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Emotional states during learning situations and students' self-regulation: process-oriented analysis of person-situation interactions in the vocational classroom

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Abstract

Background: In reference to the interactionist paradigm, we analyse how students' emotional states during class are affected by student' self-regulation, by time-varying characteristics within learning situations, and by the interaction of self-regulation abilities and learning situations during class.

Methods: We refer to existing empirical research on teaching and learning processes in vocational education and report findings from a process-oriented video study in naturalistic settings that was realised at a German vocational school. Altogether, 92 students were investigated during 1440 min of instruction by use of videography and continuous-state-sampling method (CSSM). The frequency of repeated measurement was 7 min, with 46–51 measures per student.

Results: Via latent class analysis, we first identified two types of students who differ in their self-regulation abilities. Then, a multilevel analysis revealed that students' self-regulation affects students' emotional states. In addition, we found that emotional states tend to be affected by the interaction of self-regulation and learning situations within lessons (but that's just a sample-related and non-significant effect).

Conclusions: In view of a holistic understanding of teaching and learning processes in vocational education, a deeper knowledge surrounding the interdependencies between personality characteristics, emotional states, and learning situations seems to be essential for an evidence-based design for teaching and learning environments in vocational education and training.

Keywords: Emotional states, Self-regulation, Person-situation interaction, Experience-sampling, Multilevel analysis, Video study

Introduction

Theoretical and empirical aspects of interactions between person and situation have been discussed for decades in personality and social psychology in terms of the interactionist paradigm (e.g. Matthews et al. 2003), in educational psychology within the scope of aptitude-treatment interaction theory (e.g. Cronbach and Snow 1977; Yeh 2012), and in vocational education and training (VET) in terms of the process-oriented research approach, investigating antecedents and effects of successful teaching and learning

processes (e.g. Achtenhagen 1996; Sembill 1984; Wild and Krapp 1996). However, concerning teaching and learning processes in school, many approaches do not consider interactions between situational conditions during class and students' personal characteristics. Therefore, our research question is whether students' emotional states are determined (1) by students' self-regulation as a personality characteristic (2) by time-varying characteristics of learning situations, (3) and by the interaction of self-regulation abilities and learning situations during class. Dealing with the theoretical background, we first depict the conception of emotional states—with reference to the German term *"Emotionale Befindlichkeit"*, introduced by Achtenhagen et al. (1988) and Sembill (1992)—and its relevance within vocational learning and teaching processes. Secondly, we present a description of the construct of self-regulation within Kuhl's personality systems interactions theory and further point to basic didactical categories of learning situations during class. Finally, the design and the findings of our empirical study will be reported and discussed.

Background

Students' emotional states during class

Theoretical framework of emotional states

Focusing on a holistic understanding of learning, teaching and the interrelations of the involved constructs, one has to consider different ontogenetic levels: *organ level* (e.g. central and autonomic nervous system), *individual level* (e.g. characteristics, beliefs), and *social/group level* (e.g. acceptance, responsibility) (Sembill 1992 et passim). From the viewpoint of action theory, emotional, motivational, and cognitive processes play an important role for an individual's development on each of the named levels, as they are indispensable to perception and action regulation because of their relevance for the evaluation and processing of internal and external information (Seifried and Sembill 2005a). A common definition of emotional processes originates from Kleinginna and Kleinginna (1981, p. 355, emphasis in original).

> They see emotions as *"a complex set of interactions among subjective and objective factors, mediated by neural/hormonal systems, which can (a) give rise to affective experiences such as feelings of arousal, pleasure/displeasure; (b) generate cognitive processes such as emotionally relevant perceptual effects, appraisals, labeling processes; (c) activate widespread physiological adjustments to the arousing conditions; and (d) lead to behavior that is often, but not always, expressive, goal-directed, and adaptive."* Moreover, we consider distinct emotions to be conscious manifestations of affects that in turn are unconscious evaluations within so-called limbic and endocrine systems (Ciompi 2005; Rausch 2011).

After decades of debate concerning the predominance of cognition or emotion, including the corresponding definitions and empirical designs—cf. the "Primacy-debate" between Zajonc (1984) and Lazarus (1984)—it is nowadays uncontested that cognitive and emotional facets of action regulation are inseparably connected (Baer et al. 2009), and a wide range of theories and concepts in the field of emotion theory do still exist. A common classification of emotional constructs is based on the differentiation of trait and state emotions. In contrast to temporally stable person-related emotional traits,

emotional states are subjective, situation-specific volatile experiences, integrating emotional, motivational, and cognitive facets, and considered to be essential for action regulation; thereby, the evaluation of internal and/or external perceptual patterns, as well as memory contents, are affected by emotional processes that in turn are triggers for motivational processes and intended actions (Sembill 2010). In this contribution, we refer to the common concept of emotional states relating to the German term "*Emotionale Befindlichkeit*", having been established decades ago within the research in VET (Achtenhagen et al. 1988; Sembill 1992).

Antecedents of emotional states

Within the person-situation debate, scholars have discussed whether stable personality characteristics *or* characteristics of the current situation predict emotional states and corresponding actions (e.g. Fleeson and Noftle 2009; Mischel 1968). On the one hand, the *situationist paradigm* emphasises variations concerning situational characteristics as determinative for variations in behaviour and psychological states (Matthews et al. 2003). For instance, Seifried and Klüber (2006) found main effects of the type of learning arrangement on emotional states: learners within a student-centred learning environment felt as if they were being taken more seriously, were more interested, and reported more situational well-being than learners of the teacher-centred learning arrangement which was characterized by a high degree of teacher instruction.

The *paradigm of dispositionism,* on the other hand, assumes that individuals are to be characterised by temporally stable personality characteristics (referring to the term "traits" used in personality psychology), which in turn are accountable for variations in behaviour and emotional states (Matthews et al. 2003). To illustrate this, Wolf and Schumacher (2010) found main effects of personality characteristics (e.g. verbal intelligence, self-efficacy beliefs) concerning the level as well as the stability of emotional states during class (e.g. situational interest, understanding of learning material, situational well-being). Apart from that, they also found variations of the person-related correlations amongst different learning arrangements, which in turn points to interactions between learning environment and personality characteristics.

