Educational self-regulation competence: toward a lifespan-based concept and assessment strategy

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Abstract

Self-regulation is crucial for learning and achievement in educational and occupational contexts. Educational self-regulation has been conceptualized as a domain-specific, context-bound *competence* that is open to interventions. Beyond students' educational self-regulation (ESR), few studies have examined ESR across the lifespan as a basis of competence assessments. We contribute to adult ESR by discussing whether ESR competence applies to intermediate and higher self-regulation levels, as represented by workplace learning and career management. Furthermore, we discuss the interplay of epistemic beliefs and metacomprehension as core processes of ESR. Finally, we outline cornerstones of an assessment strategy for adult ESR.

Keywords Self-regulation · Lifelong learning · Career management

Résumé

La compétence d'autorégulation scolaire : Vers un concept et une stratégie d'évaluation basés sur le lifespan

L'autorégulation est cruciale pour l'apprentissage et la réussite dans les contextes scolaires et professionnels. L'autorégulation scolaire a été conceptualisée comme une compétence spécifique à un domaine et liée à un contexte, et elle est ouverte aux interventions. Au-delà de l'autorégulation scolaire (ARS) des élèves, peu d'études ont examiné l'ARS tout au long de la vie comme une base pour l'évaluation des compétences. Nous contribuons à la compréhension du rôle de l'ARS chez les adultes en examinant si cette dernière s'applique aux niveaux d'autorégulation intermédiaires et supérieurs tels que représentés par l'apprentissage sur le lieu de travail et la gestion

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de carrière. De plus, nous discutons de l'interaction entre les croyances épistémiques et la métacompréhension en tant que processus fondamentaux de l'ASR. Enfin, nous décrivons les principes d'une stratégie d'évaluation de l'ASR chez les adultes.

Zusammenfassung

Pädagogische Selbstregulationskompetenz: Auf dem Weg zu einem lebensspannenbasierten Konzept sowie einer Erhebungsstrategie

Selbstregulation ist entscheidend für Lernen und Erfolg in schulischen und beruflichen Kontexten. Pädagogische Selbstregulation wurde als eine domänenspezifische, kontextgebundene Kompetenz konzipiert, die offen ist für Interventionen. Über die pädagogische Selbstregulation (educational self-regulation, ESR) von Studierenden hinaus haben nur wenige Studien die ESR über die Lebensspanne als Grundlage von Kompetenzerfassungen untersucht. Wir leisten einen Beitrag zur ESR im Erwachsenenalter, indem wir erörtern, ob die ESR-Kompetenz auch für mittlere und höhere Selbstregulationsstufen gilt, wie sie durch Lernen am Arbeitsplatz und das Laufbahnmanagement repräsentiert werden. Weiterhin diskutieren wir das Zusammenspiel von erkenntnistheoretischen Überzeugungen sowie des Verständnisses der Metaebene als Kernprozesse der ESR. Abschließend skizzieren wir Eckpfeiler einer Erhebungsstrategie für ESR bei Erwachsenen.

Resumen

Competencia de autorregulación educativa: hacia un concepto y una estrategia de evaluación basados en el ciclo vital

La autorregulación es fundamental para el aprendizaje y el rendimiento en contextos educativos y ocupacionales. La autorregulación educativa se ha conceptualizado como una competencia específica del ámbito y vinculada al contexto, que está abierta a intervenciones. Más allá de la autorregulación educativa de los estudiantes, (ESR, siglas en Inglés), son escasos los estudios que han examinado la ESR a lo largo de la vida como base para la evaluación de competencias. Contribuimos a la ESR de las personas adultas analizando si la competencia de ESR se aplica a niveles intermedios y superiores de autorregulación, representados por el aprendizaje en el lugar de trabajo y la gestión de la carrera. Además, discutimos la interacción de las creencias epistémicas y la metacompreensión como procesos centrales de la ESR. Por último, describimos los pilares de una estrategia de evaluación de la ESR en personas adultas.

