To address these, solvers systematically interact with the complex problem to generate the necessary information (Fischer et al., 2012).

SRL can support this process by facilitating the definition of proximal learning goals (Locke & Latham, 2006; Seijts & Latham, 2005), which guide interaction activities to generate knowledge.

Unlike outcome goals, which focus on the final product, learning goals center on how to solve the task itself (Schunk & Swartz, 1993). By setting learning goals, problem solvers become more aware of their knowledge deficits and can identify the specific information required to address them. For example, while the main goal is to maximize profit, learning goals may include identifying the optimal pricing strategy or analyzing additional market opportunities. Setting proximal goals also increases persistence during the problem solving process, intrinsic interest in the tasks, and finally one's self-efficacy (Bandura & Schunk, 1981). Higher self-efficacy can empower problem solvers to tackle challenges with confidence. However, self-efficacy must be calibrated effectively. Overconfidence, driven by excessive self-efficacy, can lead solvers to overestimate their abilities, neglect relevant knowledge gaps, and fail to engage in adequate information acquisition (cf. Baron et al., 2016). On the other hand, highly self-regulated learners mitigate overconfidence biases by dynamically calibrating their self-efficacy through reflection and adjustment (Zimmerman, 2008). Visualization of prior successes can boost self-efficacy, while careful calibration ensures that problem solvers remain aware of potential challenges and gaps in their understanding. It could help, for example to ask experienced problem solvers of how they tackled similar problems or to engage with critics who primarily focus on identifying potential risks. This could result in the need to search for additional information.

Additionally, stepwise approaches to goal setting, like motto goals (Storch, 2009), can help solvers create positive associations with personal goals and manage affective states effectively. Low negative affect has been associated with high CPS performance (Rohe et al., 2016), and proximal goals can trigger positive affect that enhances engagement and persistence.

Hence, we propose the following:

Proposition 2: SRL enables problem solvers to set proximal learning goals that guide information acquisition.

Building on this, SRL further supports problem solvers in calibrating their self-efficacy to balance confidence and realism. By reducing or even avoiding overconfidence and maintaining an accurate perception of their abilities, solvers can repeatedly set challenging yet achievable goals, even in dynamically changing situations. Thus:

Proposition 3: SRL enables problem solvers to calibrate their self-efficacy to set challenging but achievable goals.

Information reduction and strategic planning

When problem solvers have gathered enough information for the moment, they need to decide which knowledge to rely on to plan their consecutive actions. This process requires reducing the complexity of the generated information by focusing on relevant features and ignoring irrelevant ones (Gonzalez & Lebiere, 2005). Designated CPS experts dissemble problems into parts, organize the generated information hierarchically, exclude less relevant elements, and create higher order chunks to approach them systematically (Bruning, Schraw, & Ronning, 1995; Fischer et al., 2012; Sweller, 2005). Self-regulated problem solvers, in particular, align their cognition, affect, and actions toward goal attainment during this phase to enhance performance (Pressley, Woloshyn, et al., 1995; Winkler et al., 2023). SRL enables problem solvers to carefully evaluate and select strategies by determining the utility value of each option and how it serves their goals previously set (Wigfield & Eccles, 2000). Relating to the already mentioned learning goal of identifying the right price, talking to a pricing expert might have a greater utility for the problem solver than engaging in plain desktop research. This alignment of strategies with utility value enhances decision-making efficiency and effectiveness.

Moreover, SRL supports the systematic and proactive planning of the selected strategies, which not only facilitates actionable steps but also gradually reduces the perception of uncertainty (McCann & Vroom, 2015) and increases situational awareness (cf. Garvey, 2022). Situational awareness, the ability to understand critical factors in the environment and predict their consequences within and to the system, is essential to navigate challenges effectively (Endsley, 1995).

By leveraging SRL, solvers can dynamically respond to situations where additional information is needed by re-engaging in information acquisition activities (Rahim et al., 2019). In contrast, those who lack SRL capabilities often rely on reactive and spontaneous learning insights, leaving them more suscepti-

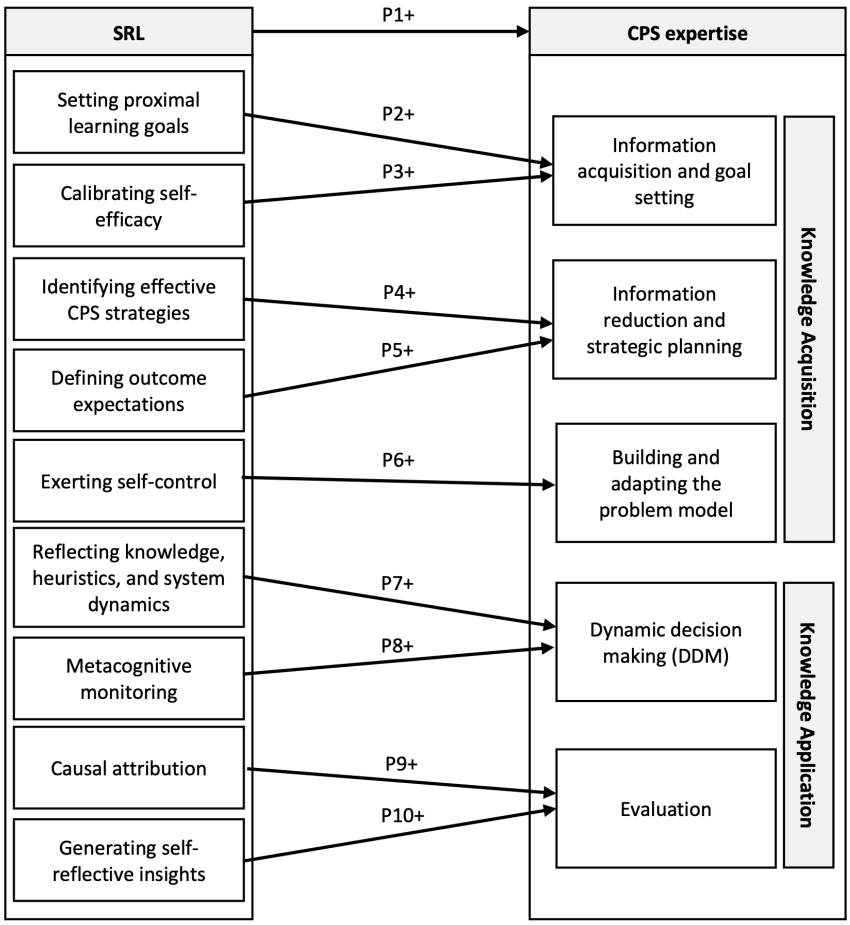

Figure 3. Overview of propositions

ble to feelings of uncertainty and overwhelm (Zimmerman, 2011). The ability to strategically plan, guided by utility value, is thus a hallmark of effective CPS processes.

Proposition 4: SRL enables problem solvers to identify effective CPS strategies by determining how their utility value serves their strategic planning.

