Integrating self-reports and electrodermal activity (EDA) measurement in studying emotions in professional learning

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Integrating self-reports and electrodermal activity (EDA) measurement in studying emotions in professional learning

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Abstract

Studies on emotions in learning have been mostly conducted through self-reporting questionnaires and interviews conducted after the learning situation, which seldom focus on professional workplace learning. Meanwhile, workplace and professional learning research has been introduced with emerging methods to capture the learning processes at multiple levels. Previous research on emotions has suggested that self-reports should be supplemented with psychophysiological data. Challenged by this, this chapter aims to present and discuss the integration of self-reported and psychophysiological data in studying emotions and professional learning. The empirical research data are obtained from five Finnish university teachers participating in a laboratory research comprising self-reported data (through the Emotion Circle application and a Stimulated Recall Interview) and psychophysiological data collected from the subjects' electrodermal activity. The process data on the quality, strength and duration of emotions are synchronised with those on psychophysiological, individual-level peaks of emotional arousal. The findings are discussed in terms of the possibilities and limitations of using complementary data in researching emotions in professional learning.

Keywords: emotions, professional learning, self-reports, multimodal methods, electrodermal activity (EDA)

1. Introduction

Amid the rapidly changing and digitalised working life, continuous professional learning is necessary for individuals as well as for work communities and organisations (Goller & Paloniemi, 2017; Harteis, 2018). Accordingly, professional learning has been extensively explored, theorised, and supported in workplace contexts (Billett et al., 2014; Tynjälä, 2013). In these contexts, professional learning is understood in various ways, such as the development of expertise and competence, organisational renewal and the (trans)formation of work practices. Recently, professional learning has also been conceptualised as the (re-)negotiation of identity (Eteläpelto et al., 2014; Vähäsantanen et al., 2017a). Such professional identity learning particularly occurs through collaboration within social interactions (e.g. Lave & Wenger, 1991), as well as experimentation and reflection regarding one's professional mission and practices (e.g. Vähäsantanen et al., 2017b; Zwart et al., 2015). Recent research has further shown that emotions play a central role particularly in group-based identity learning (Vähäsantanen et al., 2020b). Despite convincing findings on professional learning, there is a lack of research on the role of emotions in professional learning. So far, only a few studies have explored emotions and professional learning among professionals (e.g. Rausch et al., 2017).

Topically, emotions are understood as situational and dynamic responses to a personally meaningful situation, event, or person (Gooty et al., 2010). They are expected to be elicited by

a specific target or cause and include physiological reactions and action sequences (Barsade & Gibson, 2007). There has long been discussions on how emotions trigger or inhibit human behaviour (Hommel et al., 2017) and how their emergence is closely related to the autonomic nervous system (ANS) activity (Levenson, 2014; Mauss et al., 2005). Accordingly, emotions are understood as multicomponential phenomena, including experiential, psychophysiological and behavioural components (Gendolla, 2017; Kreibig, 2010; Mauss & Robinson, 2009).

However, the findings obtained so far on emotions in professional learning settings are mostly based on questionnaires or interview data collected after the learning situations. Thus, such self-reports have neither captured the multicomponential nature of emotions nor have they been gained to capture the process data of emotions in learning. Consequently, it has been suggested that self-reports should be combined with other methods that measure the psychophysiological and behavioural components of emotions (Azevedo et al., 2016). However, in such multimethod measurements, one must address the questions of complementarity, interchangeability, validity and reliability (Eteläpelto et al., 2018). In addition, there are challenges regarding the differing time windows of the various modalities. The questions then arise as to how to overcome the methodological challenges of multicomponential measurement and how to apply methodologically advanced tools in rigorous ways to investigate emotions in professional learning.

In this chapter, we focus on researching emotions in the professional learning process and the integration of self-reported and psychophysiological research data within the field of professional learning and development. We start by briefly introducing emotions and learning, and then applying the self-reports and psychophysiological measurement of electrodermal activity (EDA) in emotion research. The empirical data utilised and illustrated later in this chapter are derived from a study exploring emotions in a professional learning process by integrating two types of self-reported data (Emotion Circle (EC) and Stimulated Recall Interview (SRI)) and EDA measurement data. In our study, professional learning is mainly understood as professional identity learning (Eteläpelto et al., 2014). Such learning covers processes in which professionals become aware of, reflect on and process their professional commitments, values and careers, as well as their strengths and weaknesses at work (Vähäsantanen et al., 2017b). It also encompasses the notion of an individual as an active and reflective participant—that is, someone who is responsible for learning and constructing change at a personal level within a given context. The integration of self-reported and EDA measurement data is illustrated through a closer look at the empirical data collected in a within-subject design.

2. Emotions related to learning

In terms of student learning, research has shown the central role of emotions in motivational processes, self-efficacy and active engagement, each of which plays a salient role in productive learning (Pekrun et al., 2006). Recently, there has been a growing interest in studying collaborative learning processes, with a focus on emotional or affective aspects alongside cognitive and motivational ones (Noroozi et al., 2020). Although research investigating the role of emotions in collaborative learning (Pijeira-Diáz, 2019; Pietarinen, 2021), self-regulated learning (Dindar et al., 2020; Järvenoja et al., 2018, 2020) and learning outcomes (Parong & Mayer, 2021) has increased, it has solely been implemented in educational contexts.