Introduction

Self-regulation has been investigated in several research fields, as it offers important practical and theoretical implications for predicting individual and groups' motivation and behavior. This review aims to shed light on self-regulatory processes in educational contexts that may contribute to successful lifelong learning in the digital age. We argue that developing educational self-regulation builds a competence to successfully manage learning in educational and occupational contexts that vary across the lifespan. We first describe empirical evidence for self-regulated learning

and the acquisition of educational self-regulation in younger ages. Afterward, we review the adult learning literature, explaining how educational self-regulation influences workplace learning and career management. The aim is to provide conclusions for the conceptualization and assessment of educational self-regulation as a competence, with consequences for different contexts across the lifespan.

Educational research in learning contexts focuses on self-regulated learning as a specific instance of general self-regulation. The general tenet is that self-regulated learners “are metacognitively, motivationally, and behaviorally active participants in their own learning process” (Zimmerman, 1989, p. 4), thus showing higher academic achievement (e.g., Chen, 2002; Lahmers & Zulauf, 2000; Vrugt & Oort, 2008). By contrast, poorer achievement is associated with behaviors indicating low levels of self-regulated learning such as test anxiety (Ruthig et al., 2004), self-handicapping (Martin et al., 2003) or believing that academic learning is irrelevant for future success (Greene et al., 1999). Boekaerts and Cascallar (2006) claimed that self-regulated learning played “a central role in influencing learning and achievement in school and beyond” (p. 199). Reflecting its role as a prerequisite of lifelong learning (Baumert et al., 1998), questionnaire measures of self-regulated learning have been included in international large-scale assessments such as PISA (Artelt et al., 2003). Yet, as a limitation, they cannot capture momentary learning processes and thus need to be complemented by further measures, as we will explain.

Competence assessments should be developed based on theoretically and empirically founded cognitive competence models (Koeppen et al., 2008). Competences are functional, context-bound, domain and demand-specific cognitive achievement dispositions that are subject to educational influence and interventions (Wirth & Leutner, 2008).

The current research addresses the concept of educational self-regulation as a competence supporting individuals in different learning and work contexts. There is substantial evidence on self-regulation in the classroom by investigating pupils and students. Concerning adults, however, few studies address educational self-regulation (ESR) across the lifespan. By drawing attention to cognitive and motivational variables that researchers have recently begun to study in and outside the laboratory, we aim to encourage cross-disciplinary dialog between the disciplines involved in educational assessment research.

Conceptualizing ESR as a competence implies it is domain and demand-specific and raises three questions. First, does ESR competence benefit the intermediate and higher levels of self-regulation involved in workplace learning and career management? Second, if there is only one ESR competence, what is its core process? We focus on the interplay of epistemic beliefs and metacomprehension as the basis for ESR. Our third question has implications for ESR competence assessments: How can current large-scale assessments be extended to capture ESR competence?

Starting points: regulation levels and the competence concept

There “are almost as many definitions and conceptions of self-regulation as there are lines of research on the topic” (Zeidner et al., 2000, p. 750). Martin and McLellan

(2008) even warned of a fragmented diversity of concepts that “may be united only in so far as they employ the same rubric of ‘self-regulation’” (p. 435). To structure those definitions and their complexity, we introduce the notion of *levels of self-regulation* and the *competence concept*.

Levels of self-regulation

Self-regulation can be defined as “those actions directed at modifying a system’s present state or activity, which are necessary either because this is diverting from a previously set goal or because the goal itself needs to be changed.” (Demetriou, 2000, p. 209). Most self-regulation models converge on this conceptual core but differ in terminology and their emphasis on components and processes. For instance, self-regulation can be distinguished from *self-control*, which implies monitoring one’s current actions and planning actions in line with intentions (Kuhl, 2001). Self-regulation is a form of volition that serves to modify action intentions by executing emotion control, impulse control, and performance control (Baumeister et al., 1994).