Based on the cyclical feedback from earlier efforts, the selected strategies need to be adjusted continuously, as there is no problem solving strategy that will work for all tasks (Zimmerman & Campillo, 2003). Hence, motivation to continuously adapt is essential. Outcome expectations positively influence this motivation by providing a clear vision of the benefits associated with achieving the goal. They interrelate with self-efficacy in that individuals with high self-efficacy are more likely to form strong and positive outcome expectations (Maddux, Norton, & Stoltenberg, 1986). However, the two constructs differ: Self-efficacy pertains to the belief in one's ability to successfully complete a task, whereas outcome expectations focus on the perceived benefits and rewards of completing that task (Bandura, 1997). For example, a problem solver whose main goal is maximizing profit might visualize being regarded as a smart entrepreneur or consider how the profit could provide opportunities for business expansion. This interplay between self-efficacy and outcome expectations reinforces motivation by not only instilling confidence in one's capabilities but also by emphasizing the tangible benefits of success (Zimmerman & Campillo, 2003). SRL supports this process by helping solvers clarify and align their outcome expectations with their goals, thereby sustaining motivation throughout the problem-solving process.

Proposition 5: SRL enables problem solvers to define outcome expectations to promote motivation to solve the problem

Building and adapting the problem model

During information reduction and strategic planning, problem solvers should develop situational awareness of the critical factors within the complex system (Endsley, 1995). Based on these insights, they draft a parsimonious model of the problem by using inductive, deductive, and abductive reasoning (Fischer et al. 2012). Inductive reasoning allows solvers to generalize patterns from observed data, while deductive reasoning applies general rules to specific cases. Abductive reasoning, by contrast, enables solvers to generate hypotheses about the underlying causes of observed phenomena, especially in situations where information is incomplete or ambiguous. Together, these reasoning processes allow solvers to create and refine internal representations of the problem to forecast system dynamics. However, such models require continu-

ous adaptation as new information emerges (Ohlsson, 1992; Resnick, 1985).

SRL supports this iterative process by promoting a sense of personal agency (Zimmerman, 1989) and leveraging self-control mechanisms like self-instruction, imagery, attention focusing, task strategies, and volitional strategies. These mechanisms help problem solvers to focus on the identified core elements of the problem while preserving their motivation (Zimmerman & Campillo, 2003). Self-instruction improves learning by verbalizing relationships between dependent variables, aiding in understanding the system's structure (cf. Schoppek, 2004; Schunk & Rice, 1985). Imagery involves creating vivid mental visualizations to encode the problem structure to draft the model (Pressley, 1977; Pressley & Levin, 1977). In our example of how to maximize profit, a solver would visualize potential arguments and prepare to appropriately respond to counterarguments for an upcoming price negotiation. Volitional strategies help to avoid ruminating about previous failures, allowing to maintain focus on the task at hand (Kuhl, 1985). Attention focusing enhances concentration by filtering out distractions ensuring goal-directed behavior (Zimmerman, 2011).

By employing these strategies and reasoning processes, problem solvers can identify patterns more effectively, enabling them to draft and adapt their problem model. For instance, CPS experts systematically analyze and structure tasks, simplifying them for better handling (Bruning et al., 1995). This structured approach allows for the continuous reorganization of core elements to reflect newly identified patterns and insights (Zimmerman & Campillo, 2003).

Proposition 6: SRL enables problem solvers to exert self-control to build and continuously adapt the parsimonious model of the problem.

Dynamic decision making

Based on the parsimonious model of the problem, solvers aim to anticipate dynamic changes in the complex system to determine their course of action effectively. DDM involves a series of interconnected decisions that rely on past actions and are influenced by the spontaneous changes in the system (Brehmer, 1992; Fischer, Greiff & Funke, 2012; Gonzalez, Vanyukov & Martin, 2005). Given the time constraints and the multitude of variables involved, problem solvers must adopt efficient and rational strategies to navigate the complexity of the situation (Fischer et al., 2012). Self-reflective SRL strategies empower individuals to critically evaluate their existing knowledge, the relevance of their decision-making heuristics, and the dynamics of the system to determine the most appropriate strategy to follow. When initial decisions fail to lead to goal achievement, problem solvers can consider alternative courses of action or reformulate the problem to reach a successful resolution (Fischer et al., 2012). This implies that problem solvers possess a wide range of different strategies from which they can choose the appropriate one(s). For instance, in a negotiation scenario, if problem solvers realize that their initial assumptions are not applicable and the negotiation partner is hesitant to accept the proposed price, they may pivot by offering additional services or warranties to enhance the negotiation process instead of settling for a lower price.

Proposition 7: SRL enables problem solvers to reflect their knowledge, their heuristics, and the system dynamics to better decide which problem solving strategies to follow.

Metacognitive monitoring plays a crucial role in enabling problem solvers to observe and analyze their DDM process, the contextual environment, and the outcomes of their decisions (Zimmerman & Paulsen, 1995; Zimmerman, 2011). This practice provides solvers with the necessary insights to evaluate the effectiveness of their strategies and learning activities. Specifically, SRL supports metacognitive monitoring by guiding to systematically assess their progress, identify discrepancies between their goals and current outcomes, and adjust their decision-making strategies accordingly (Kitsantas & Zimmerman, 2002; Mayer, 1992).

For instance, by examining past experiences and outcomes, problem solvers can identify areas requiring adjustment. This process helps solvers integrate new information with their existing knowledge base and reflect on emotional responses to decision outcomes (Sanders & McKeown, 2008; Campitelli & Labollita, 2010). By doing so, they can adapt their actions effectively to dynamic and evolving circumstances, contributing to improved decision-making (Winkler et al., 2023).

Metacognitive monitoring extends beyond passive observation, acting as a proactive mechanism to refine strategies and decision-making processes iteratively. This iterative learning process allows solvers to enhance their cognitive processes, optimize decision-making, and manage their time more effectively to achieve desired outcomes (Chi, Glaser, & Rees, 1982). For example, by being more aware of their past solution approaches, solvers can better leverage insights to refine their strategies for future challenges (Haynie et al., 2010; Zimmerman & Kitsantas, 1996).

SRL facilitates this process by embedding reflective practices within the DDM cycle, ensuring solvers not only monitor their problem solving performance but also actively adjust their strategies in real-time to align with the demands of the problem context. This dynamic alignment enables solvers to maintain adaptability and effectiveness in the face of complexity.

Proposition 8: SRL enables problem solvers to metacognitively monitor and adjust DDM.

Evaluation

Problem solvers need to challenge their parsimonious model of the problem and evaluate their progress towards an appropriate solution continuously (Fischer et al., 2012). Outcome evaluations can be compared

to error management. Problem solvers need to differentiate between the effects of their actions and the autonomous development of the complex system (Schaub, 2007). Supporting SRL strategies are causal attribution and self-reaction (Zimmerman, 2002; Winkler et al., 2023). Causal attribution increases the understanding of the effectiveness of one's applied strategies and the influence of system dynamics (Locke & Latham, 2002; Osman, 2010). Problem solvers who attribute failure to controllable variables like insufficient problem representation or poor strategy use can redraft the problem model and increase motivation to adjust their behavior accordingly (Zimmerman & Kitsantas, 1999). Attributing failure to uncontrollable variables like low ability leads to negative emotions and withdrawal from further solution efforts (Ucbasaran et al., 2013). Hence, a self-regulated problem solver would attribute a failed price negotiation to the wrong or insufficient preparation and not to reasons corresponding to personality such as low extraversion.

Proposition 9: SRL enables problem solvers to attribute failure to controllable variables to learn and adjust their future problem solving approaches accordingly.