The debate about the impact of person or situation on intraindividual variations of behaviour and psychological states resulted in the *interactionist paradigm*. Within the latter, *main effects* of person and situation, as well as *interaction effects* between person and situation, are assumed. The interrelation between personal and situational characteristics is assumed to solidify in corresponding behaviour and situation-related states (Nezlek 2007). In this context, Magnussen (1982) emphasises that an "objective" situation is perceived, cognitively interpreted, and emotionally evaluated by the individual. Moreover, the process of mentally transforming "objective" features into subjective representations is mainly co-determined by personality characteristics (Krohne 1990; Matthews et al. 2003). Therefore, personality characteristics are supposed to affect perception, interpretation, and mental representation of situational conditions, maintaining relative stability over time, but actually they can change over longer periods (e.g. years) (Nezlek 2007). With regard to the interactionist paradigm, it seems obvious that the same "objective" situation is experienced and handled by different individuals in various ways depending on their individual characteristics (Sembill 2012). Compared

to personality characteristics, states vary in a stronger intensity over points in time and situations, whereas personal characteristics function as dispositional predictors of actual psychological responses (Nezlek 2007). Changes in situational states are caused by situational factors in terms of past, present, and anticipated events (Wild and Krapp 1996; Sembill et al. 2002; Wolf and Schumacher 2010). Examples of theoretical frameworks and/or of the empirical investigation of person-situation interactions in VET can be found in Sembill (2004), Seifried (2005), Winther (2009), Kögler (2015), and Kärner (2015).

Related research on emotional states in VET: methodological aspects and findings

Empirical studies focusing on emotional states should consequently build on instruments that are able to cover the volatility of individual experiences "in situ" instead of using retrospective questionnaires. The latter potentially lead to self-report biases due to retrospectivity and are not able to reveal the dynamics of the situation. Experience-sampling methods based on the work of Csikszentmihalyi and colleagues (Csíkszentmihályi and Larson 1987; Hektner et al. 2007) represent a suitable way of collecting data "in situ" by offering a couple of advantages. But when implementing an experience-sampling procedure, one has to decide whether to choose a time-sampling structure of measurement points over an event-sampling one and if the measurement points should be randomised or not. The decision depends on the research objectives. In order to understand students' emotional states during class, it is important to identify every individual reaction to a change of didactical setting or an interaction with others. Thus, a measurement is needed which is able to cover the volatility and that, at the same time, creates only minimal interruptions to the lesson. Hence, it is important to balance the necessities of the measurement approach with the pedagogical demands. Continuous-state-sampling method (CSSM) as a variation of typical experience-sampling procedures offers a high degree of ecological validity and is characterised by a high frequency and equidistance of measurement points during a defined period (Sembill et al. 2008).

The consideration of emotional states is also relevant within learning and teaching processes, and there are currently a variety of empirical studies using corresponding experience-sampling methods (e.g. Goetz et al. 2016; Kärner 2015; Kögler 2015). For example, Sembill and colleagues conducted different quasi-experimental studies on the concept of self-organised learning and corresponding subjective experiences. They applied a process-oriented research approach, i.e. using high-frequency measured state-items to gain more in-depth information about students' learning and emotional states. For example, self-organised learners reported that they could participate more actively in the classroom and that they were significantly more interested in the subject matter than students in teacher-centred (instructed) learning arrangements. Furthermore, Sembill et al. (2002) found that compared to teacher-centred learning, self-organised learning leads to a much better learners' ability to solve complex problems, and that self-organised learners experience significantly more support and autonomy (for a synopsis of the key findings of the studies on self-organised learning see Sembill et al. 2007). Other current studies emphasise that emotional and motivational states are pivotal facets of domain-specific problem-solving competence as a higher-order outcome of learning processes in VET. Rausch et al. (2016) developed a computer-based office simulation

using the embedded-experience-sampling method assessing emotional and motivational states of testees during the problem-solving process. Amongst other findings, they found small to medium positive correlations between cognitive and non-cognitive facets of competence (Rausch et al. 2016; see also Rausch and Wuttke 2016; Seifried et al. 2016; Wuttke et al. 2015).

Personal characteristics: students' self-regulation abilities

Kuhl's personality systems interactions theory and the concept of self-regulation

In the current analysis, we refer to students' self-regulation as an important personality characteristic because it is an essential precondition as well as a target dimension of all formal and informal learning processes (Sembill et al. 2007; Weinert 1982). In consideration of the wide range of definitions and concepts of self-regulation (Martin and McLellan 2008), we further refer to the self-regulation theory of Kuhl and colleagues, as it is a well-founded and commonly established framework. Kuhl's concept of self-regulation is grounded on the so-called personality systems interactions (PSI) theory as a functional model of the personality architecture. It integrates theoretical assumptions and empirical findings from cognitive and motivation theory, personality psychology, and neurobiology (Kuhl et al. 2006 for a further description and discussion of the PSI theory see Kuhl 2000a). One basic assumption of the PSI theory is that human motivation and personality are affected and mediated by a hierarchy of regulatory systems that integrates three levels: (1) at the lowest level is the *object recognition system*, which supports fundamental sensation, including external perceptual stimuli and internal "objects" of experience, as well as *intuitive behaviour control*, which controls intuitive and automatic motor and behavioural programs; (2) at the mid-level are located *positive and negative affect systems*, which regulate approach and avoidance behaviour; (3) at the highest level of the hierarchy of regulatory systems, two subsystems are located that are responsible for sequential analytic information processing (*intention memory, "thinking"*) as well as for parallel holistic information processing (*extension memory, "feeling"*) (Kuhl et al. 2006). The subsystems are interrelated to each other on the basis of a reciprocal antagonism: "The more strongly one system is activated, the more strongly it inhibits the activation of adjacent systems" (Kuhl 2000b, p. 134). Moreover, different modulation assumptions build the ground for the antagonistic relationship, for instance in the case of volitional facilitation and inhibition (e.g. relevant for procrastination of activities), self-relaxation and emotion-regulation, and self-motivation (for a further description and discussion see Kuhl (2000b).

With regard to the PSI theory, in our study self-regulation is conceptualised as the ability to make decisions and pursue individual goals against internal and external resistances. Furthermore, it is associated with the regulation of subjective states in terms of the coordination of internal motivational, cognitive, and emotional processes to transform goals into concrete actions (Fröhlich and Kuhl 2003). Moreover, self-regulation is not one-dimensional, but rather to be seen as a configuration of different personality characteristics which are involved in dynamic processes regulating situational states (Kuhl 2000a, 2000b). Thus, self-regulation plays an important role within the individual's adaptation to situational demands, affect regulation, and learning (Kuhl 2000a; Fröhlich and Kuhl 2003; Kuhl and Fuhrmann 1998).