Yet, the research on emotions and professional learning or learning at work is still largely missing. Only a few studies have addressed the interplay of emotions and learning at work. A

recent literature review on emotions and learning at work (Hökkä et al., 2020) has utilised the existing empirical evidence on the topic and showed that the relation between emotions and learning is understood in various ways within the field. Within the studies reviewed, emotions are mainly defined as emotional experiences and responses, and learning at work mainly refers to learning through participatory practices. Most of these studies have focused on the active role of emotions in supporting and/or hindering learning at work, where some have a viewpoint of emotions at work being influenced by learning. As only a few studies have investigated the interplay of emotions and learning at work, the role of emotions in professional learning and learning at work needs to be better understood (see also Benozzo & Colley, 2012).

So far, there exists some evidence on the role of emotions in professional identity learning. Meijers (2002) emphasised that a safe environment is essential for teachers' identity learning. This is not an environment that protects individuals from pain and uncertainty, as these emotions are also important starting points for the whole identity process. Rather, a safe environment allows an individual to handle and process such emotions in productive and creative ways and share them so that one's burden becomes lighter. Similarly, Winkler (2018) showed the complex role of emotions in professional identity work. First, emotions (e.g. self-doubt, fear, confusion, and dissatisfaction) can work as triggers for identity work. Second, identity work can be seen as an emotional endeavour that can include many emotions, such as fear, anxiety, unhappiness, uncertainty, shame and frustration. Third, emotions can be seen as outcomes of identity work; that is, successful and unsuccessful identity work can bring about emotions such as happiness, relief, frustration, shame and worry. Vähäsantanen et al. (2020) also showed that professional identity learning is a rich emotional endeavour during which emotions both support (e.g. inspiration) and hinder (e.g. fear) identity learning processes, and that emotions (e.g. compassion and shame) emerge as outcomes of the identity learning process.

In the research conducted on adult learning, positive emotions have been found to broaden the scope of perception, whereas negative emotions of anxiety and fear have been found to be related to narrowing of the perception and curiosity necessary for active and agentic learning (Fredrickson & Branigan, 2002; Perry, 2006; Storbeck & Maswood 2015; Sung & Yih 2015; Vähäsantanen et al., 2017b). In team-based learning, social and self-conscious emotions, such as compassion, love, shame, anxiety and anger, have been found to influence how team members see each other and how they perceive the team's future (Homan et al., 2015). Similarly, emotions have been found to act as precursors for active teamwork and collaboration (Mäkikangas et al., 2017; Watzek et al., 2019). Negative emotions and emotion-focused coping have been found to be provoked by errors at work (Rausch et al., 2017). However, the relation between negative emotions and learning is not straightforward. There is evidence that negative emotions can also foster learning (Hökkä et al., 2020). Consequently, the complex relation between pleasant and unpleasant emotions and learning needs to be further explored (Hökkä et al., 2020; Pietarinen, 2021; Vähäsantanen et al., 2020).

Despite the growing evidence on the meaning of emotions in learning settings, there is still no shared theoretical understanding of emotions. The discrete approach to emotions refers to the universally shared basic emotions that correspond to specific facial expressions, such as anger or joy (Damasio, 1999; Ekman, 2016). The dimensional approach understands emotions through the pleasant–unpleasant and low–high intensity dimensions (e.g. Ekman, 2016; Harmon-Jones et al., 2016). Emotions are then characterised in terms of valence, which refers to the subjective feeling of pleasantness or unpleasantness, and arousal, which refers to the subjective state of feeling activated or deactivated (Barrett & Russell, 1999). Mauss and

Robinson (2009) concluded that the dimensional perspective has gained more support. In addition, emotions can be understood as culturally coded social entities, such as safety, pride or embarrassment. In this way of thinking, emotions are seen as mixed and socially produced categories that have a weight of tradition and the everyday experience behind them (Russell, 2003). Despite the variation in ways of understanding emotions, scholars have broadly agreed that emotions can be characterised as situational and intense, involving certain physiological responses to an event, entity, or person (Gooty et al., 2010; Mauss & Robinson, 2009; Zelenski & Larsen, 2000).

3. EDA measurements in emotion and learning research

An agreement on the multicomponential nature of emotions implies a multimethod measurement of emotions (e.g. Eteläpelto et al., 2018). Recently, there has been a growing interest in exploring multimodal data in learning research. So far, however, only a few empirical studies have focused on emotions and professional learning that utilise multimodal data. To date, self-reports (i.e. questionnaires and interviews) have been the most widely used methods in researching emotions, particularly those in learning settings (Noroozi et al., 2020). As an economic data collection device, there are many advantages of utilising self-reports: they enable a nuanced description of personally meaningful emotions, producing differentiated and detailed descriptions of emotions, thoughts and bodily sensations (Pekrun, 2016) in certain contexts and situations. However, self-reports are limited to conscious emotional responses and are most often collected retrospectively. In addition, there are both individual and cultural differences in the ways emotions are expressed, or even in the awareness of one's emotions (Azevedo et al., 2016). This implies that self-reporting methods should be supplemented with other types of data that capture, for example, the physiological component of emotions.

Another aspect that is important in considering self-report methods is that the data are usually collected retrospectively after the learning situation. This is often the case if, for example, interviews or questionnaires are used. Due to the time and nature of the learning situation, it is seldom the case that self-reports on emotions can easily be done during the learning situation. In the last few years, applications for online self-reporting on emotions have been introduced and experimented (Eteläpelto et al., 2018; Lehtonen et al., 2020). The study described in this chapter aims to develop an online assessment EC tool of emotions, especially for professional learning situations (see also Seifried & Rausch, Chapter 2, and Rausch et al., this volume; Rausch et al., 2015). The first version described here paved the way for the development of the mobile online version of the EC (www.emotioncircle.fi).