Self-reaction is the conclusion about if and how actions need to be adjusted to solve the problem (Zimmerman, 2002). This reflective process not only informs goal setting and planning in entrepreneurial endeavors, like adjusting marketing strategies based on past marketing campaign performance in tech startups, but also contributes to expertise development over time (Winkler et al., 2023). Personal motivation is not influenced by the goal achievement itself, but the self-evaluative reaction to the solution approach (Zimmerman & Campillo, 2003). By conditioning self-satisfaction on goal achievement and persistently adjusting strategies based on feedback, entrepreneurs can enhance decision-making, sustain persistence, and improve problem-solving efforts. For instance, when launching a fitness app, entrepreneurs can adapt features based on user engagement metrics to make sure the app meets users' needs and preferences (Schunk, 1982; Haynie et al., 2012; Shepherd et al., 2007).

Proposition 10: SRL enables problem solvers to generate self-reactive insights on if and how their CPS activities need to be adjusted in the future to gradually develop expertise.

Discussion

CPS research so far has primarily focused on cognitive processes like inductive and deductive reasoning while acquiring and reducing information, building a parsimonious problem model, making dynamic decisions, and evaluating the problem solving process (Fischer, 2012; Fischer & Neubert, 2015). SRL can support CPS with motivational self-beliefs, metacognitive monitoring, and affective self-reactions (Zimmerman & Campillo, 2003) to self-regulate cognition and motivation while solving complex problems and building the ground for continuous learning. This is in line with Fischer and Neubert (2015), who discuss competencies containing knowledge, skills, abilities, and other components (KSAO) being relevant for CPS to explain why performance in one problem setting does not necessarily lead to performance in another one. A potential explanation is that CPS training so far may not have defined problem solving broadly enough (cf. Zimmerman & Campillo, 2003). A key stimulus of CPS is declarative knowledge. Declarative knowledge can be acquired by information generation efforts and structured through information reduction (Fischer et al., 2012). Skills allow the transfer from knowledge into practice (cf. Anderson, 1987). Next to the declarative knowledge it is important to know how to apply heuristics and strategies effectively (Dörner, 1986; 1996; Güss et al., 2015), whereas abilities are required to solve complex problems efficiently (Süß, 1999). To store and process much information at the same time, problem solvers need working memory. Working memory capacity and the processes involved in gathering system specific knowledge have great impact on CPS performance (Danner et al., 2011; Süß, Oberauer, & Kersting, 1993; Wittman & Süß, 1999). To detect systematic patterns, i.e., develop hypotheses about the system structure (Brehmer, 2004; Wittmann & Hattrup, 2004), and to transfer knowledge to novel problems, high degrees of reasoning ability are required (Süß, 1996; Wittmann & Hattrup, 2004). In addition to knowledge, skills, and abilities Fischer and Neubert (2015) formulate other factors related to CPS. Frustration tolerance (Funke et al., 2018) and a positive attitude toward the problem (D'Zurilla & Nezu, 2006) support the solving process. Cognitive reflection (Toplak, West, & Stanovich, 2011) is important to counteract cognitive biases and monitor consequences of CPS activities (Donovan, Güss, & Naslund, 2015). Also learning and achievement motivation might be helpful (cf. Greiff & Neubert, 2014). Hence, research already suggests going beyond cognitive abilities to fully explain CPS performance. We build onto this development by introducing SRL as a powerful concept to foster CPS competency. Especially in novel problem situations containing high degrees of uncertainty, focusing more on existing knowledge than on the consequences of actions can potentially hinder learning (Fust et al., 2018) and as a consequence, can lead to wrong conclusions based on mental fixations (Garud, Kumaraswamy, & Karnøe, 2010; Ucbasaran, Westhead, & Wright, 2011). We argue that metacognitive and motivational SRL strategies support the cognitive processes being addressed by CPS research.

Metacognition is responsible for monitoring, evaluating, and regulating cognitive processes during CPS (Mishra 2017). It helps to develop situational awareness to identify which knowledge is needed to solve the problem and to formulate deficits that can be addressed (Baron & Henry, 2010; Endsley, 1995). Metacognitive monitoring, similar to cognitive reflection, enables problem solvers to encounter cognitive biases, negatively influencing the interpretation of com-

plex problem situations and adjust problem representations according to new information (Mishra, 2017). Solvers who continuously challenge and adjust their mental models of the problem situation automatically engage in double loop learning to build up expertise successively (Argyris & Schön, 1978). Causal attribution supports the evaluation of problem solving efforts and builds the fundament to accelerate CPS expertise by enabling solvers to focus on their contribution to failure and success (cf. Ucbasaran, Shepherd, Lockett, & Lyon, 2013).

Additionally, problem solvers must be motivated to develop additional cognitive and metacognitive capabilities to overcome obstacles when facing complexity (Zimmerman & Campillo, 2003). During the problem solving process motivation may vary. Therefore, individuals benefit from knowledge and experience about the use of motivational strategies and about how to regulate their own motivation. Hence, motivation and metacognition are interrelated. Setting proximal learning goals increases motivation by promoting persistence during strategy application, intrinsic interest in the tasks and self-efficacy concerning the solution finding process (Bandura and Schunk, 1981). Strategic planning reduces the perception of potential uncertainties (McCann & Vroom, 2015). Self-control mechanisms like volitional strategies or attention focusing preserve motivation during CPS (Hiller & Hambrick, 2005; Ucbasaran et al., 2011; Zimmerman, 2011). Self-reaction is essential to stimulate motivation and learning for subsequent SRL cycles (Zimmerman, 2011). Problem solvers need to actively engage in these learning processes during performance control phases to develop expertise over time (Zimmerman, 2006).

In summary, SRL provides a holistic perspective on the capabilities needed to enhance CPS competencies and develop expertise by integrating motivational and metacognitive processes. This is in line with Dörner and Funke's (2017, p. 6) latest definitions of CPS: "complex problem solving is a collection of self-regulated psychological processes and activities necessary in dynamic environments to achieve ill-defined goals that cannot be reached by routine actions [...]".

Implications for Education

SRL is rooted in Bandura's (1977, 1986) social cognitive theory, which relies on a cyclical process, reciprocal determinism, the assumption of proactive learners, and different hierarchy levels. In contrast to CPS, several studies have already proved the successful training of SRL, as SRL is not a stable mental capability, but a cyclic process of forethought, performance, and self-reflection (Cleary & Zimmerman, 2004; Schunk & Ertmer, 2000; Schunk & Zimmerman, 1998). Hence, training should provide learning environments where participants reflect their learning process while solving complex problems. Reciprocal determinism suggests that human beings are proactive and reflective in nature and influenced by their social environment (Pajares, 2008). Thus, SRL training should incorporate personal, behavioral, and environmental factors. To enable proactivity of learners, direct instruction should be reduced during SRL development and sequentially substituted with educational scaffolds to structure the problem solvers' learning processes (Athanassiou, McNett, & Harvey, 2003). Examples of scaffolds are coaching, and reflection sessions facilitated by educators, deadlines, outcome-related expectations, and peer-support (O'Donnell, Dansereau, & Hall, 2002). To foster higher order thinking and learning, scaffolding results in much better outcomes than traditional approaches (Schmidt et al., 2009).