Action- and state-orientation as distinct profiles of self-regulation

As individuals might differ from each other in regards to their self-regulation abilities, the terms *action- and state-orientation* (from the German terms *"Handlungs- und Lageorientierung"*) describe different profiles of modulation within complex personality systems interactions (Fröhlich and Kuhl 2003). In the context of self-regulation theory, as distinct profiles action- and state-orientation are associated with differences in emotion-regulation, self-motivation, or goal-oriented attentiveness, as well as with differences relating to academic achievement (Bossong 1994; Fröhlich and Kuhl 2003). In demanding situations, state-oriented individuals are characterised by a sustained inhibition of self-access and action regulation that in turn negatively affects their emotional states and subsequent actions (Kuhl 1994, 2000b; Kuhl and Fuhrmann 1998). They are often trapped in states of negative experience and show signs of volitional and behavioural inhibition (Kuhl and Beckmann 1994). On the other hand, emotional states play an important role in individual growth and development and are an integrated element of action regulation processes (Achtenhagen et al. 1988; Sembill 1992; Sembill et al. 2013). For instance, Bossong (1994) points out that state-oriented students focus on their failures for long periods of time and tend to ruminate extensively over possible causes and consequences, thus potentially resulting in further performance impairment. Kuhl and Fuhrmann (1998) describe in detail six concomitants and consequences of volitional inhibition that are typical for state-oriented individuals. They show a deficit of energy and impaired attentiveness that results from an inhibition of the pathway from plans and intentions to the behavioural facilitation system. With respect to motivation control, state-oriented individuals demonstrate a tendency toward anxiety-based self-motivation in terms of anticipating negative consequences from not reaching a goal or not acting. Further, they display an increased incidence of intrusive thoughts, and they tend to procrastinate goal-related activities.

State-oriented students normally possess the appropriate knowledge structures to perform well, but the knowledge loses applicability in demanding situations. Under stress, state-oriented individuals exhibit motivational deficits, energy deficits, impaired attentiveness, and a certain reduction of goal-oriented attentiveness, tending to internalise goals that have not been self-selected and that are not compatible with implicit self-representations (Baumann et al. 2005). Baumann et al. (2005) point out that state-oriented individuals have impaired abilities to cope with negative affects, which is associated with self-infiltration when an external or internal stressor is present. Such effects may be impacted by the loss of access to volitional functions caused by stress induction (Kuhl and Fuhrmann 1998).

In contrast, action-oriented individuals are able to reduce their negative affect under stress to a greater degree, they show better emotion-regulation and better performance under stress, and they pursue individual goals against internal and external oppositions without self-infiltration (Fröhlich and Kuhl 2003; Baumann et al. 2005). Nevertheless, state-orientation is not only associated with disadvantages. Kuhl (1994) points out that state-oriented individuals are able to perform just as well or even better than action-oriented individuals if they are relaxed, feeling accepted by others, and not negatively affected.

So far, it is to be assumed that self-regulation plays an important role within the adaptation to situational demands and within the regulation of emotion and motivation (Kuhl 2000a; Fröhlich and Kuhl 2003). Furthermore, a stabilisation of positive emotional states by recurring motivating and self-enhancing episodes (Kuhl 2000b) can be supported by appropriate situational conditions in the classroom. Against this background, different types of didactical settings and corresponding empirical findings are described in the following section.

Situational characteristics: different learning settings at school

General classification of learning environments and basic options of teaching methods

In general, there are different conceptual frameworks for the classification of learning environments in the classroom and for differentiating activities and cognitive processes during learning. For instance, de Kock et al. (2004) present a classification scheme for learning environments in secondary education. They present aspects of learning goals and student–student interrelations as differentiation criteria between learning environments. Therefore, learning goals can be related to learning results (e.g. knowledge of content matter, problem-solving competence, affective learning skills) and to cognitive, affective, and metacognitive aspects of the learning process. The roles of learners in relation to each other can be separated into the categories of competition, individualisation, and cooperation. Chi (2009) pointed to the differentiation of passive, active, constructive, and interactive learning settings in which the levels of students' engagement and cognitive processes vary. In that regard, *attending* cognitive processes implicates the activation of existing knowledge and the assimilation, encoding, or storage of new information. *Creating* processes implies the reasoning of new information and its integration into existing knowledge structures. And creating processes *together with others* implicates communication about content matter and different solutions.

Concerning concrete teaching methods during class, one needs to distinguish teacher instruction and student-centred, mainly self-regulated learning as the two basic options when creating learning opportunities (Sembill et al. 2002; Seifried 2009). Teacher instruction may be characterised by a clear manifestation of control over learning methods, teacher-student interaction, and temporal resources: scope of action and the available time for students to work on the subject matter are mainly determined by the teacher. On the other hand, student-centred learning is characterised by higher degrees of self-determination and autonomy concerning learning objects and contents, increased numbers of interactions between students and teacher, and a greater use of time resources during class. Moreover, student-centred learning is usually a constructive and interactive process and implies collaborative activities within learning groups (cf. Chi 2009; de Kock et al. 2004; Sembill et al. 2002). Therefore, in phases of student-centred learning, students have extended scopes of action and the time to find their own pace, but they are also confronted with higher degrees of complexity, uncertainty, and ambiguity (Deci and Ryan 1985; Kärner 2015; Rozendaal et al. 2005; Seifried 2009; Sembill et al. 2002).

Potentials of student-centred learning settings

In the common practice of everyday schooling, a fluent passage occurs between student-centred learning and teacher instruction. Nevertheless, the latter is still the common

method in vocational education (Seifried 2008; Seifried et al. 2006; Kögler 2015), even though empirical findings show that student-centred learning supports learners' problem solving activities and their socio-emotional development (Sembill et al. 2002). Sembill et al. (2002) state that if students perceive the learning environment as being regulated and initiated by themselves, their motivation has a more intrinsic quality, which in turn positively affects higher-order learning outcomes in terms of problem solving competence. Winther and Achtenhagen (2008) identified self-regulation in students as crucial to learning processes and accordingly conducted a quasi-experimental study in the field of VET. They found that different methods of assistance during the learning process affected the learning outcomes, and that the interrelations were mediated by self-regulative states.

There is also evidence concerning the meaning of students' self-regulation on a micro-didactic level. Findings of a quasi-experimental field study by Wuttke (1999) show that the type of learning environment affects the application of (meta-)cognitive learning strategies: learners in student-centred learning applied a greater number of high-quality strategies in acquiring knowledge and solving problems than learners in a teacher-instructed learning arrangement. With regard to general learning content, there is empirical evidence that phases of student-centred learning are associated with the acquisition of new learning contents, while phases of teacher instruction are predominantly associated with the repetition of learning contents (Kärner 2015). Within student–teacher interaction, high-quality student questioning and argumentation seem to be especially important for creating new knowledge and for solving problems (Wuttke 2012). Existing findings show that student questioning is associated with positive emotional states, especially in student-centred learning arrangements (Sembill and Gut-Sembill 2004). Moreover, students' deep reasoning questions are positively associated with intrinsic motivation, and negatively associated with extrinsic motivation (Seifried and Sembill 2005b). Furthermore, in student-centred learning arrangements, students ask questions at a rate 35 times higher than that in teacher-centred learning. Existing studies also reveal some outcomes that specifically occur in teacher-centred environments. For instance, learners' participation during teacher-centred classroom talk mainly depends on learners' characteristics like domain-specific prior knowledge (Kärner and Warwas 2015) or on teachers' prejudices resulting from implicit personality theories (cf. the so called "Pygmalion effect" Seifried 2009; Sembill 1984; Sembill and Dreyer 2009). In sum, student-centred learning settings seem to enhance learning activities and outcomes in a holistic way.