It has long been recognised that the autonomic nervous system (ANS) plays a central role in emotions. As Levenson (2014) noted, 'when it comes to emotions, all roads lead to ANS'. ANS functions through two opposite but interacting regulation systems: the sympathetic and the parasympathetic nervous system. In experiences of fear and anxiety, the sympathetic nervous system produces the 'fight or flight' response, whereas the parasympathetic nervous system is responsible for calming our body and mind ('rest and digest'). From the multicomponential perspective of researching emotions, the main value of ANS measurement is that it creates visible reactions and experiences that are neither spoken nor observable (Karvonen, 2017). Although there is an agreement on the multicomponential nature of emotions, there is no agreement on the relations among the components of subjective experience, ANS and behavioural changes. These relations are often addressed in terms of coherence, referring to the coordination, or association, of a person's experiential, behavioural and physiological responses as an emotion unfolds over time (Mauss et al., 2005).

Several (psycho)physiological indicators have been used in research in various disciplines, including heart rate (HR), heart rate variability (HRV), cortisol measurements and electroencephalography (EEG) (see also Kärner & Sembill, this volume, and Silvennoinen et al., this volume). In this chapter, we focus on one of the most often used psychophysiological measurements in emotion research: EDA. With a history of more than a century, EDA is a term used for variations in electrical conductance of the skin, including phasic changes that result from sympathetic activity (Bouschein, 2012; Kreibig, 2010). The notion of sympathetic arousal is present whenever EDA is used as a psychophysiological indicator. The skin is innervated by the sympathetic nervous system, which is the controller of the so-called 'fight-or-flight' response. EDA represents a valid indicator of emotional arousal (Kreibig, 2010). It refers to changes in skin conductance (SC) and can be measured with non-intrusive techniques providing information on emotional arousal, increased cognitive workload and task engagement. The higher the conductance level rises, the more elevated an individual's emotional arousal becomes. Compared to, for example, cardiovascular measurements, EDA is the only one considered to be a pure marker of sympathetic activation (Pijeira-Diáz, 2019). The eccrine sweat glands, uniquely innervated by the sympathetic nervous system, are the primary determinants of EDA (Boucshein, 2012). Their highest density occurs in the palmar and plantar (or sole) regions. Thus, EDA can be easily measured with a properly spaced pair of electrodes in the palm and sole areas. However, as the placing of electrodes on such regions interferes with daily activities, alternative locations, such as the wrist, are also used. The most recently advanced wearable devices for EDA measurement are wristbands (Dindar et al., 2020; Järvenoja et al., 2018; Pijeira-Diáz, 2019) and smart rings (Lehtonen et al., 2020). Furthermore, measuring arousal is theoretically linked to the circumplex model (Russell, 2003) of researching emotions.

Although there are challenges with data collection and analysis, technological solutions have already provided advanced methods for both EDA data collection and analysis. So far, they have not yet been widely used in learning research, combining various research methods and data. In their recent review on using multimodal data in learning research, Noroozi et al. (2020) found that the most widely used method combinations were interviews, surveys and observations. In contrast, the least-used methods were biometric and objective measures, with no studies utilising EDA. This is attributed to the finding that in learning research, cognitive and motivational aspects are overwhelmingly represented, not the emotional dimension. Furthermore, none of the studies included in the review were conducted in workplace learning or in vocational education contexts. Consequently, the triangulation of subjective (e.g. self-reports) and objective (e.g. arousal measurement) data is largely missing within the field of researching emotions in the learning of adults, especially in workplace and professional learning research.

So far, self-reported and EDA data have been used together in studies implemented in educational and schooling contexts (e.g. Dindar et al., 2020; Järvelä et al., 2019; Järvenoja et al., 2018; Villanueva et al., 2018), as well as virtual learning environments (e.g. Parong & Mayer, 2021). One of the few studies combining self-reports in the working life context was conducted by Lehtonen et al. (2020), who collected electrodermal activity data through smart rings and self-reported data on emotions and learning through the Learning Tracker application and interviews. The results showed that the participants reported more positive than negative emotions at work, the most frequent emotions being contentment and frustration. Concerning arousal, the level was higher during the morning hours of work and decreased during the afternoon hours. However, the study did not investigate the relations among arousal, emotions

and learning. As the data were analysed independently, the question of integration and supplementary understanding remains open.

In the study described in this chapter, we aim to investigate the integration and complementarity of subjective experiences (self-reports) and psychophysiological (ANS) data. Accordingly, we understand emotions as multicomponential, dimensional and personally meaningful situational responses to an event or person/s that are elicited by a particular target or cause (see also Eteläpelto et al., 2018). The empirical study presented next illustrates the integration of self-reported interview data with EDA measurements in studying emotions in professional identity learning.