Zimmerman (2001) theorizes that SRL capabilities develop across a four-level hierarchy, which consists of observation, emulation, self-control, and self-regulation. First, the observation level of problem solving refers to the ability of observers to deduce the underlying strategy from a role model's performance and verbally predict future moves before they are executed. Second, emulation level is attained when participants are able to replicate the role model's strategy with the support of the trainer. Third, on a self-control level, problem solvers can execute this strategy independently. Fourth, self-regulation level is achieved when individuals can transfer the role model's strategy to a novel complex problem on their own (cf. Zimmerman & Campillo, 2003).

For the trainer, teaching proximal learning goals begins with explaining the concept and importance of setting such goals to address novel problem situations. By illustrating the rationale behind the concept, learners can grasp its relevance (Winkler et al., 2023). Subsequently, sharing best practice examples of setting learning goals in complex problem scenarios helps participants with the observation of effective goal-setting strategies. Trainers then assist learners in formulating their own learning goals for emulation and self-regulation, emphasizing the role of external feedback in enhancing self-reflection and self-awareness to align with self-regulatory behavior (Zimmerman & Pike, 1972; Zimmerman & Rosenthal, 1974). Throughout the training, the initial guidance provided by trainers should gradually decrease, allowing participants to assume control of their learning processes and bolster their SRL capabilities through independent practice (Ericsson, Krampe, & Tesch-Romer, 1993). The ultimate goal is to automate this behavior, paving the way for the attainment of self-regulation as the final stage (Zimmerman, 2001). At this stage, learners can adapt their SRL strategies to evolving individual and contextual circumstances. To advance towards achieving self-regulation, problem solvers should engage in reflective practices and challenge their individually set learning goals within a group setting. Participating in moderated group discussions enables learners to glean insight from one another, fostering a collaborative learning environment that promotes growth and development.

Thus, a SRL training fostering CPS should be put in a complex problem context, address personal, behavioral, environmental factors, apply educational scaffolds, and build on the four hierarchy levels.

Conclusion

The social cognitive view of SRL (Zimmerman, 2000, 2006) supports the process perspective on CPS (Fischer et al., 2012) and contributes to CPS research in several ways.

First, we expand CPS research by introducing SRL. This concept supports the cognitive CPS elements with metacognitive and motivational SRL strategies to demonstrate how problem solvers may develop CPS competency and accelerate their expertise (Winkler et al., 2023; Zimmerman, 2001). Metacognition enables problem solvers to regulate, monitor, and evaluate their CPS activities to gradually develop expertise (Ifenthaler, 2012). Understanding and executing motivational strategies helps to stay motivated in CPS processes and to enhance resilience to better deal with drawbacks when facing obstacles (Zimmerman & Campillo, 2003).

Second, SRL is a powerful approach for problem solvers addressing novel complex situations containing dynamic changes and unexpected events where experience is not available or even disadvantageous (Eesley & Roberts, 2012; Ucbasaran et al., 2009). Executing self-control by self-regulating behavior, cognition, motivation, and affect supports dealing with changing circumstances (Winkler et al., 2023). This adaptive capacity is essential for entrepreneurs who often face ambiguous and uncertain situations that require continuous learning and adjustments.

Third, we provide some concrete SRL strategies that problem solvers can apply to improve their CPS process, develop CPS competency, and accelerate CPS expertise in the long run. To guide their information acquisition, individuals should set proximal learning goals as part of their motivational regulation. The gathered knowledge is structured hierarchically to detect interconnections and patterns in various situations. SRL enables to differentiate between previous experiences and the requirements of novel settings (Winkler et al., 2023). While planning CPS strategies, solvers should guide their affect and behavior towards previously set goals (Pressley, 1995). They can identify effective problem solving strategies based on their utility value. Furthermore, outcome expectations help to promote and retain motivation during CPS. Regularly assessing and monitoring problem solving activities leads to either aligning goals or adapting strategies, which improves the way of learning. To continuously improve the CPS process, setbacks should result in an adjustment of one's problem representation, not an attribution to low ability, therefore, negative emotions and a withdrawal from further solution efforts (Ucbasaran et al., 2013).

Fourth, existing CPS training approaches can be adjusted by acknowledging the four-level hierarchy of SRL (Zimmerman, 2001) and scaffolding higher-order thinking and learning (Athanassiou, McNett, & Harvey, 2003). There is evidence that the motivation and problem-solving skills of learners who follow this four-step approach are superior to those of learners who skip these steps (Zimmerman & Kitsantas, 1997, 1999; Kitsantas, Zimmerman, & Cleary, 2000). Integrating the problem solvers' cognitive, motivational, and metacognitive processes while dealing with complexity into educational training enables the continuous entrepreneurial development. Especially in uncertain and dynamic environments it is ineffective and can be costly to only rely on learning from experience and trial-and-error learning (Fust et al., 2018).

Limitations and future research

The implementation of SRL strategies can lead to enhancement in goal setting, strategic planning, information reduction, and DDM, ultimately accelerating the development of CPS expertise (Winkler et al., 2023).

It is important, however, to acknowledge the limitations of this theoretical framework. There is a lack of empirical evidence supporting the direct impact of SRL on the development of CPS competency. An additional empirical validation through longitudinal studies or experimental designs would be essential to establish causal relationships and measure the effectiveness of integrating SRL strategies in CPS training. Additionally, we have analyzed the relationship between SRL and CPS from an entrepreneurial perspective. Investigating the transferability of SRL to further contexts will contribute to the development of practical guidelines for educators seeking to enhance CPS competency.

In conclusion, while the theoretical framework presented in this paper highlights the potential benefits of incorporating SRL to improve CPS competency, empirical validation and further research are essential to verify the propositions and provide actionable insights for developing CPS expertise.

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References

Anderson, J. R. (1980). *Cognitive psychology and its implications*. W. H. Freeman and Company. https://archive.org/details/cognitivepsychol0005ande

Anderson, J. R. (1987). Skill acquisition: Compilation of weak-method problem situations. *Psychological Review*, 94(2), 192. https://doi.org/10.1037/0033-295X.94.2.192

Argyris, C., & Schön, D. A. (1978). *Organizational Learning: A Theory of Action Perspective*. Addison-Wesley.

Athanassiou, N., McNett, J. M., & Harvey, C. (2003). Critical thinking in the management classroom: Bloom's taxonomy as a learning tool. *Journal of Management Education*, 27(5), 533–555. https://doi.org/10.1177/1052562903252515 a Baggen, Y., Mainert, J., Kretzschmar, A., Lans, T., Biemans, H. J., Niepel, C., & Greiff, S. (2017). Complex problems in entrepreneurship education: Examining complex problem-solving in the application of opportunity identification. *Education Research International*, 2017. https://doi.org/10.1155/2017/1768690

Baggen, Y., Mainert, J., Lans, T., Biemans, H. J., Greiff, S., & Mulder, M. (2015). Linking complex problem solving to opportunity identification competence within the context of entrepreneurship. *International Journal of Lifelong Education*, 34(4), 412–429. https://doi.org/10.1080/02601370.2015.1060029

Bandura, A. (1991). Self-regulation of motivation through anticipatory and self-reactive mechanisms. In R. A. Dienstbier (Ed.), *Perspectives on Motivation: Nebraska Symposium on Motivation* (Vol. 38, pp. 69–164).

Bandura, A. (1991). Social cognitive theory of self-regulation. *Organizational Behavior and Human Decision Processes*, 50(2), 248–287. https://doi.org/10.1016/0749-5978(91)90022-L

Bandura, A. (1997). *Self-efficacy: The exercise of control*. W.H. Freeman.