Nevertheless, based on the differentiating of action-oriented and state-oriented individuals by their differences around goal orientation and goal maintenance, procrastination of goal-related activities, (anxiety-based) self-motivation, and emotion-regulation (e.g. Baumann et al. 2005; Kuhl and Fuhrmann 1998), it is crucial to question how student-centred learning arrangements should be designed in order to produce supportive effects for learners with unfavourable self-regulation abilities. Against this background, the following factors seem to be relevant: When offering a certain scope of action, it is indispensable to (1) provide support concerning the planning, realisation, and evaluation of learning activities, (2) enhance social involvement and the feeling of being accepted by others, (3) enhance guided self-reflection and the pursuit of individual goals

against internal and external oppositions, (4) reduce time pressure and provide support for emotion-regulation and learning motivation, and (5) offer the opportunity to make mistakes and fail in the first try (cf. Sembill et al. 2002).

Research questions and hypotheses

Experimental studies investigating person-situation interactions do already exist, but field studies in naturalistic educational settings have been underrepresented (e.g. Kärner 2015; Sembill et al. 2002). In this context, Ellenbogen (2012) asserts that one of the most important challenges is closing the gap between experimental research and naturalistic field studies. Furthermore, there are fewer studies (e.g. Adam 2006; Goetz et al. 2008) simultaneously analysing personal characteristics, continuously changing situational characteristics and emotional states, and especially taking account of interactions. Based on the theoretical foundations and reported findings, we focus on the following research questions and hypotheses: How and to what extent are students' emotional states affected by their self-regulation ability and situational characteristics during class? Does an interaction exist between personal and situational characteristics?

With respect to the self-regulation theory of Kuhl and colleagues we (1) assume that different types of students can be identified empirically by their self-regulating abilities (cf. Kuhl and Fuhrmann 1998; Fröhlich and Kuhl 2003). (2) Furthermore, we hypothesise a main effect of students' self-regulation on students' emotional states during learning processes (cf. Kuhl 2000a; Fröhlich and Kuhl 2003), (3) main effects of student-centred learning settings on emotional states (cf. Sembill et al. 2002), (4) and an interaction effect between students' self-regulation and learning situations on emotional states in such a way that learners with unfavourable self-regulation abilities in particular benefit from supportive potentials of student-centred learning (cf. Kuhl 1994; 2000b, Sembill et al. 2002, 2007).

Methods

Participants and data collection

We conducted a video study in naturalistic learning settings, realised at a German vocational school. A total of 92 students (36 male, 56 female; mean age = 14.91 years, SD = .85, Min. = 14, Max. = 18) in four classes were investigated over a period of 4 weeks, with four lessons per week. All students were ninth graders at the time of investigation. The subject matter ("wage and salary accounting") was the same for all participants. Thus, we analysed 1440 min of education (4 classes × 8 lessons × 45 min). The study was designed following a process-oriented approach, investigating main and interaction effects of students' self-regulation (questionnaire before learning process) and situational characteristics (video-based observation during learning process) on emotional states during class (continuous-state sampling during learning process) (see Fig. 1). The study was approved by the responsible authority. All participants of full age and the parents of underage persons signed declarations of informed consent.

First, data referring to personal characteristics were collected by self-report questionnaires in the week before the videography. During the lessons, students' emotional states were measured with a continuous-state-sampling method using portable digital data-entry devices (Palm Tungsten E2®). The frequency of repeated measurement was 7 min.

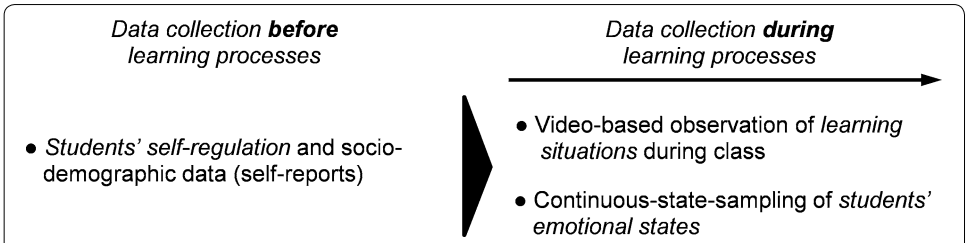

Fig. 1 Data collection before and during learning process

This measurement interval had proved itself valuable in previous studies of the research group, as, depending on the number of implemented items, it is short enough to capture relevant changes and long enough to prevent too much disruption of the lesson. In the current study there are 46–51 measures per student, adding up to 4386 measurements in total. The lessons were recorded for subsequent video analysis of the situational characteristics during class. To this end, three cameras were installed to capture all occurrences during class. The different views were interconnected and temporally synchronised for analysis.

Measures and operationalisation

Students' self-regulation

Facets of students' self-regulation were assessed by using the 32-item German short-version (Rheinberg and Wendland 2003) based on the *Volitional Components Inventory* by Kuhl and Fuhrmann (1998). Students rated the items on a five-point Likert-type scale (1 = "I fully disagree", 5 = "I fully agree"). The items arithmetically averaged to the following total scales: *Self-control and goal pursuit* (11 Items, $\alpha = .78$, $M = 3.63$, $SD = .52$, e.g.: "Most of the things I plan to do are put into action"); *Self-motivation and emotion-regulation* (7 Items, $\alpha = .68$, $M = 3.0$; $SD = .58$; e.g.: "Cheering myself up to make things work"); *Energy deficit and impaired attentiveness* (8 Items, $\alpha = .71$, $M = 3.06$, $SD = .66$, e.g.: "Feeling dull"); *Procrastination* (6 Items, $\alpha = .83$, $M = 2.94$, $SD = .81$, e.g.: "I kick many things down the road").