Models of self-regulated learning (SRL, see Puustinen & Pulkkinen, 2001) are specific applications to learning contexts with the capability for acquiring knowledge and skills in academic learning and achievement. Researchers stressed the importance of metacognitive monitoring by defining self-regulated learning as *metacognitively guided behavior* (Winne & Perry, 2000). Zimmerman (1989) captured the social-cognitive nature of self-regulated learning by positing that students learn to apply self-regulatory learning skills from observation (of a role model), imitation (use of modeled skills while receiving social feedback), self-control (application of self-regulatory skills in the absence of a model), and self-regulation (adaptation of skills to changing learning environments). Demetriou (2000) concluded that in order to implement self-regulatory action, people need a *self-system* that includes *self-monitoring* and *self-modification skills* that keep track of learning-related activities and progress toward learning goals. These skills are necessary to change one’s learning activities to reach an initial goal as well as revising that goal whenever one notices conflict or insufficient goal progress.

ESR can be included in this framework by distinguishing the behaviors that help people reach educational outcomes. Lord et al.’s (2010) distinction of self-regulation levels is helpful. The *feedback loop* (Carver & Scheier, 1998; Powers, 1973) as the core process distinguishes self-regulation at high, intermediate, lower, and micro levels, of which the first two are relevant for this review. The feedback loop is crucial because people set goals, monitor their progress toward these goals and use feedback to modify their behavior to ensure goal attainment. As Lord et al.’s (2010) central assumption, the content of self-regulatory processes depends on different self-regulation levels to complete the *cycle time* of one feedback loop. At the intermediate level of regulation, cycle times range from a few minutes to days, such that self-regulation refers to goals that are attainable in a short time frame and relevant for a current task. Regulation at higher levels, by contrast, involves cycle times from several months to years. Feedback is evaluated in terms of its relevance to one’s self.

As a second important distinction, Boekaerts and Corno (2005) referred to *top-down* versus *bottom-up* self-regulation. In bottom-up regulation, cues from

the environment trigger self-regulatory processes and thus facilitate learning. In classroom learning, feedback from the task and classroom reward structures facilitate establishing goals and changing work styles. Bottom-up regulation, therefore, enables the external control of learning, which could also be provided by technological cues in online environments (Bittner & Zondervan, 2015). Furthermore, technology may support this type of regulation by establishing cooperation goals in classroom and organizational settings (Bittner et al., 2016).

In top-down regulation, motivational factors (e.g., interest, values, expected satisfaction) co-determine goal-setting, which then steers the learning process. Accordingly, top-down regulation is more internally controlled. For procrastination, under both forms learners may prioritize learning versus wellbeing goals, depending on the affordances of the situation (Boekaerts, 1997; Boekaerts & Niemivirta, 2000).

Educational self-regulation competence

Competence “is attributed to individuals ... when they possess the conditions for achieving specific developmental goals and meeting important demands presented by the external environment” (OECD, 1999, p. 3). Educational research focuses on the context-bound, domain and demand-specific cognitive achievement dispositions subject to educational influence and interventions (Wirth & Leutner, 2008). Competences are unlike domain-general, context-free cognitive functions such as intelligence or working memory capacity.

Self-regulated learning was often described as an aptitude (Karoly, 1993), a disposition that is relatively stable within learners across situations and topics (see Winne & Perry, 2000). As its empirical support was not convincing, however, research moved away from the aptitude concept. For instance, Pintrich and García (1993) obtained only weak correlations between a questionnaire measure of strategic learning and seminar grades. Sinkavich (1994) found that grades were not associated with students’ self-reports on cognitive and metacognitive strategies in questionnaires at the start of a semester. Veenman (2005) noted that the variance explained in questionnaire studies averaged around 3%. Sub-processes of self-regulation such as attention regulation (i.e., the ability to organize incoming stimuli) seem to depend on characteristics of the central nervous system and might therefore be relatively stable individual characteristics (Kandel et al., 2000). However, the entire self-regulation process of monitoring and self-control appears to rely on flexible adjustments to situations that involve a variety of motivational and instructional differences (Boekaerts, 1999). Thus, conceptions are warranted of “domain-specific self-regulatory skills that develop through experience within and across situations” (Boekaerts & Corno, 2005, p. 200).