Bandura, A. (2015). On deconstructing commentaries regarding alternative theories of self-regulation. *Journal of Management*, 41(4), 1025–1044. https://doi.org/10.1177/0149206315572826

Bandura, A., & Schunk, D. H. (1981). Cultivating competence, self-efficacy, and intrinsic interest through proximal self-motivation. *Journal of Personality and Social Psychology*, 41, 586–598. https://doi.org/10.1037/0022-3514.41.3.586

Baron, R. A., & Ensley, M. D. (2006). Opportunity recognition as the detection of meaningful patterns: Evidence from comparisons of novice and experienced entrepreneurs. *Management Science*, 52(9), 1331–1344. https://doi.org/10.1287/mnsc.1060.0538

Baron, R. A., & Henry, R. A. (2010). How entrepreneurs acquire the capacity to excel: Insights from research on expert performance. *Strategic Entrepreneurship Journal*, 4(1), 49–65. https://doi.org/10.1002/sej.82

Barth, C. M., & Funke, J. (2010). Negative affective environments improve complex solving performance. *Cognition and Emotion*, 24(7), 1259–1268. https://doi.org/10.1080/02699930903223766

Bhaskar, R., & Simon, H. A. (1977). Problem solving in semantically rich domains: An example from engineering thermodynamics. *Cognitive Science*, 1, 193–215. https://doi.org/10.1207/s15516709cog0102_3

Boekaerts, M. (1999). Self-regulated learning: Where we are today. *International Journal of Educational Research*, 31(6), 445–457. https://doi.org/10.1016/S0883-0355(99)00014-2

Brehmer, B. (1992). Dynamic decision making: Human control of complex systems. *Acta Psychologica*, 81(3), 211–241. https://doi.org/10.1016/0001-6918(92)90019-A

Brehmer, B. (2004). Some reflections on microworld research. In S. G. Schiflett et al. (Eds.), *Scaled worlds: Development, validation and application* (pp. 22–37). Ashgate.

Brehmer, B., & Dörner, D. (1993). Experiments with computer-simulated microworlds: Escaping both the narrow straits of the laboratory and the deep blue sea of the field study. *Computers in Human Behavior*, 9(2–3), 171–184. https://doi.org/10.1016/0747-5632(93)90005-D

Bruning, R. H., Schraw, G. J., & Ronning, R. R. (1995). *Cognitive psychology and instruction* (2nd ed.). Merrill.

Buehner, M. J., & Cheng, P. W. (2005). Causal Learning. In K. J. Holyoak, & R. G. Morrison (Eds.), *The Cambridge Handbook of Thinking and Reasoning* (pp. 143–168). University Press.

Chi, M. T. H., Glaser, R., & Rees, E. (1982). Expertise in Problem Solving. In R. J. Sternberg (Ed.), *Advances in the Psychology of Human Intelligence, Vol. 1* (pp. 7–75). Erlbaum.

Cleary, T. J., & Zimmerman, B. J. (2004). Self-regulation empowerment program: A school-based program to enhance self-regulated and self-motivated cycles of student learning. *Psychology in the Schools*, 41(5), 537–550. https://doi.org/10.1002/pits.10177

Danner, D., Hagemann, D., Holt, D. V., Bechthold, M., Schankin, A., Wüstenberg, S., & Funke, J. (2011). Measuring performance in a Complex Problem Solving task: Reliability and validity of the Tailorshop simulation. *Journal of Individual Differences*, 32, 225–233. https://doi.org/10.1027/1614-0001/a000055

Davis, G. A. (1973). *Psychology of problem solving: Theory and practice*. Basic Books.

Dodson, C. S., & Schacter, D. L. (2002). When false recognition meets metacognition: The distinctiveness heuristic. *Journal of Memory and Language*, 46(4), 782–803. https://doi.org/10.1006/jmla.2001.2822

Dörner, D. (1975). Wie Menschen eine Welt verbessern wollten [How people wanted to improve the world]. *Bild der Wissenschaft*, 12(2), 48–53.

Dörner, D. (1986). Diagnostik der operativen Intelligenz [Assessment of operative intelligence]. *Diagnostica*, 32(4), 29.

Dörner, D. (1989). *Die Logik des Misslingens. Strategisches Denken in komplexen Situationen [Logic of failure. Strategic thinking in complex situations]*. Rowohlt.

Dörner, D. (1996). *The Logic of Failure*. Holt.

Dörner, D., & Funke, J. (2017). Complex problem solving: What it is and what it is not. *Frontiers in Psychology*, 8, 1153. https://doi.org/10.3389/fpsyg.2017.01153

Donovan, S.J., Güss, C.D., & Naslund, D. (2015). Improving dynamic decision making through training and self-reflection. *Judgment and Decision Making*, 10(4), 284–295. https://doi.org/10.1017/S1930297500005118

Dreyfus, S. E. (2004). The five-stage model of adult skill acquisition. *Bulletin of Science, Technology & Society*, 24(3), 177–181. https://doi.org/10.1177/0270467604264992

D'Zurilla, T. J., & Nezu, A. M. (2006). *Problem-solving therapy: A positive approach to clinical intervention*. Springer.

Endsley, M. R. (1995). Measurement of situation awareness in dynamic systems. *Human Factors*, 37(1), 65–84. https://doi.org/10.1518/001872095779049499

Eesley, C. E., & Roberts, E. B. (2012). Are you experienced or are you talented? When does innate talent versus experience explain entrepreneurial performance? *Strategic Entrepreneurship Journal*, 6(3), 207–219. https://doi.org/10.1002/sej.1141

Ericsson, K. A., Krampe, R. T., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert perfor-

mance. *Psychological Review*, 100(3), 363–406. https://doi.org/10.1037/0033-295X.100.3.363

Fischer, A., Greiff, S., & Funke, J. (2011). The process of solving complex problems. *Journal of Problem Solving*, 4(1), 19–42. https://doi.org/10.7771/1932-6246.1118

Fischer, A., & Neubert, J. C. (2015). The multiple faces of complex problems: A model of problem solving competency and its implications for training and assessment. *Journal of Dynamic Decision Making*, 1, 6–6. https://doi.org/10.11588/jddm.2015.1.23945

Frensch, P. A., & Funke, J. (Eds.) (1995a). *Complex Problem Solving: The European Perspective*. Erlbaum.

Frensch, P. A., & Funke, J. (1995b). Definitions, traditions, and a general framework for understanding complex problem solving. In P. A. Frensch & J. Funke (Eds.), *Complex Problem Solving: The European Perspective* (pp. 3–25). Lawrence Erlbaum.