4. Integrating self-reports and EDA: An empirical study on emotions in professional learning

The empirical study described here originates from a Finnish research project, *The Role of Emotions in Agentic Learning at Work.* The project aimed to develop innovative tools for the online assessment of emotions, together with utilising complementary research methodology within the field. In this chapter, we utilise a study conducted in the early phases of the project, when we started piloting the research methodology and the online emotion assessment tool. This was done by continuing the research collaboration with university teachers who had participated in our research project on professional identity and agency a few years earlier (Vähäsantanen et al., 2017b, 2020). As part of this collaboration, the teachers participated in an identity coaching programme comprising six workshops conducted in small groups. The workshops were video-recorded, and we could use this material in the project, now focusing on the emotional aspects of professional learning.

The present study has two aims. First, to examine the types of emotions that emerge while participants assess professional learning situations. The following research question is addressed: What types of emotions do the participants report while watching personally meaningful professional learning episodes of an identity coaching programme? The second aim is to integrate multiple methods and data in researching emotions connected to professional learning processes. In doing so, we focus on answering the following question: What types of information do self-reports and EDA provide for understanding emotions in professional learning?

Research design and data collection

As suggested by the researchers investigating concurrent responses and addressing the coherence of multiple sub-systems of emotions (Kreibig, 2010; Levenson, 2014; Mauss & Robinson, 2009), a within-subject design was chosen for the study. The study reported here aimed to capture emotions simultaneously on two levels: 1) subjective experience (self-reports) and 2) ANS (psychophysiological measurement). Our purpose was to investigate concurrent measures applicable to changing emotions, especially those occurring within learning processes. In the best case, this would provide us insights into the subjective experience of emotions—observed concurrently with ANS functioning—as well as indications on how the measures can provide information on emotions in learning.

The data were collected in a laboratory setting where five university teachers watched selected video recording episodes (Figure 1) from an identity coaching programme in which they had previously participated (Vähäsantanen et al., 2017b). The selection of video episodes was based

on the participants' own assessments of the most important and meaningful learning situations during the identity coaching programme. All episodes were derived from the last workshop meeting, in which the participants worked via using an arts-based professional body method. This method combines individual and collective processes of identity work. As an individual task, the participants created their professional bodies using various materials, such as clippings and drawings (Vähäsantanen et al., 2020). While personalising their bodies, the participants were guided to address different themes, such as professional history, core commitments and future dreams. In the last workshop of the programme, professional bodies served as material for collective processes. For example, each participant talked about one's own body, and the others responded to them by applying drama methods. The selected video episodes were organised and presented to the participants according to the principles of reverse counterbalancing design (ABBA; Goodwin, 2008). Accordingly, the first (A1) and last (A2) video episodes were selected in terms of representing neutral episodes. The second (B1) and third (B2) episodes represented the most meaningful learning situations for each participant.

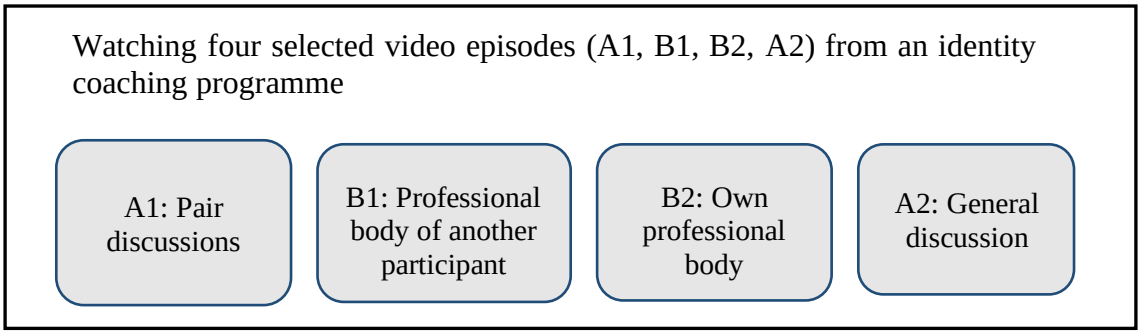

Figure 1. Description of four selected video episodes.

The teachers participated in the study individually, and the procedure comprised consecutive Sessions 1 and 2. In Session 1, the teachers watched four video episodes, and subjective emotion reports were elicited using an online application EC (Eteläpelto et al., 2018), especially developed for the self-assessment of emotions concurrently with watching videos. The EC contained 12 written emotion words with a colourful graphic interface (Figure 2) and was developed in line with the circumplex model of emotions (Russell, 2005) as well as the data-driven analysis of identity coaching participants' assessments of the emotions during the programme. In Session 1, the participants were asked to evaluate the nature and quality of their emotions through the EC while watching the video episodes. During this session, the participants freely used the EC according to their own choice by clicking on the emotion words. For the purposes of the study reported here, only the frequencies of emotions reported were included, while the level of a certain emotion was not accounted for.

Immediately after the first session, in Session 2, the participants' emotion assessments (as well as their connections to learning) were elaborated in an emotion-driven stimulated recall interview (SRI (Kagan et al., 1963). Here, the video episodes, together with one's EC assessments, were shown to the participants. Furthermore, the participants were encouraged to describe, explain and elaborate the emotion assessments they had made through the EC and to freely share their thoughts and feelings with the researcher. The video was stopped while the participants were talking, to give them space and time to reflect on their emotion assessments

and the learning situation at hand. The SRI data were obtained through video recording of the whole laboratory setting.

Figure 2. Display of EC.

Throughout Sessions 1 and 2, psychophysiological data were collected. The ANS activity was measured using the QuickAmp amplifier and data acquisition system (Brain Products, Gilching, Germany; www.brainproducts.com). EDA was measured through two skin conductance (SC) electrodes, which were placed on the participants' non-dominant palms to avoid as much measurement error as possible (Karvonen, 2017).