Koeppen et al. (2008) pointed out that competence assessment instruments require theoretically and empirically founded cognitive models that address three issues. First, does self-regulation competence contribute to both the high and intermediate levels of ESR? Second, what is the core process of ESR competence? Finally, how can this process be assessed?

Intermediate and high levels of educational self-regulation in adults

For students, ESR is mostly a goal of education. If we consider the “school-to-work” transition and lifelong learning processes, then ESR increasingly becomes an *outcome* of education. Consistent with the finding that certain competences (e.g., mathematical, reading, verbal) are positively associated with outcomes as diverse as school grades, income, position level or job satisfaction (Kristen et al., 2005), our tenet is that to the extent students acquire ESR competence at school they will show higher levels of ESR in learning contexts later in life.

Only indirect evidence is available so far on long-term benefits of ESR. Demetriou and Bakracevic (2009) studied performance differences in several reasoning tasks as a function of education and self-regulation. As one of the main findings, participants with higher education outperformed participants with lower education and at the same time had higher self-monitoring and self-regulation scores. The authors took this as evidence of a positive influence of education on self-representations that include self-regulation.

Concerning the question whether ESR competence acquired at school accounts for ESR later in life, we discuss workplace learning and career management as important ESR domains. These two concepts differ substantially in their self-regulatory demands but illustrate the impact of ESR on adults.

Workplace learning

Matthews (1999) defined workplace learning as “reasoned learning toward desirable outcomes for the individual and the organization” (p. 19), which includes the acquisition, improvement or extension of work-related knowledge and skills. This broad definition covers organization-led “off-the-job-training” (e.g., structured, formal seminars and courses) that count as *formal learning* (Clarke, 2004), as well as *informal learning*, which receives increasing attention in companies’ training and development activities (e.g., Cross, 2007; Marsick, 2006). Informal learning covers “on-the-job-learning” (Clarke, 2004, p. 142) and comes as, for instance, e-learning, participation in quality circles, job rotation or mentoring. Consistent with a competence view on informal learning (Schulz & Stamov Roßnagel, 2010), self-regulation is sensitive to contextual influences rather than to the expectation of cognitive decline with increasing age.

In a survey of managers, Hashim (2008) demonstrated that communication and managerial competences were acquired through on-the-job training. Moreover, competence acquisition was associated with self-directed learning readiness. Addressing formal workplace learning, Santhanam et al. (2008) showed for e-learning-based information technology training that those workers scored higher who had been instructed to use self-regulated learning strategies.

In contrast to seminar-based trainings, active learning formats allow learners to control their learning by assuming responsibility for their decisions, such as selecting learning activities or monitoring their progress. Active learning approaches promote inductive learning that can benefit the development of self-structured evaluation and metacognition.

In conclusion, higher levels of self-regulation are associated with higher learning performance (Bell & Kozlowski, 2008). Self-regulation competence can be fostered by active learning formats, including simulations and scenarios like formal learning (e.g., error management training).

Career management

Career management focuses on workers' self-initiated behaviors directed at attaining career success (Hall, 2002). Globalization and workforce aging increase the demands for innovation and technological change in contemporary workplaces (Anderson et al., 2004), creating the need to engage in career self-management to ensure employability. The necessity for lifelong learning leads to novel job structures that involve informal communication structures, flattened organizational hierarchies, virtual teams, and teleworking (Savickas, 2001). Beyond traditional training and development, the pressure for change and lifelong learning arises from work challenges and relationship conflicts. Therefore, acquiring *metaskills* (e.g., learning to learn, developing self-knowledge) gains importance. Workers increasingly manage their careers proactively, driven by personal values that give rise to subjective criteria for evaluating career success (Hall, 2002).