Fuchs, L. S., Fuchs, D., Prentice, K., Burch, M., Hamlett, C. L., Owen, R., & Schroeter, K. (2003). Enhancing third-grade students' mathematical problem solving with self-regulated learning strategies. *Journal of Educational Psychology*, 95(2), 306–315. https://doi.org/10.1037/0022-0663.95.2.306

Funke, J. (2001). Dynamic systems as tools for analysing human judgement. *Thinking and Reasoning*, 7, 69–89. https://doi.org/10.1080/13546780042000046

Funke, J. (2010). Complex problem solving: A case for complex cognition? *Cognitive Processing*, 11(2), 133–142. https://doi.org/10.1007/s10339-009-0345-0

Funke, J., Fischer, A., & Holt, D. V. (2018). Competencies for complexity: Problem solving in the twenty-first century. In E. Care, P. Griffin, & M. Wilson (Eds.), *Assessment and Teaching of 21st Century Skills: Research and Applications* (pp. 41–53). https://doi.org/10.1007/978-3-319-65368-6_3

Fust, A. P., Jenert, T., & Winkler, C. (2018). Experiential or self-regulated learning: A critical reflection of entrepreneurial learning processes. *Entrepreneurship Research Journal*, 8(2), 20170098. https://doi.org/10.1515/erj-2017-0098

Garud, R., Kumaraswamy, A., & Karnøe, P. (2010). Path dependence or path creation? *Journal of Management Studies*, 47(4), 760–774. https://doi.org/10.1111/j.1467-6486.2009.00914.x

Garfield, C. A., & Bennett, Z. H. (1985). *Peak performance: Mental training techniques of the world's greatest athletes*. Warner.

Garvey, B. (2022). Locating Uncertainty Along the Risk Spectrum. In B. Garvey, D. Humzah & S. Le Roux (Eds.), *Uncertainty Deconstructed: A Guidebook for Decision Support Practitioners* (pp. 21–46). Springer.

Gonzalez, C., & Lebiere, C. (2005). Instance-based cognitive models of decision making. In D. Zizzo & A. Courakis (Eds.), *Transfer of Knowledge in Economic Decision Making*. Palgrave McMillan.

Gonzalez, C., Vanyukov, P., & Martin, M. K. (2005). The use of microworlds to study dynamic decision making. *Computers in Human Behavior*, 21(2), 273–286. https://doi.org/10.1016/j.chb.2004.02.014

Greiff, S., Wüstenberg, S., & Funke, J. (2012). Dynamic problem solving: A new assessment perspective. *Applied Psychological Measurement*, 36(3), 189–213. https://doi.org/10.1177/0146621612439620

Greiff, S., Wüstenberg, S., Holt, D. V., Goldhammer, F., & Funke, J. (2013). Computer-based assessment of complex problem solving: Concept, implementation, and application. *Educational Technology Research and Development*, 61, 407–421. https://doi.org/10.1007/s11423-013-9301-x

Greiff, S., Wüstenberg, S., Csapó, B., Demetriou, A., Hautamäki, J., Graesser, A. C., & Martin, R. (2014). Domain-general problem solving skills and education in the 21st century. *Educational Research Review*, 13, 74–83. https://doi.org/10.1016/j.edurev.2014.10.002

Güss, C. D., & Dörner, D. (2011). Cultural differences in dynamic decision-making strategies in a non-linear, time-delayed task. *Cognitive Systems Research*, 12(3–4), 365–376. https://doi.org/10.1016/j.cogsys.2010.12.003

Güss, C. D., Evans, J., Murray, D., & Schaub, H. (2009). Conscious versus unconscious processing in dynamic decision making tasks. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, 53, 227–231. https://doi.org/10.1177/154193120905300414

Halford, G.S., Wilson, W.H., & Phillips, S. (1998). Processing capacity defined by relational complexity: Implications for comparative, developmental and cognitive psychology. *Behavioral and Brain Sciences*, 21, 803–865. https://doi.org/10.1017/S0140525X98001769

Haynie, M., & Shepherd, D. A. (2009). A measure of adaptive cognition for entrepreneurship research. *Entrepreneurship Theory and Practice*, 33(3), 695–714. https://doi.org/10.1111/j.1540-6520.2009.00322.x

Haynie, J. M., Shepherd, D. A., & Patzelt, H. (2012). Cognitive adaptability and an entrepreneurial task: The role of metacognitive ability and feedback. *Entrepreneurship Theory and Practice*, 36(2), 237–265. https://doi.org/10.1111/j.1540-6520.2010.00410.x

Haynie, J. M., Shepherd, D., Mosakowski, E., & Earley, P. C. (2010). A situated metacognitive model of the entrepreneurial mindset. *Journal of Business Venturing*, 25(2), 217–229. https://doi.org/10.1016/j.jbusvent.2008.10.001

Hermes, M., & Stelling, D. (2016). Context matters, but how much? Latent state–trait analysis of cognitive ability assessments. *International Journal of Selection and Assessment*, 24(3), 285–295. https://doi.org/10.1111/ijsa.12147

Hiller, N. J., & Hambrick, D. C. (2005). Conceptualizing executive hubris: The role of (hyper-) core self-evaluations in strategic decision-making. *Strategic Management Journal*, 26(4), 297–319. https://doi.org/10.1002/smj.455

Hsieh, C., Nickerson, J.A., & Zenger, T.R. (2007). Opportunity Discovery, Problem Solving and a Theory of the Entrepreneurial Firm. *Journal of Management Studies*, 44(7), 1143–1171. https://doi.org/10.1111/j.1467-6486.2007.00725.x

Ifenthaler, D. (2012). Determining the effectiveness of prompts for self-regulated learning in problem-solving scenarios. *Journal of Educational Technology & Society*, 15(1), 38–52. https://www.jstor.org/stable/jeductechsoci.15.1.38

Kitsantas, A., Zimmerman, B. J., & Cleary, T. (2000). The role of observation and emulation in the development of athletic self-regulation. *Journal of Educational Psychology*, 92(4), 811. https://doi.org/10.1037/0022-0663.92.4.811

Klahr, D., & Dunbar, K. (1988). Dual space search during scientific reasoning. *Cognitive Science*, 12, 1–48. https://doi.org/10.1207/s15516709cog1201_1

Klauer, K.C. (1993). *Belastung und Entlastung beim Problemlösen. Eine Theorie des deklarativen Vereinfachens [Charge and discharge in problem solving. A theory of declarative simplification]*. Hogrefe.

Kluge, A. (2008). What you train is what you get? Task requirements and training methods in complex problem-solving. *Computers in Human Behavior*, 24(2), 284–308. https://doi.org/10.1016/j.chb.2007.01.013

Kretzschmar, A., & Süß, H. M. (2015). A study on the training of complex problem solving competence. *Journal of Dynamic Decision Making*, 1, 4. https://doi.org/10.11588/jddm.2015.1.15455

Kuhl, J. (1985). Volitional mediators of cognition-behavior consistency: Self-regulatory processes and action versus state orientation. In J. Kuhl & J. Beckman (Eds.), *Action Control: From Cognition to Behavior* (pp. 101–128). Springer. https://doi.org/10.1007/978-3-642-69746-3_6

Leutner, D., Wirth, J., Klieme, E., & Funke, J. (2005). Ansätze zur Operationalisierung und deren Erprobung im Feldtest zu PISA 2000 [Approaches concerning operationalization and their testing in the field test in the context of PISA 2000]. In E. Klieme, D. Leutner & J. Wirth (Eds.), *Problemlösekompetenz von Schülerinnen und Schülern* (pp. 21–36). VS Verlag für Sozialwissenschaften. https://doi.org/https://doi.org/10.1007/978-3-322-85144-4_3

Locke, E. A., & Latham, G. P. (1990). *A theory of goal setting & task performance*. Prentice Hall.

Locke, E. A., & Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American Psychologist*, 57(9), 705–717. https://doi.org/10.1037/0003-066X.57.9.705

Locke, E. A., & Latham, G. P. (2006). New directions in goal-setting theory. *Current Directions in Psychological Science*, 15(5), 265–268. https://doi.org/10.1111/j.1467-8721.2006.00449.x

Loehr, J. E. (1991). *The mental game*. Penguin Books.