Data analysis

The analysis started by processing the different data sources separately and was conducted in line with the research questions. When investigating the types of emotions that are reported when watching and assessing professional learning situations, the self-reporting data collected through the EC were utilised. In doing so, we calculated the frequency of the emotion words that the participants reported when watching the video episodes (i.e. during Session 1).

The total number of emotions reported through the online EC was 357 (Table 1). Both pleasant and unpleasant emotions emerged in the participants' EC self-reports. The majority (n = 294) of reported emotions were pleasant, with joy being the most commonly reported emotion (n = 78), followed by surprise (n = 50) and excitement (n = 47). In addition, courage and compassion, as pleasant emotions, were assessed to characterise the professional identity learning occurring in the identity coaching programme. The most common unpleasant emotion reported was frustration (n = 17), followed by sorrow (n = 15) and anxiety (n = 9).

Table 1. Total number of emotions reported through the EC.

Emotion words	Jane	Heather	Carol	Elsa	Lena	Total
Excitement	13	5	19	1	10	47
Surprise	7	8	20	15		50
Joy	11	20	29	10	8	78
Courage	8	3	15	2	5	33
Compassion	2	13	18	13	2	48
Safety	3	6	13	2	14	38
Sadness	1		6	8		15
Frustration	6	10	1			17
Shame	3	3		2		8
Fear	5			1		6
Anxiety	5	1		3		9
Irritation		6		2		8
Total	63	75	121	59	39	357

The participants differed from each other in terms of what emotions they reported, how many different emotions they reported and how many times they clicked on the emotion word while watching the video episodes. The individual variation in the number of emotions reported ranged from 39 to 121. Out of the 12 available emotions in the EC, some participants reported a broader range of emotions than others (range 5–11). These differences were attributable to the personal differences in experiencing, acknowledging and expressing emotions. Alternatively, the episodes they watched might not have caused emotional responses. Clearly, the self-reported data through the EC alone were not sufficient for investigating emotions and professional learning.

Concerning the subject-specific EDA data, we focused on the skin conductance response (SCR) peaks during Session 1. These peaks are strongly associated with emotional responses to experimental conditions (Järvenoja et al., 2018; Manolov & Onghena, 2017). EDA was analysed with the Ledalab programme (version 3.4.6) written in Matlab (Benedek & Kaernbach, 2010; www.ledalab.de). Before the analysis, the sampling rate was reduced to 10 Hz, which was high enough to represent rapid changes in skin conductance (SC) related to SNS activation. The rapid components of SC were extracted as skin conductance responses (SCRs) and written in a Microsoft Excel file. The SCRs were normalised by computing the average and standard deviation of the sessions and calculating the z-scores. Values above 2.0 were considered statistically significant at the $p < .05$ level. Given that 5% of the values exhibited this property on two tailed normal distribution, they can be considered to represent statistically significant SNS activation.

The EDA levels and high peaks indicated emotional arousal for each participant. All five participating teachers had EDA peaks with an agreed-upon level of z-score >2. In addition, the number of peaks varied across the participants, as did the z-score levels. However, these peaks alone gave us little information, especially in terms of emotions and learning being the ultimate focus of the study. Physiological reactions remain as reactions unless they are accompanied by individual emotional interpretations of the situation (Järvenoja et al., 2018). Thus, we matched the two datasets of EC reports and EDA together for a visual analysis. In this way, we could identify the moments in which both emotional arousal and self-report on emotions were present.

A within-subject analysis applying visual analysis was used to scrutinise the possible connections between the EDA peaks and self-reported emotions through the EC. The basic assumption was that high-level EDA indicates emotional arousal, whereas low-level EDA relates to passive action (e.g. Kreibig, 2010). Thus, we looked for the possible connections between EDA level peaks (z-score >2 = $p < .05$) and self-reported emotions. An example of a subject-specific combination of EDA at the bottom and the EC data on the top is presented in Figure 3, where the horizontal line illustrates the emotional arousal level significant in the data, the colourful lines above represent the 12 emotions in EC and the dots represent the participant's assessments of these emotions.