Students' emotional states

When measuring emotional states during learning situations via CSSM, students rated their current situation-specific experience on a continuous rating scale from 0 (= "I fully disagree") to 100 (= "I fully agree") in regard to the following single items: *situational understanding* ("I understand subject matter", $M = 74.98$, $SD = 26.8$), *perceived time to reflect on subject matter* ("Time to reflect is adequate for me", $M = 73.96$, $SD = 25.7$), *situational interest* ("I'm interested", $M = 64.13$, $SD = 28.69$), and *perceived meaningfulness of learning activity* ("Currently, I'm doing something meaningful", $M = 72.2$, $SD = 27.31$).

Most of the items were adapted from previous video studies of the research group, for instance in the field of self-organised learning (e.g. Sembill et al. 2002). They are partly based on the self-determination theory of Deci and Ryan (1985) and refer to basic psychological needs at the core of any emotional experience. In our study, students'

situational understanding refers to learners' subjective competence, which also implies the feeling of self-confidence when being able to follow the lesson. *Perceived time to reflect* refers to the subjective fit of pace in the process of working through subject matter and is related to students' subjective autonomy. The items *situational interest* and *perceived meaningfulness of learning activity* refer to the person-object theory of interest from Krapp (1999). In this regard, the specificity of learning objects, contents and materials plays an important role for individual engagement with the subject matter during class.

Assessing the structural relationship between the four state-items, we applied an exploratory factor (principal component) analysis with varimax rotation and referred to the Kaiser criterion (eigenvalue > 1). The state-items formed a one-factor solution which showed satisfactory reliability ($\alpha = .90$) and that accounts for 65.62 % of the total variance. For further analysis, we used the factor scores as estimated values of the factor "students' emotional states."

Situational characteristics

Characteristics of learning situations during the observed lessons were assessed by video-based time-sampling analysis (cf. Faßnacht 1995) using the software Videograph® (Rimmele 2013) and a defined category system which we adopted from Seidel et al. (2001) and Seidel (2005). Time intervals of 10 s each were coded. For the analyses, the single coded 10-s intervals were aggregated to 7-min intervals, synchronising observational data and subjective experiences assessed by CSSM.

- On the one hand, we categorised the *organisation of classroom interaction* (from the German term *"Sozialform"*) into student-centred learning and teacher instruction. *Student-centred learning* is defined by individual work or group work phases where learners had to work independently from the teacher. *Teacher instruction* is characterised by a predominant presence of the teacher (for a further description see section "Situational characteristics: Different learning settings at school").
- On the other hand, we considered the *learning content*. All lesson phases where familiar contents were repeated and recalled were coded as *repetition*. The phases of the lesson in which new contents were explicitly worked on were coded as *learning new contents*.

To assess the reliability of the codings, one-fourth of the videos were coded by two independent coders. We considered a Cohen's kappa score of .97 regarding the organisation of classroom interaction, and .74 for the learning content, as satisfactory. As student-centred learning phases and teacher instruction ($r = -.36$) as well as dealing with new contents and repetitive phases ($r = -.63$) correlate moderately high with each other, we calculated the differences between student-centred learning and teacher instruction (Sc–Ti) and between learning new contents and repetition (Lnc–R) in order to exclude effects of multicollinearity in the multilevel analysis. In this way, a value at Sc–Ti *higher* than zero represents a higher proportion of student-centred learning in relation to teacher instruction within the current 7-min interval, and a value of Sc–Ti *lower* than zero represents a higher proportion of teacher instruction in relation to student-centred

learning within the current 7-min interval. We thus proceeded analogously with the learning content: a value at Lnc–R *higher* than zero represents a higher proportion of learning new contents in relation to repetition within the current 7-min interval, and a value at Lnc–R *lower* than zero represents a higher proportion of repetition in relation to dealing with new contents within the current 7-min interval.

Data analysis

Latent class analysis

Different types of students (in terms of self-regulation abilities) were identified by latent class analysis using Mplus® (Muthén and Muthén 1998) based on the subscales of the short-version of the *Volitional components inventory* (Kuhl and Fuhrmann 1998; Rheinberg and Wendland 2003). Following Muthén and Muthén (1998), the observed dependent variables (in our case the facets of self-regulation) are referred to as continuous latent class indicators of students' self-regulation.

Multilevel analyses

With regard to adequate methods for investigating person-situation interactions, most of the existing approaches analyse by way of analysis-of-variance or via multivariate regression analysis how dichotomous situational variations affect an outcome variable that depends on individual characteristics (Cronbach and Snow 1977; Carver and Scheier 2008). However, many approaches do not consider how interactions between continuously changing situational characteristics and personal characteristics affect high-frequency measured states. For that reason, we made use of a multilevel analysis which provides the opportunity to simultaneously analyse different data levels and which also considers an autoregressive structure of covariance of the time series data (Nezlek 2007; Heck et al. 2010). In this context, our data can be seen as hierarchical data, with repeated measures nested within persons (Hox 2002; Heck and Thomas 2009; Twisk 2006; Scollon et al. 2003) points out that multilevel modelling is useful when analysing panel data because multiple measures are nested in a single individual. In our analysis, the measures for students' emotional states are not only nested within persons but also nested within situations, because all learners in the classroom are treated with the same methods during that class at a given time. Therefore, we applied a cross-classified multilevel model that considers multiple memberships (cf. Goldstein 1994; Heck et al. 2010; Hill and Goldstein 1998). With reference to the longitudinal data structure, the parameters of individual growth trajectories can be estimated, whereby person-related slopes are allowed to vary randomly among the individuals (Heck et al. 2010). Compared to conventional multivariate methods, multilevel models are more flexible regarding the requirements of data. For instance, the number of observations per individual or the space between the single observations may vary (Bryk and Raudenbush 1992). In the present analysis, we applied the following data structure:

- Level 2 represents the person-level where students' self-regulation, as well as socio-demographic control variables relating to each person, are modelled. This level describes the variance between-persons. Additionally on level 2 also the observation

units during class are modelled to be the same for all students of one class at a current point in time.
- On level 1, within-persons and within-situation differences are modelled by time-varying emotional states.
- Furthermore, person-situation interactions are modelled by interaction-terms built by combining personal variables and situational characteristics. If the effect of the interaction term remains significant, this can be interpreted as a moderator effect, whereby the moderating variable (students' self-regulation) affects the relationship between independent (learning situation) and dependent (students' emotional states) variable (cf. Baron and Kenny 1986; Hayes and Matthes 2009).

The multilevel analysis was realised by using the IBM SPSS® MIXED Procedure™ (SPSS 2005) and using SPSS 23® (IBM®, Chicago, USA), which is able to examine autocorrelated data and variables with unequal variances (cf. Heck et al. 2010; Peugh and Enders 2005). With regard to the repeated measures, we modelled a first-order autoregressive covariance structure with homogenous variances (cf. Littell et al. 2000).