Mayer, R. E. (1992). *Thinking, problem solving, cognition*. WH Freeman/Times Books/Henry Holt & Co.

McCann, B. T., & Vroom, G. (2015). Opportunity evaluation and changing beliefs during the nascent entrepreneurial process. *International Small Business Journal: Researching Entrepreneurship*, 33(6), 612–637. https://doi.org/10.1177/0266242614544198

Mishra, C. S. (2017). *Creating and sustaining competitive advantage: Management logics, business models, and entrepreneurial rent* (pp. 307–355). Springer International Publishing. https://doi.org/10.1007/978-3-319-54540-0

Moore, M. T. (1990). Problem finding and teacher experience. *Journal of Creative Behavior*, 24, 39–58. https://doi.org/10.1002/j.2162-6057.1990.tb00527.x

Newell, A., & Simon, H.A. (1972). *Human Problem Solving*. Prentice-Hall.

O'Donnell, A. M., Dansereau, D. F., & Hall, R. H. (2002). Knowledge maps as scaffolds for cognitive processing. *Educational Psychology Review*, 14, 71–86. https://doi.org/10.1023/A:1013132527007

OECD (2014). *PISA 2012 Results: Creative Problem Solving (Volume V): Students' Skills in Tackling Real-Life Problems*. OECD Publishing. https://doi.org/10.1787/9789264208070-en

OECD (2013). *Skills Outlook 2013*. OECD Publishing. https://doi.org/10.1787/9789264204256-en

Ohlsson, S. (1992). Information processing explanations of insight and related phenomena. In M. T. Keane & K. J. Gilhooly (Eds.), *Advances in the Psychology of Thinking*. Harvester Wheatsheaf.

Osman, M. (2010). Controlling uncertainty: a review of human behavior in complex dynamic environments. *Psychological Bulletin*, 136(1), 65. https://doi.org/10.1037/a0017815

Pajares, F. (2008). Motivational role of self-efficacy beliefs in self-regulated learning. *Motivation and Self-regulated Learning: Theory, Research, and Applications*, 111–139.

Pearce, C. L. (2004). The future of leadership: Combining vertical and shared leadership to transform knowledge work. *Academy of Management Perspectives*, 18(1), 47–57. https://doi.org/10.5465/ame.2004.12690298

Pressley, M. (1977). Imagery and children's learning: Putting the picture in developmental perspective. *Review of Educational Research*, 47(4), 585–622. https://doi.org/10.3102/00346543047004458

Pressley, M. (1990). *Cognitive strategy instruction that really improves children's academic performance*. Brookline Books.

Pressley, M., & Levin, J. R. (1977). Task parameters affecting the efficacy of a visual imagery learning strategy in younger and older children. *Journal of Experimental Child Psychology*, 24(1), 53–59. https://doi.org/10.1016/0022-0965(77)90019-4

Pressley, M., & McCormick, C. (1995). *Advanced educational psychology for educators, researchers, and policymakers*. Allyn & Bacon.

Puustinen, M., & Pulkkinen, L. (2001). Models of self-regulated learning: A review. *Scandinavian Journal of Educational Research*, 45(3), 269–286. https://doi.org/10.1080/00313830120074206

Resnick, L. B. (1985). Cognition and instruction: Recent theories of human competence. In B. L. Hammonds (Ed.), *Psychology and Learning: The Master Lecture Series* (Vol. 4, pp. 127–186).

Rohe, M. S., Funke, J., Storch, M., & Weber, J. (2016). Can motto-goals outperform learning and performance goals? Influence of goal setting on performance and affect in a complex problem solving task. *Journal of Dynamic Decision Making*, 1(3). https://doi.org/10.11588/jddm.2016.1.28510

Schaub, H. (2007). The importance of the characteristics of the task to understand team mental models. *CoDesign*, 3(1), 37–42. https://doi.org/10.1080/15710880601170800

Schoppek, W. (2004). Teaching structural knowledge in the control of dynamic systems: Direction of causality makes a difference. In *Proceedings of the Annual Meeting of the Cognitive Science Society* (Vol. 26, No. 26).

Schoppek, W., & Fischer, A. (2017). Common process demands of two complex dynamic control tasks: transfer is mediated by comprehensive strategies. *Frontiers in Psychology*, 8, 2145. https://doi.org/10.3389/fpsyg.2017.02145

Schunk, D. H. (1982). Progress self-monitoring: Effects on children's self-efficacy and achievement. *The Journal of Experimental Education*, 51(2), 89–93. https://doi.org/10.1080/00220973.1982.11011845

Schunk, D. H. (1989). Social cognitive theory and self-regulated learning. In B. J. Zimmerman & D. H. Schunk (Eds.), *Self-Regulated Learning and Academic Achievement: Theory, Research, and Practice* (pp. 83–110). Springer.

Schunk, D. H. (2001). Social cognitive theory and self-regulated learning. In B. J. Zimmerman & D. H. Schunk (Eds.), *Self-regulated Learning and Academic Achievement: Theoretical Perspectives* (2nd ed., pp. 1–37). Lawrence Erlbaum.

Schunk, D. H., & Ertmer, P. A. (2000). Self-regulation and academic learning: Self-efficacy enhancing interventions. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of Self-Regulation* (pp. 631–649). Academic Press.

Schunk, D. H., & Rice, J. M. (1985). Verbalization of comprehension strategies: Effects on children's achievement outcomes. *Human Learning: Journal of Practical Research & Applications*.

Schunk, D. H., & Swartz, C. W. (1993). Goals and progress feedback: Effects on self-efficacy and writing achievement. *Contemporary Educational Psychologist*, 18, 337–354. https://doi.org/10.1006/ceps.1993.1024

Schunk, D. H., & Zimmerman, B. J. (1998). Conclusions and future directions for academic interventions. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-Regulated Learning: From Teaching to Self-Reflective Practice* (pp. 225–234). Guilford.

Seijts, G. H., & Latham, G. P. (2005). Learning versus performance goals: When should each be used? *The Academy of Management Executive*, 19(1), 124–131. https://doi.org/10.5465/ame.2005.15841964

Shepherd, D. A., McMullen, J. S., & Jennings, P. D. (2007). The formation of opportunity beliefs: Overcoming ignorance and reducing doubt. *Strategic Entrepreneurship Journal*, 1(1-2), 75–95. https://doi.org/10.1002/sej.3

Simon, H. A., & Lea, G. (1974). Problem solving and rule induction: A unified view. In L. W. Greff (Ed.), *Knowledge and Cognition* (pp. 105–127). Erlbaum.

Spering, M., Wagener, D., & Funke, J. (2005). The role of emotions in complex problem solving. *Cognition and Emotion*, 19(8), 1252–1261. https://doi.org/10.1080/02699930500304886

Sternberg, R. J. (1995). Expertise in complex problem solving: a comparison of alternative conceptions. In P. A. Frensch & J. Funke (Eds.), *Complex Problem Solving: The European Perspective* (pp. 295–321). Erlbaum.

Storch, M. (2009). Motto-Ziele, SMART-Ziele und Motivation [Motto goals, SMART goals, and motivation. In B. Birgmeier (Ed.), *Coachingwissen: Denn sie wissen nicht, was sie tun?* (pp. 183–205). VS Verlag für Sozialwissenschaften.