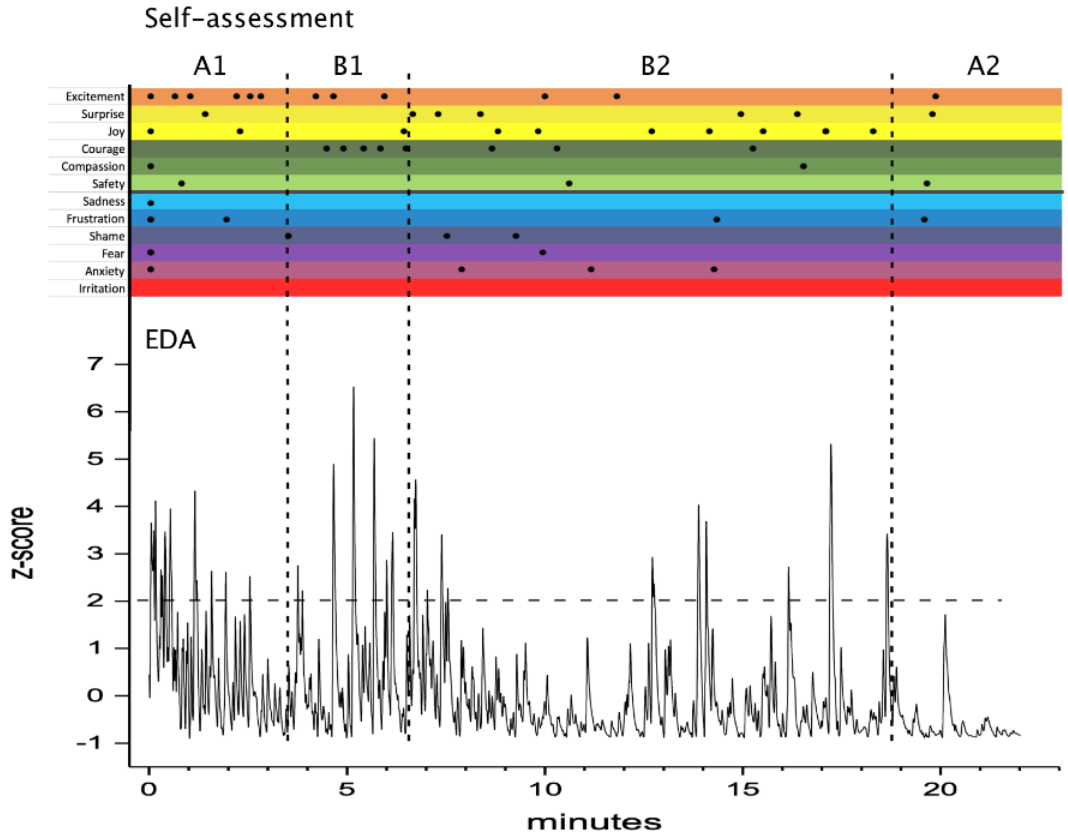

Figure 3. Example of a visual combination of the self-report of emotions through EC and EDA data.

Integrating EDA and self-reports from EC and SRI

To broaden our understanding and utilise multimodal data in examining emotions, we proceeded first with matching SRI self-report data with the EC and EDA data. SRI data, together with the video transcriptions, were used to capture the subjective interpretations of the moments at hand and the related emotion assessments. The moments with high EDA peaks were examined more deeply. In doing so, the available self-reported data (i.e. transcripted video episodes, emotions reported through EC and transcripted SRI data) were examined simultaneously. We focused on the descriptions, reflections and assessments that the participant reported concerning the original learning situation (i.e. the video episodes from an

identity coaching programme), the research situation (i.e. watching the video episodes) and in terms of the emotions reported through EC.

In focusing on the relatedness of the EDA peaks (i.e. objective data) and self-reported emotions (i.e. subjective data), we went through the data to see whether only one or both of them were present. Consequently, to understand connectedness, especially in terms of professional identity learning, we focused on closely analysing the moments in which both were present. The participants described, explained and reflected on their emotion assessments in the emotion-driven SRIs. The emotion-driven SRI data showed, in detail, how the reported emotions emerged and were related to professional learning. Joy and surprise emerged in connection to learning, such as the contents of the learning situation and discussing one's professional identity. In addition, joy was reported in the happy moments within the group. Excitement was reported by the participants in connection to one's own membership and participation in the group (collective sharing and creation) and to the actions of other members and the coach. Safety (as well as compassion) was reported in connection to other group members and to the importance of a psychologically safe learning environment in identity work. Concerning the unpleasant emotions reported, frustration and irritation (accompanied by shame) were connected to perceiving oneself professionally, as well as to one's own behaviour in the group. Furthermore, these unpleasant emotions emerged in connection to a slow pace of working, boring contents or behaviour of other group members. Eventually, the emotion-driven SRI data facilitated the addition of a new layer to the data analysis and increased our understanding of which and how emotions are related to the professional learning that occurs in the context of identity coaching programmes.

For a closer look at the integration of self-reports and EDA, we took Carol as an example. Figure 4 illustrates the EDA data at the bottom and the EC data at the top. The z-score value of 2 is marked with a horizontal line to illustrate the emotional arousal level significant in the data. Individual peaks larger than 2 are marked with red circles. The higher the EDA level, the higher the arousal. The above colourful lines represent the 12 emotions available in EC, and the dots represent single assessments of the emotions expressed by the participants (i.e. they clicked the emotion word in EC). In Carol's case, the total duration of watching the four video episodes (A1, B1, B2 and A2) was slightly less than 17 min. There are 10 circulated EDA peak moments in Figure 3. Based on the self-report datasets of EC and SRI, these moments included the following emotion assessments through EC, and based on the SRI data, the emotions were related to different events and/or persons:

Peak 1: Sadness towards one group member.
Peak 2: Sadness towards one group member.
Peak 3: No emotion reported—laughs aloud.
Peak 4: Surprised when seeing the video contents after a long time.
Peak 5: Excitement related to learning within the group.
Peak 6: Excitement related to professional identity work.
Peak 7: Joy, safety and compassion towards other group members.
Peak 8: Compassion towards one group member.
Peak 9: Sadness towards one group member.
Peak 10: Sadness towards one group member.