Similar to self-regulation competence, the Integrative Contextual Model (ICM; Lapan, 2004) assumes that an adaptive, proactive approach to one's career hinges on skills such as *goal-setting* and *self-regulated learning* to maximize one's educational and vocational opportunities. Other authors emphasized the importance of *career reflection*, i.e., forming an appropriate image of the competences relevant for one's career (Kuijpers & Scheerens, 2006) and reviewing one's personal resources and motives (e.g., Hall & Mirvis, 1995). Workers might also use their *career control* competence to plan and structure their learning processes to reach their career goals (Nabi, 2000). Other approaches underscore the need to adapt to changes both in job content and in career development (van der Heijde & van der Heijden, 2006).

An important question is whether previous studies in the work context contribute to a lifespan-based perspective on ESR. Although career management research with adult samples has been limited (Briscoe et al., 2006), there is some evidence on the role of self-regulation for career management. Turner et al. (2006) found in a student sample associations of goal-setting and self-regulated learning skills with career-related proactivity. In Kuijpers et al.'s (2006) worker sample, career control, a variant of goal-setting, predicted career success.

A theory that includes regulation strategies is the theory of Selection, Optimization, and Compensation (SOC Theory; Baltes & Baltes, 1990). Under a *selection* strategy, individuals focus on acquiring skills that are in line with their needs and preferences. At the same time, they may apply an *optimization* strategy by practicing and refining goal-relevant skills and resources. With age, goals shift (Staudinger et al., 1995) and people adopt a *compensation* strategy by investing remaining resources into maintaining or regaining functioning. Consistently, older workers reporting a frequent use of SOC strategies demonstrated higher levels of job competences (Abraham & Hansson, 1995). Also, SOC strategies were associated with career satisfaction and global wellbeing (Wiese et al., 2000). A positive relationship

of SOC behaviors with job performance was demonstrated by Bajor and Baltes (2003). Most important for self-regulation as an overarching competence, Abele and Wiese (2008) linked SOC behavior to career planning. This illustrates that career management outcomes might be more ambiguous than achievements in workplace learning, given that career decisions are interdependent and oftentimes decisions under risk.

We wish to draw attention to the dividing line between workplace learning and career management that offers important perspectives for lifelong learning research. Some informal workplace learning activities comprise relatively long time frames (e.g., working in a different division during job rotation) and therefore border career management. The asymmetrical relationship between workplace learning and career management, however, may result in workers' attending regular trainings to meet job demands while not engaging much in career management (e.g., because they are satisfied with their position). Proactive career managers, in contrast, will more likely engage in workplace learning to promote their careers. Career management can thus be a higher-level regulation, not only in terms of cycle time, but also of complexity.

Core processes of ESR competence

Demetriou (2000) identified as the least common denominators of self-regulation models the processes of self-monitoring and self-modification, operating in a self-system, similar to the feedback loop (Carver & Scheier, 1998). Looking at this common core of self-regulation models, a series of comparisons appears as a central process in learning contexts, leading to progress monitoring in self-regulated learning (Wirth & Leutner, 2008). In the first self-regulated learning phase, goal-directed action is part of the planning, starting by comparing available options (i.e., learning strategies) on their usefulness for reaching learning goals. In the final evaluation phase, learners compare their attained learning state with the intended learning outcome.

We review metacomprehension in the next section that provides a conceptual and methodological platform for ESR competence assessments. Modeling the interactions of metacomprehension, epistemic beliefs, and self-regulation could inform a comprehensive assessment strategy.

Metacomprehension

Metacomprehension research assumes that the continuous *monitoring* of one's learning enables *control* (e.g., through study time allocation) and thus facilitates learning (Nelson, 1996). As they cannot fully introspect their cognitive processes, learners use cues for monitoring (*cue utilization framework*; Koriat, 1997), for example, the ease of processing (Begg et al., 1989) or the subjective probability of memorizing certain learning content (judgment of learning, JOL; e.g., Nelson & Dunlosky, 1991). In JOL studies, participants study learning material and subsequently rate how likely they will answer questions about that material. Such *metacomprehension*

ratings have been shown to be correlated with learning performance, and the magnitude of that correlation provides a measure of *metacomprehension accuracy* (Dunlosky & Lipko, 2007; Maki, 1998). By judging their learning progress, learners establish the basis for comparing their performance to their learning goals, which may serve as feedback to regulate further learning. Concerning ESR, higher levels of self-regulation competence should be associated with higher metacomprehension accuracy.