Empirical results

Latent class analysis on the basis of students' self-regulation

Based on the facets of self-regulation, two clusters have been identified via latent class analysis. The model fit information showed satisfactory results. Likelihood-based fit indices: H_0 Value = −306.442, H_0 scaling correction factor for maximum likelihood estimation with robust standard errors = 1.211. Information criteria: AIC = 638.884, BIC = 671.667, sample-size adjusted BIC = 630.632, entropy = .749. As expected, there are significant cluster differences, which were examined by multivariate analysis of variance (see Table 1).

There are 51 students in a cluster that can be labelled as "state-oriented students" characterised by *low/unfavourable* self-regulation abilities. Another cluster consists of 41 students that can be labelled as "action-oriented students" characterised by *high/favourable* self-regulation abilities. State-oriented students show significantly higher group means for *energy deficit and impaired attentiveness* as well as for *procrastination*. By contrast, action-oriented students show significantly higher means for *self-control and*

Table 1 Differences in facets of self-regulation between the identified clusters

Facets of self-regulation	Self-regulation ↓ "State-oriented students" (n = 51)		Self-regulation ↑ "Action-oriented students" (n = 41)		$F_{(df)}$	p	η^2
	M	SD	M	SD			
Self-control and goal pursuit	3.29	.32	4.04	.38	$106.72_{(1)}$	<.001	.543
Self-motivation and emotion-regulation	2.67	.41	3.42	.48	$65.18_{(1)}$	<.001	.420
Energy deficit and impaired attentiveness	3.36	.55	2.67	.59	$33.66_{(1)}$	<.001	.272
Procrastination	3.40	.67	2.38	.58	$60.11_{(1)}$	<.001	.400

Multivariate analysis: Wilks-Lambda = .357, $F_{(dF)} = 39.153_{(4)}$, p < .001, $\eta^2 = .643$

goal pursuit as well as for *self-motivation and emotion-regulation*. Figure 2 graphs the cluster differences by using standardised values (M = 0, SD = 1).

χ^2-tests indicate that there are neither cluster-specific differences concerning the four investigated classes ($\chi^2 = .290$, df = 3, p = .962) nor gender differences ($\chi^2 < .001$, df = 1, p = .985). Furthermore, there are no mentionable differences concerning the age structure between the two identified clusters (self-regulation ↓: M = 14.98, SD = .91; self-regulation ↑: M = 14.83, SD = .77; $F_{(df)} = .721_{(1)}$, $\eta^2 = .008$, p = .398).

Multilevel analyses of students' self-regulation, learning situations, and students' emotional states

Previous analyses—intercorrelations between variables

Pearson product-moment correlations were calculated in order to identify multicollinearity (see Table 2).

The correlations between students' emotional states and the control variable age are significantly positive, though weak. Furthermore, students with high self-regulation abilities tend to report higher values concerning their emotional states (r = .16), which in turn are positively associated with the number of student-centred learning phases (r = .05) as well as with learning new contents (r = .03). In addition, the acquisition of new learning contents especially takes place during phases of student-centred learning (r = .39).

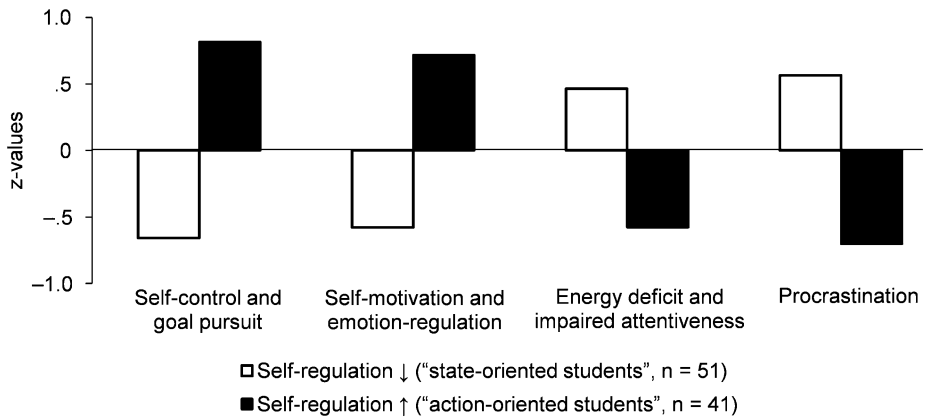

Fig. 2 Differences in facets of self-regulation between the identified clusters

Table 2 Intercorrelations between variables

		1	2	3	4	5
1	Gender[a]					
2	Age	.05**				
3	Students' self-regulation[b]	.02	–.09***			
4	Student-centred learning—teacher instruction	–.03*	–.03*	–.01		
5	Learning new contents—repetition	–.01	–.01	.00	.39***	
6	Students' emotional states	–.01	.12***	.16***	.05**	.03*

[a] *0* male, *1* female

[b] Self-regulation ↓, "state-oriented students" = 0; self-regulation ↑, "action-oriented students" = 1

*** p < .001, ** p < .01, * p < .05

Multilevel analyses

The analysis of the *null model with repeated measures nested within students and within situations* shows a between-students variance of the intercepts of .455 (SE = .07, p < .001), a between-situations intercept variance of .045 (SE = .007, p < .001), and a residual variance of .509 (SE = .011, p < .001). Checking possible nesting-effects of class-affiliation, we additionally calculated the *null model with repeated measures nested within classes*. We found a nonsignificant proportion of variance of the individual intercepts of .063 (SE = .053, p = .227) and a residual variance of .954 (SE = .020, p < .001). That indicates that the nesting-level is the students- and situations-level (cf. cross-classification) and not the class-level.

Table 3 shows the results of the analysis of the *two-level model*, integrating main effects of students' self-regulation and learning situations as well as interaction effects.

The fixed effect of students' self-regulation shows that state-oriented students (self-regulation ↓) report significantly lower emotional state values (in terms of situational understanding, perceived time to reflect on subject matter, situational interest, and perceived meaningfulness of learning activity) than action-oriented students (self-regulation ↑). There are no main effects of the organisation of classroom interaction (student-centred learning vs. teacher instruction) nor of the type of learning contents

Table 3 Multilevel analysis of students' self-regulation, learning situations, and emotional states