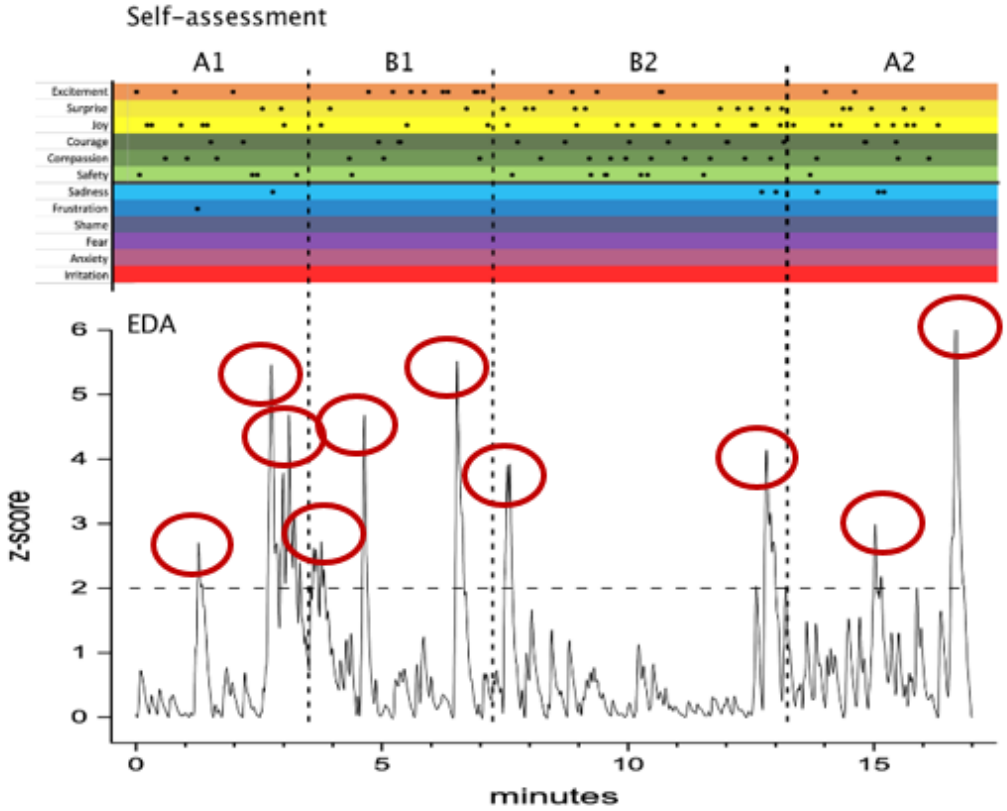

Figure 4. 'Carol's' self-reported emotions through EC and EDA peaks.

The above 10 moments of high EDA peaks reveal that the interpretation of EC reports and EDA is not a straightforward process. Not all peaks in the EDA data are related to self-reports on emotions. In Carol's case, peak 3 is an example in which there is no self-reported emotion at all, but the EDA level rises due to laughing aloud (which, as such, represents emotional behaviour). In addition, even though there is a connection between self-reported emotion and the EDA peak, there is not necessarily a relation with professional learning. For example, Carol reported sadness when watching the video episodes and said that it was related to seeing certain people and thinking of the unexpected changes in their personal lives after the coaching programme ended. The high EDA level in relation to sadness can also be attributed to the physical behaviour (crying and wiping the tears). In addition, Carol reported that sadness as an unpleasant emotion was related to the notion that the unique and meaningful moments with other participants and the identity coaching programme are already in the past and, thus, out of reach. This clearly illustrates that one emotion can emerge in different situations and be related to much different contents and events. This is also the case with excitement in Carol's case: excitement was found to have several positive associations with the professional learning process.

Carol's most often-reported emotions in addition to excitement were joy, surprise and compassion (Table 1). She explained in the SRI that joy and excitement were related to the ways of working in the identity coaching programme (e.g. drama methods) and to the learning processes and outcomes these methods produced. Furthermore, joy was related to the possibilities of sharing experiences with other group members and to be heard in shared encounters. In terms of social membership within the group, she reported compassion and safety as meaningful emotions supporting professional identity learning.

In general, the study findings revealed the emergence of both pleasant and unpleasant emotions in professional learning (see also Vähäsantanen et al., 2020). Emotions with positive valence activated and elicited professional identity learning. Furthermore, positive mixed social emotions were meaningful for the participants' learning in a group. Theoretical and educational significance emerged from a deeper understanding of complementarity and the different relations between the self-reported data on the quality of emotions and the psychophysiological data on the intensity of emotions. However, the questions of how to overcome the methodological challenges of multicomponential measurements and how to apply methodologically advanced tools in rigorous ways remain to unanswered (see also Al-Machot et al., 2019; Dindar et al., 2020; Järvenoja et al., 2018; Pijeira-Díaz, 2019). Thus, more research needs to be conducted to determine an optimal integration of various methods, as well as in terms of utilising multimethod approaches for understanding emotions in authentic professional learning contexts.

5. Discussion

Emotional aspects and the meaning of emotions in learning processes have gained increasing attention recently. Most of the studies have been conducted in educational and classroom contexts and have focused on the emotions of students. Thus far, the role of emotions in professional and workplace learning has remained largely underexplored. The vast development of research methods in emotion research has slightly entered the field of professional learning research as well. One developmental path is to use multimodal or multicomponential methods and data integration. Taken together, it is both the lack of knowledge and research on emotions in learning processes and the opportunities offered by advanced and innovative research methods that set new challenges and possibilities for researching professional and workplace learning processes in the future.