Süß, H.-M. (1996). *Intelligenz, Wissen und Problemlösen. Kognitive Voraussetzungen für erfolgreiches Handeln bei computersimulierten Problemen* [Intelligence, knowledge, and problem solving: Cognitive prerequisites for effective performance in computer-simulated problems.]. Hogrefe.

Süß, H.-M. (1999). Intelligenz und komplexes Problemlösen [Intelligence and complex problem solving]. *Psychologische Rundschau*, 50(4), 220–228. https://doi.org/10.1026//0033-3042.50.4.220

Süß, H.-M., Oberauer, K., & Kersting, M. (1993). Intellektuelle Fähigkeiten und die Steuerung komplexer Systeme [Intellectual Abilities and the Control of complex systems]. *Sprache & Kognition*, 12, 83–97.

Sweller, J. (2005). Implications of cognitive load theory for multimedia learning. *The Cambridge Handbook of Multimedia Learning*, 3(2), 19–30. https://doi.org/10.1017/CBO9780511816819.003

Toplak, M., West, R. F., & Stanovich, K. E. (2011). The Cognitive Reflection Test as a predictor of performance on heuristics and biases tasks. *Memory and Cognition*, 39, 1275–1289. https://doi.org/10.3758/s13421-011-0104-1

Tricot, A., & Sweller, J. (2013). Domain-specific knowledge and why teaching generic skills does not work. *Educational Psychology Review*, 26(2), 1–19. https://doi.org/10.1007/s10648-013-9243-1

Ucbasaran, D., Shepherd, D. A., Lockett, A., & Lyon, S. J. (2013). Life after business failure: The process and consequences of business failure for entrepreneurs. *Journal of Management*, 39(1), 163–202. https://doi.org/10.1177/0149206312457823

Ucbasaran, D., Westhead, P., & Wright, M. (2009). The extent and nature of opportunity identification by experienced entrepreneurs. *Journal of Business Venturing*, 24(2), 99–115. https://doi.org/10.1016/j.jbusvent.2008.01.008

Ucbasaran, D., Westhead, P., & Wright, M. (2011). Why serial entrepreneurs don't learn from failure. *Harvard Business Review*, 89(4), 26–26.

Voss, J. F., Greene, T. R., Post, T. A., & Penner, B. C. (1983). Problem-solving skill in the social sciences. In G. H. Bower (Ed.), *Psychology of Learning and Motivation* (Vol. 17, pp. 165–213). Academic Press. https://doi.org/10.1016/S0079-7421(08)60099-7

Weinert, F. E., & Waldmann, M. R. (1988). Wissensentwicklung und Wissenserwerb [Knowledge development and knowledge acquisition]. In H. Mandl, & H. Spada (Eds.), *Wissenspsychologie* (pp. 161–199). Psychologie Verlags Union.

Wigfield, A., & Eccles, J. S. (2000). Expectancy–value theory of achievement motivation. *Contemporary Educational Psychology*, 25(1), 68–81. https://doi.org/10.1006/ceps.1999.1015

Winne, P. H., & Nesbit, J. C. (2010). The psychology of academic achievement. *Annual Review of Psychology*, 61, 653–678. https://doi.org/10.1146/annurev.psych.093008.100348

Winkler, C., Fust, A., & Jenert, T. (2023). From entrepreneurial experience to expertise: A self-regulated learning perspective. *Journal of Small Business Management*, 61(4), 2071–2096. https://doi.org/10.1080/00472778.2021.1883041

Wittmann, W. W., & Hattrup, K. (2004). The relationship between performance in dynamic systems and intelligence. *Systems Research and Behavioral Sciences*, 21, 393–409. https://doi.org/10.1002/sres.653

Wittmann, W., & Süß, H.-M. (1999). Investigating the paths between working memory, intelligence, knowledge, and complex problem-solving performances via Brunswik symmetry. In P. L. Ackerman, P. C. Kyllonen, & R. D. Roberts (Eds.), *Learning and Individual Differences: Process, Trait, and Content Determinants* (pp. 77–108). APA.

Zimmerman, B. J. (1989). A social cognitive view of self-regulated academic learning. *Journal of Educational Psychology*, 81(3), 329. https://doi.org/10.1037/0022-0663.81.3.329

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of Self-Regulation* (pp. 13–39). Academic Press.

Zimmerman, B. J. (2001). Achieving academic excellence: A self-regulatory perspective. In M. Ferrari (Ed.), *The Pursuit of Excellence through Education* (pp. 85–110). Lawrence Erlbaum.

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into Practice*, 41(2), 64–70. https://doi.org/10.1207/s15430421tip4102_2

Zimmerman, B. J. (2006). Development and adaptation of expertise: The role of self-regulatory processes and beliefs. In K. A. Ericsson, N. Charness, P. J. Feltovich, & R. R. Hoffman (Eds.), *The Cambridge Handbook of Expertise and Expert Performance*, 186, 705–722.

Zimmerman, B. J. (2007). Goal setting: A key proactive source of academic self-regulation. In B. J. Zimmerman & D. H. Schunk (Eds.), *Motivation and Self-Regulated Learning: Theory, Research, and Applications* (pp. 267–298). Erlbaum.

Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American Educational Research Journal*, 45(1), 166–180. https://doi.org/10.3102/0002831207312909

Zimmerman, B. J. (2011). Motivational sources and outcomes of self-regulated learning and performance. In B. J. Zimmerman & D. H. Schunk (Eds.), *Handbook of Self-Regulation of Learning and Performance* (pp. 49–64). Routledge.

Zimmerman, B. J., & Campillo, M. (2003). Motivating self-regulated problem solvers. In J. E. Davidson & R. J. Sternberg (Eds.), *The Psychology of Problem Solving* (pp. 233–262). Cambridge University Press. https://doi.org/10.1017/CBO9780511615771.009

Zimmerman, B. J., & Kitsantas, A. (1996). Self-regulated learning of a motoric skill: The role of goal setting and self-monitoring. *Journal of Applied Sport Psychology*, 8(1), 60–75. https://doi.org/10.1080/10413209608406308

Zimmerman, B. J., & Paulsen, A. S. (1995). Self-monitoring during collegiate studying: An invaluable tool for academic self-regulation. In P. Pintrich (Ed.), *New Directions in College Teach-*

ing and Learning: Understanding Self-Regulated Learning (No. 63, Fall, pp. 13–27). Jossey-Bass.

Zimmerman, B. J., & Pike, E. O. (1972). Effects of modeling and reinforcement on the acquisition and generalization of question-asking behavior. *Child Development*, 43(3), 892–907. https://doi.org/10.2307/1127640

Zimmerman, B. J., & Schunk, D. H. (2011). Self-regulating learning and performance: An introduction and an overview. In B. J. Zimmerman & D. H. Schunk (Eds.), *Handbook of Self-Regulation of Learning and Performance* (pp. 1–12). Routledge.

Zimmerman, B. J., Schunk, D. H., & Di Benedetto, M. K. (2015). A personal agency view of self-regulated learning. In F. Guay, H. Marsh, D. M. McInerney, & R. Craven (Eds.), *Self-Concept, Motivation and Identity: Underpinning Success with Research and Practice* (pp. 83–101). Information Age Publishing.