As a disadvantage of the metacomprehension approach, learners' accuracy has repeatedly been shown to be rather low (Dunlosky et al., 2005). Across 25 studies, Maki (1998) found an average correlation of .27 between judgments and performance, indicating that participants discriminated poorly between well-learned and less well-studied material. Moreover, research suggests that adult learners might be overconfident in their comprehension (Hacker et al., 2000; Maki et al., 2005). Still, research into the factors underlying accuracy is important because it provides deeper insights into the ESR competence core. According to Zhao and Linderholm's (2008) anchoring and adjustment model of metacomprehension, learners anchor their judgments on their general performance expectations, which mainly reflect self-perceptions of ability. Learners then incorporate their experience of the task at hand into the judgment, using ease of processing cues to adjust away from the anchor.

Although relatively simple materials (e.g., lists of word pairs, short expository texts) and short retention intervals limit the insights from metacomprehension research, some studies suggest that the metacomprehension approach could be used in more complex settings. In one study, Nietfeld et al. (2005) had students over the course of a semester make JOLs on three intermediate exams and the final exam. Those judgments predicted the intermediate grades and the final grade. De Bruin et al. (2007) assessed metacomprehension judgments on chess problems and found that judgments predicted participants' solving those problems. Serra and Dunlosky (2010) showed an association of learning performance with JOLs for material containing complex text-picture combinations.

Epistemic beliefs

Epistemic beliefs (or epistemological beliefs) refer to the nature of knowledge and of knowing. A well-established framework assumes four belief dimensions (Buehl & Alexander, 2001; Hofer & Pintrich, 1997): *certainty* (perceived stability and strength of evidence), *simplicity* (connectedness of pieces of knowledge), *justification* (individual approach to evaluating and substantiating knowledge claims), and *source* (internal vs. external knowledge). Other approaches (Greene et al., 2008; Schommer-Aikins, 2004) differ in the number and content of dimensions but converge in modeling epistemic beliefs as multidimensional.

To illustrate, a learner might hold the naïve beliefs that knowledge in a specific domain is simple (i.e., consists of separate parts) and stable (i.e., well-proven and reliable). This learner would be likely to perceive an objectively complex task as simpler than it is and therefore not engage in extensive information processing. By contrast, if a learner holds the sophisticated beliefs that knowledge in a specific

domain is complex (e.g., consists of interrelated and inseparable pieces) and tentative (e.g., could be changed by scientific discovery), that learner might anticipate a much more complex task. Bromme et al. (2010) argued that epistemic beliefs affect learners' internal standards for metacognitive monitoring and control. These standards will influence subsequent metacognitive *calibration* by describing the alignment between learning processes and external conditions (e.g., type of learning materials, study time set by teachers). Learners holding more sophisticated beliefs show better calibration, while more naïve beliefs restrict the calibration flexibility.

Epistemic beliefs are malleable, developing from *naïve* to *sophisticated* beliefs as a function of education. Moving toward more sophisticated beliefs during education, learners become aware that knowledge is more complex and relativistic, which enables them to take into account diverse perspectives on a topic (King & Kitchener, 2002). If epistemic beliefs are changeable, they could also be improved by providing explicit instructions in situations with self-regulated learning (Donker et al., 2014). This would offer opportunities for interventions incorporating ESR competence in classroom and work instructions.

Assessment of ESR in adults

We described the monitoring and control of one's self-regulated learning as the ESR core process. Metacomprehension, in turn, depends on epistemic beliefs. Assessing the interplay of epistemic beliefs and metacomprehension provides an opportunity to study self-regulation competence in action.