Effect	Estimate	SE	p	95 % CI	
				LB	UB
Fixed effects					
Intercept	.189	.106	.078	–.021	.400
Age	.142	.070	.047	.002	.281
Students' self-regulation[a] [= 0]	–.338	.140	.018	–.617	–.059
Student centring—Teacher instruction (Sc–Ti)	.018	.026	.491	–.033	.070
Learning new contents—Repetition (Lnc–R)	.003	.024	.904	–.044	.050
Self-regulation ↓ × Sc–Ti[b]	.036	.026	.159	–.014	.087
Self-regulation ↓ × Lnc–R[c]	.023	.024	.327	–.023	.069
Self-regulation ↓ × Sc–Ti × Lnc–R	–.001	.022	.970	–.043	.042
Self-regulation ↑ × Sc–Ti × Lnc–R	.015	.023	.508	–.030	.060
Random effects					
Random intercept variance (person)	.426	.066	<.001	.314	.577
Random intercept variance (situation)	.041	.007	<.001	.030	.056
Repeated measures effect					
AR1 diagonal	.499	.011	<.001	.477	.521
$-2LL_{(2\text{-level model/null model})}$	9827.192/10,039.848				
$AIC_{(2\text{-level model/null model})}$	9835.192/10,045.848				
$BIC_{(2\text{-level model/null model})}$	9860.670/10,065.006				
McFadden-Pseudo-R^2	.021				
Analysis of deviance (χ^2-test)	$\Delta_{-2LL} = 212.656$, $\Delta_{df} = 9$, $p < .001$				

Depended variable Students' emotional states

[a] Self-regulation ↓ = 0, self-regulation ↑ = 1, self-regulation ↑ [= 1] as reference

[b] [Self-regulation ↑ × Sc–Ti] as reference

[c] [Self-regulation ↑ × Lnc–R] as reference

(learning new contents vs. repetition). The effect of students' self-regulation remains stable after controlling for age. Gender has not been added to the model, because there is no significant Pearson product-moment correlation (see Table 2).

With regard to the modelled person-situation interactions, we found no significant interaction effects between self-regulation and learning content, between self-regulation and organisation of classroom interaction, or between self-regulation, learning content and the organisation of classroom interaction (as possible three-way interactions). But descriptively and with reference to the current sample we found a small interaction between self-regulation and the organisation of classroom interaction, as graphed in Fig. 3.

The sample-related (non-significant) interaction between self-regulation and the organisation of classroom interaction can be interpreted as follows: students' self-regulation affects the relationship between the organisation of classroom interaction and the experience of learning situations in terms of students' emotional states. The greater the amount of student-centred learning per 7-min interval (related to the amount of teacher instruction in the same interval), the greater the increase of situational understanding, perceived time to reflect on subject matter, situational interest, and perceived meaningfulness of the learning activity for students with low self-regulation abilities

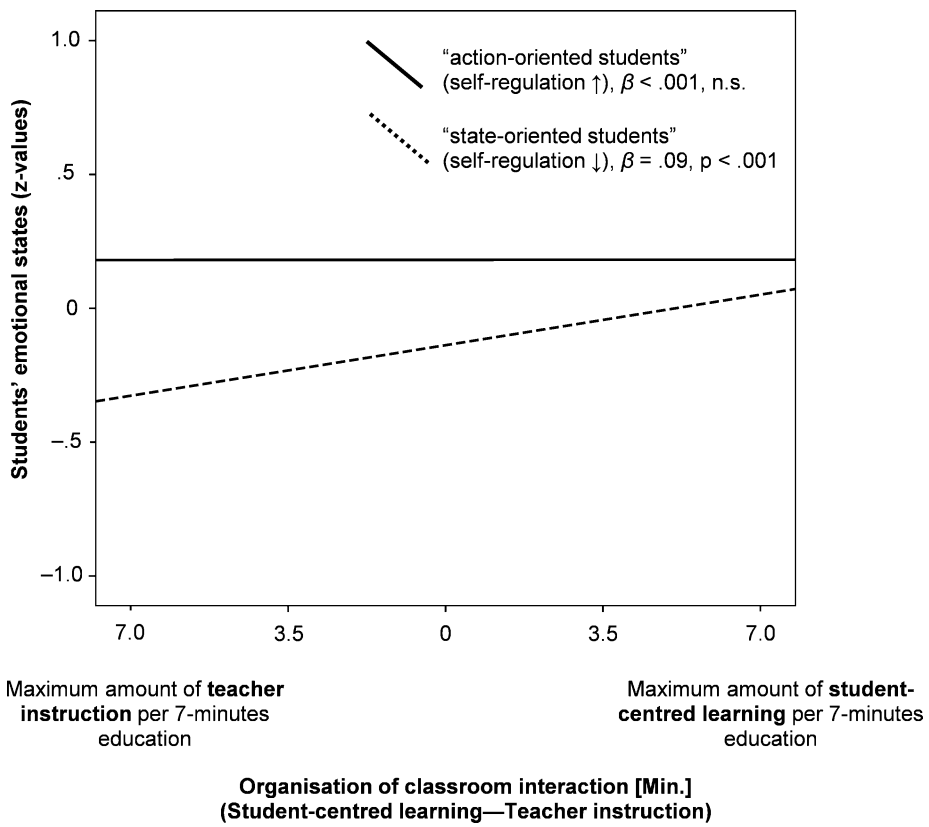

Fig. 3 Sample-related (non-significant) interaction effect between students' self-regulation and organisation of classroom interaction (*Note* Because of the calculated differences between student-centred learning and teacher instruction (Sc–Ti), a value at Sc–Ti above zero (on the *right-hand side*) represents a higher proportion of student-centred learning in relation to teacher instruction and a value of Sc–Ti below zero (on the *left-hand side*) represents a higher proportion of teacher instruction in relation to student-centred learning)

($\beta = .09$, $p < .001$). In contrast, students with high self-regulation abilities do not seem to be affected by the degree of student-centred learning respective to teacher instruction ($\beta < .001$, n.s). But as mentioned earlier, the described interaction remains only sample-specific and not significant.

Table 3 also contains the variances of the random effects as well as of the repeated measurements effect. Here, 42.6 % of the intercept variance is located between the students and 4.1 % of the intercept variance is located between the situations. With regard to the repeated measures effect, the analysis suggests a value at AR1 diagonal of 49.9 % as the variance for measurement points (cf.; Heck et al. 2010).

As indicator for the improvement from the null model to the two-level model, we calculated McFadden's (1973) adjusted R-squared ($= 1-[-2LL_{\text{2-level model}}/-2LL_{\text{null model}}] = 1-[9{,}827.192-10{,}039.848]$) and found an error reduction of only 2.1 percent, but which remains significant by analysis of deviance (χ^2-test).

Discussion and conclusions

Summary of results

Students' emotional states are considered as important and integral components of learning and achievement processes (e.g. Rausch et al. 2016; Sembill et al. 2002). In accordance with the interactionist paradigm, it was assumed that emotional states are affected by personality characteristics, by time-varying characteristics of learning situations, and by the interaction of personal and situational characteristics (e.g. Matthews et al. 2003; Nezlek 2007). These multiple interrelations illustrate why different individuals experience the same situation in diverse ways. In terms of personality characteristics, self-regulation plays an important role in the adaptation to situational demands (Kuhl 2000; Fröhlich and Kuhl 2003) especially within learning processes (Sembill et al. 2007; Weinert 1982) and is therefore a worthwhile construct to investigate in conjunction with emotional states.