Metacomprehension measures apply to a wide age range. Learners can regulate their learning from around eight years of age (Lockl & Schneider, 2003). Although learning performance tends to decline for participants over 60 years, metacomprehension accuracy is spared from this decline (Hertzog et al., 2010). Epistemic beliefs were shown to differ as a function of both age and education. Schommer (1998) found in a cross-sectional survey that age was negatively associated with beliefs about the ability to learn, whereas higher levels of education were linked to more sophisticated beliefs about the structure and stability of knowledge. Schommer et al. (1997) showed in a longitudinal study that students' beliefs became more sophisticated from the first to the fourth high school year. The acquisition of self-monitoring competency can be an educational outcome also for learners at higher ages.

To assess ESR competence, we propose combining the standard correlational approach of many large-scale assessments with *online measures* to be suitable to gain insight into the antecedents, correlates, and outcomes of ESR across the lifespan. Online measures such as think-aloud protocols or error detection tasks allow for assessing self-regulated learning in different contexts "as an event" (Winne & Perry, 2000). As they tap into cognitive processes during learning, they are the most direct competence assessment possible. This approach can be implemented by time series or experience sampling data (Schmitz & Wiese, 2006). Online platforms could yield additional insights into ESR through ambulatory assessments (Trull & Ebner-Priemer, 2013), which not only improve assessments but also enable new methods of teaching and instruction that serve as interventions to develop ESR competence.

Self-report instruments have been criticized for low predictive validity (e.g., Veenman, 2005; Winne et al., 2002), which limits insight into the competence processes (Braun et al., 2012). Despite their lower accuracy in capturing self-regulated learning *behaviors*, self-reports might serve as indicators of *knowledge* about self-regulated learning, thus benefiting research on the development of metacognitive knowledge. For elementary school children, high levels of knowledge predict the development of strategies use over a 2-year period independent of cognitive ability (Annevirta & Vauras, 2006), while there is no clear association for children with average knowledge levels.

For online measures, experimental metacomprehension paradigms have been developed that could prove useful for ESR competence assessments (Pieschl et al., 2008a, b). Participants systematically adapted their learning by using learning strategies that were correlated with task complexity. On complex tasks, students used more strategies categorized as *planning*. Thus, calibration was related to epistemic beliefs.

Future research could apply the calibration paradigm to the *trace* method (Perry & Winne, 2006) that records actual learning behaviors through the traces (e.g., bookmarks) that learners leave on learning materials. Traces can serve as accurate, time-referenced observations of learners' interactions with content. The learning tasks can systematically be constructed at various levels of difficulty (Anderson et al., 2001). In sum, the trace method is another promising approach for examining the relationships between epistemic beliefs, calibration, and self-regulation.

Extending the calibration approach (Stahl et al., 2006) to workplace learning and career management offers novel opportunities. One solution could be to assess in a calibration paradigm those instances of learning that are representative of most workers' learning activities. E-learning might satisfy these criteria because it can come as formal and informal learning and is increasingly used in white-collar and blue-collar jobs (ASTD, 2008). A calibration paradigm could be adapted to implement e-learning-based competence tests in field settings. To assess less structured learning activities (e.g., job rotation), the calibration approach could be used in a *vignette* format. Study participants would answer calibration questions on a detailed description of a hypothetical learning scenario (i.e., an upcoming learning task); questions could tap epistemic beliefs. To assess career management, vignettes could be created from best-practice databases and could include the advice of experts and supervisors. Extending the beliefs component, workers' beliefs in the changeability of career-relevant competences could be assessed that have emerged as predictors of participation in training and development programs and that influence career management through workers' general learning orientation (Maurer & Lippstreu, 2008).

As a second challenge to ESR competence assessments in the workplace, objective performance indicators are difficult to establish as standards against which to evaluate self-regulation behaviors. Van der Heijde and van der Heijden (2006) measured *occupational expertise* (e.g., "I consider myself competent to indicate when my knowledge is insufficient to perform a task or solve a problem"), and *personal flexibility* (e.g., "How easily would you say you can adapt to changes in your workplace?"), which both involve self-regulation in terms of self-assessment and comparison. Employing a calibration approach in future research, an association could

be established between calibration of career management vignettes, career success, and career management process indicators, such as flexibility and corporate sense behaviors.

Discussion

Based on adult samples that allow for conclusions on the assessment of educational self-regulation competence, we formulated an interdisciplinary perspective on lines of research that have so far developed in isolation. Learning is a lifelong process and so is the development of the self-regulation competence to monitor and control one's learning activities. This competence is important in any phase across the lifespan and should be supported by interventions at school and the workplace. ESR competence is not an intangible key competence that defies measurement, as was said of some competencies (Harris, 2001). Rather, it can be developed further across the entire lifespan. To facilitate this development, assessment strategies might support learners not only in their present learning activities but also in their long-term development of self-regulatory strategies. Establishing an assessment strategy would involve an overarching model that integrates all ESR facets. Ideally, theory building and assessments would go hand in hand.

Limitations

Its breadth and the interdisciplinarity of the literature on self-regulation and self-regulated learning are limitations of this review. As one limitation, we did not address the implications of the fact that ESR unfolds in a context of emotions. Muis et al. (2018) posited that learners experience *epistemic emotions* from appraising the alignment of learning content with their epistemic beliefs or knowledge structures. Learners likely experience joy when information is consistent with their prior knowledge or epistemic beliefs but they may feel anxious, angry or frustrated in case of inconsistencies, which affects subsequent self-regulation. Following a poor exam performance, for instance, learners may assume they have little control over outcomes. Reciprocal causation exists between appraisals and emotions (see Pekrun, 2006) such that appraisals predict emotions and achievement but emotions and achievement may also predict changes in appraisals. As a learner's appraisals are continuously updated through feedback from the learning environment, epistemic emotions and achievement influence each other over time. Longitudinal evidence shows that negative emotions predicted lower achievement, which, in turn, predicted these emotions in future learning situations (Pekrun et al., 2017). It is plausible that epistemic-emotional processes influence ESR through epistemic beliefs and metacomprehension.

A second limitation concerns cultural differences in ESR. Most educational self-regulation research adopted a North American and European perspective. Little research has addressed cultural differences, which may have important implications (see McInerney & King, 2018). Lau (2012), for instance, questioned whether the

positive effects of self-regulated learning would apply in Chinese societies where learner autonomy is of little importance and found that most students regarded teacher control as very natural. They preferred teacher involvement rather than autonomy or choice in class. Given those differences in their role, compared to the “Western view,” Chinese teachers found it difficult to directly implement self-regulated learning principles. In times of increasing student and worker mobility, an important question is how studying or working in a culture different from one’s culture of educational socialization affects performance and how ESR may help cope with negative effects of moving to a different culture.

Directions for further research

Our research and assessment suggestions may be summarized to the insight that developing the field of educational self-regulation will hinge on a multi-method strategy with multimodal assessments based on a boundary-spanning theory fundament. Consistently, we argue that it would be worthwhile to explore the opportunities of learning analytics, “the ... elicitation and analysis of static and dynamic information about learners and learning environments, for the near real-time modeling, prediction and optimization of learning processes, and learning environments” (Ifenthaler, 2015, p. 447). Learning analytics have recently come to be seen as a method to support the acquisition of 21st Century Skills, the knowledge and skills that prepare people for lifelong learning in a complex and uncertain world (Buckingham Shum & Crick, 2016). The computational support for tracking, feeding back, and reflecting learning *processes* in times of the digitalisation of school and work may help evidence ESR in ways that have been impractical until now. Importantly, learning analytics are increasingly used beyond the higher education sector so that learner insights from academic learning may be connected to learner path modeling in the workplace, providing a unique opportunity for formative assessments of learners’ ESR use and development. Comprehensive and consistent ESR models along the lines we have described in this review would meaningfully contribute to a coherent approach.

Concluding remark

We sought to review empirical and theoretical literature to expand the possibilities for ESR analysis and assessment. The need to combine studies with different methodologies renders the integration of the complex results a challenge. Still, this review provides a platform for future studies that could compare in more detail the empirical and theoretical results. Future reviews will benefit from more specific search criteria to interpret and analyze the literature.

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