Against this background, we focused on the research question: How and to what extent are students' emotional states affected by their self-regulation abilities, by situational characteristics during class, and by the interaction of self-regulation and learning situations? We conducted a process-oriented video study in naturalistic vocational education settings and investigated students' emotional states by using the well-tested continuous-state-sampling method. With regard to our *first hypothesis*, via latent class analysis we identified "state-oriented students," characterised by low/unfavourable self-regulation abilities, and "action-oriented students," characterised by high/favourable self-regulation abilities (see Table 1; Fig. 2). According to our *second* and *third hypotheses*, we found weak yet significantly positive Pearson product-moment correlations between students' emotional states and students' self-regulation, the proportion of student-centred learning phases (in comparison to teacher instruction), and the proportion of learning new contents (in comparison to the repetition of already known learning contents) (see Table 2). In the multilevel analysis, we found a stable main effect of students' self-regulation on students' emotional states, but no main effect of the characteristics of learning situations (see Table 3). Furthermore, the hypothesized interaction effects between personal and situational variables failed statistical significance (cf. our

fourth hypothesis; see Table 3). But descriptively and with reference to the current sample, we found a small interaction between self-regulation and the organisation of classroom interaction (see Fig. 3).

Discussion

State-oriented students (in the current sample) seem to be slightly more responsive to situational changes in learning settings than action-oriented students. Thus, students with high self-regulation abilities seem to be more stable in their subjective experiences of situational understanding and interest, as well as concerning the perceived time to reflect and perceived meaningfulness of the learning activities. On the other hand, students with low self-regulation abilities show decreases in emotional states in teacher-centred phases, and vice versa: increases of emotional states with increasing amounts of student-centred learning. The decrease of emotional states is possibly associated with the higher amount of external (teacher) control during instruction phases. This in turn leads to restrictions regarding individual scopes of action and of opportunities to participate in classroom talk (cf. Seifried 2004). On a volitional level, a higher number of teacher instruction phases may lead to an adoption of external goals and potentially diminishes the capacity of state-oriented students to successfully realise their own intentions (cf.; Fröhlich and Kuhl 2003). As mentioned previously, student-centred learning settings are in turn associated with higher degrees of self-determination and autonomy alongside an expansion of individual scopes of action. In particular, the interrelation between self-regulation and emotional states may be especially relevant for state-oriented students, who are characterised by an inhibition of self-regulation and are potentially trapped in states of negative experience while under stress (Kuhl and Beckmann 1994). However, if they are relaxed, feeling accepted by others and not negatively affected, they are able to perform just as well or even better than action-oriented individuals (Kuhl 1994). A stabilisation of positive emotional states by repeated self-motivational and self-enhancing episodes (Kuhl 2000) could be reached with a supportive design of student-centred learning phases on a macro- as well as micro-didactic level (cf. Seifried 2009; Sembill et al. 2002, 2007; Wuttke 1999). However, the mentioned interaction effect remains not significant. That could result from possible confounding variables in naturalistic settings or from aspects of the operationalization of the situational variables but it seems to be worthwhile to be investigated in future research by attempting to replicate the findings under controlled conditions and using other situational variables.

Limitations and further research

The design of our study has advantages as well as limitations. On the one hand, the naturalistic educational setting and the continuous sampling of states at high frequency offer a high degree of ecological validity (cf. Sembill et al. 2008). On the other hand, field research in naturalistic settings bears the risk of barely controllable confounding variables—especially caused by non-randomised samples and non-standardized test conditions—that may bias the results (cf. internal validity). For further research, a combination of (quasi-experimental) field studies and experimental conditions seems to be worthwhile and fruitful (cf. Ellenbogen 2012). Here, micro-analytic field study designs

can be used to identify crucial parameters of successful learning and coping processes (maximising external validity). Afterwards, effects of the identified parameters on the dependent variable(s) can be validated within experimental studies (maximising internal validity).

Assuming that different ontogenetic levels—i.e. organ level (e.g. central and autonomic nervous system)—are involved in learning and coping processes, and though not necessarily present in self-reporting, it would also seem fruitful to investigate neurophysiological antecedents and correlates of psychological states, as well as of actions within vocational learning processes (e.g. Kärner 2015; Sczesny 1994), that in turn can be conducive for a psycho-physiological theory of teaching and learning processes (Beck 1994; Beck and Sczesny 1993; Sembill 2015).

Furthermore, the current research only focuses on a relatively narrow scope within the discussion about heterogeneity between learners. We considered students' self-regulation to be an important construct with respect to learning and corresponding subjective experiences. Under consideration of the wide range of other personality characteristics, further research should also focus on the impact of other relevant variables (such as domain-specific prior knowledge, intelligence, or self-efficacy beliefs). Furthermore, additional situational characteristics (such as concrete parameters of classroom talk, educational quality, or variations of domain-specific learning contents) and other dependent variables (such as psychological, physiological, and behavioural states) should be taken into account. Nevertheless, the presented approach—combining continuous-state-sampling and video-based analysis by a multilevel analysis, taking into account multiple interaction effects—represents a possible method in reaching a more holistic understanding of teaching and learning processes in VET.

Moreover, an extension of the survey period (as realised by Sembill et al. 2002 or Seifried 2004) could substantiate our findings, especially concerning the assumed interaction effect, which turned out to be quite small and not significant. In our study, we only considered a period of eight lessons per class. Thus, further research designs should consider longer survey periods, investigating causal relationships and regulatory feedback mechanisms between personality characteristics, situational conditions, person-related states, and learning outcomes. In that regard, emotional states could in turn affect personal characteristics over longer periods, as has already been found in research on the variability and stabilisation of personality characteristics over the life span (Lang et al. 2006) as well as in research on time-referenced interdependencies between academic self-concept and achievement in school (Pekrun 1987). In conclusion, a deeper knowledge about the complex interrelations between personality characteristics, emotional states, and learning situations seems to be essential for the identification of crucial aspects for an evidence-based design of teaching and learning environments in vocational education and training.

Authors' contributions

KK conceived, designed, and coordinated the study. TK participated in data collection. TK and KK conceptualized the aim and structure of the research paper. Furthermore, both authors managed the literature searches and statistical analyses and wrote the paper. Both authors contributed substantially to and have approved the final manuscript. Both authors read and approved the final manuscript.

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Competing interests
The authors declare that they have no competing interests.

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