In this chapter, we discussed the role of emotions in professional identity learning. The most often reported emotions in such a learning context were found to be pleasant. Similar to a previous study (Winkler, 2018), in this study as well, joy and excitement were found to be important activating emotions in learning. In addition, the role of a safe environment in professional identity learning was critical (Meijers, 2002). Our findings further indicated that social, mixed emotions (such as compassion, safety and courage) are the most important for active and open membership and participation within a group (see also Vähäsantanen et al., 2020). Overall, the professional identity learning process is not without emotions—in contrast, it is an emotional endeavour in which the phases of a learning process are intertwined with various emotions.

For the development of researching emotions and professional learning, we argue for a need to apply a multimethod approach. The study illustrated here provides support for integrating self-reporting and especially electrodermal activity data in researching emotions in professional learning. High EDA levels are related to both pleasant and unpleasant self-reported emotions in the context of professional identity learning. As such, arousal does not indicate a specific emotion but needs to be connected to a subjective description and report on the emotion in a specific learning context and situation. Thus, using self-reported and psychophysiological data within the subjects provides complementary information on the valence and arousal of emotions.

Our study confirmed the previous notion that electrodermal activity is a valid measurement of arousal and is applicable to researching emotions (e.g. Karvonen, 2017; Pijeira-Diáz, 2019). The data are fairly easy to collect and implement, and the interpretation of EDA levels alone is quite straightforward. However, EDA is also an indicator of physiological arousal, meaning that the subjects' movements should be minimised when measuring EDA. This was also evident in Carol's case, where physical movement in relation to joy (laughing) and sadness (crying) was present. Such behavioural-level reactions can result in EDA peaks and explain why, for example, sadness was related to high EDA levels in our study. Despite the vast development of mobile measurement technologies, the validity of EDA data (Milstein & Gordon, 2020) is still a challenge in implementing research under natural settings (e.g. in everyday learning situations at work). Furthermore, the skin conductance (SC) level is individual and dependent on many subjective (e.g. age, sex, medication and physical exercise) and contextual factors (e.g. temperature and humidity). In our study, even though conducted in a controlled laboratory setting, there were individual differences in the EDA levels between the participants. As we adopted a within-subject design in the study, this was not a problem. However, when implementing a between-subject study utilising EDA, these are important aspects to be considered (Karvonen, 2017). One of the challenges in investigating emotions and professional learning in the future is how to move on to research designs focusing on a between-subject study.

The study described in this chapter had a methodological aim of integrating self-reported data and psychophysiological measurement data in researching the role of emotions in professional learning situations. The implementation of the study and the findings supported the notion of utilising complementary data in researching emotions in professional learning processes. Based on the study results, we argue that self-reported data on the quality of emotions and psychophysiological data on emotional arousal provide data for a more comprehensive understanding of the role of emotions in professional learning processes. Furthermore, the emotion circle (EC) application developed and used in this study offered a promising online tool for concurrent self-reporting of emotions during the learning situation. The stimulated recall interview (SRI) method was crucial in determining the most meaningful learning moments and the specific quality of reported emotions during these moments. Self-reported data on the valence of emotions and psychophysiological data on emotional arousal can provide complementary data for understanding the role of emotions during professional learning processes. The practices, descriptions and reflections of learning situations and processes need to be carefully collected and documented. Without a clear relation to when and what is happening in terms of learning, the complementarity of the data remains scarce. In our study, it was the SRI interview that enabled this contextual and subjective interpretation.

However, the integration of multicomponential data is not without challenges. One basic challenge is the synchronisation of data. The research design with several data collection devices needs to be carefully set in terms of time frames. In our laboratory study, this was enabled and cross-checked through video recordings and sound marks at certain points. Thus, the self-reported and EDA data could be synchronised for the purposes of the analysis. Another aspect that needs special attention is the direction of the analysis. There are several choices to be made and questions to be answered concerning the analysis: Where should one start and with what data? Should the datasets be first analysed separately and then combined? Which of the datasets is the one directing the interpretation of the combined data? When using complementary multicomponential data, the relation between research questions and the data used becomes critical. Hence, the ultimate question is how the different data types complement each other in answering the research question set. In addition, as using and analysing multiple

data types is time-consuming, there is a need to identify valid and economic ways for research and practical purposes. Consequently, more research on how to determine an optimal combination and integration of various data collecting and learning analytics methods is required.

Future steps

The study described in this chapter was conducted in a laboratory setting in the early phases of the research project. Through this study, we have been able to further develop the EC application and narrow down our focus on methodological combinations in a way that meets the multicomponential understanding. In developing the EC application, we have asked about the most meaningful and relevant emotions for and in learning to be included in such a self-reporting tool. Together with the usability approach, having less cognitive stress when using the application has been an important aspect in developing the EC further (Eteläpelto et al., 2018). Consequently, an online application with an iconic design including the six most important emotions in terms of learning was launched in 2019. The current version of the EC application is more user-friendly and easier to use in different learning contexts. Our next aim is to focus further on the usability and content-specific development of the EC in specific work domains in everyday learning situations. This raises the question of how to include descriptive self-reported data on the application. For research purposes in particular, there is also a need to develop an application that can be more easily synchronised with other types of research data. Thus, the development of an online self-reporting application of emotions at work offers one layer of data for the integration of various data collection and analytics methods in researching emotions during professional learning processes.

New insights and elaborations for researching emotions and professional learning in real working-life situations are still missing. Novel technologies and applications will open up new research opportunities to be utilised in studying emotions in working-life learning settings. Various intelligent sociotechnical systems have rapidly emerged in emotion recognition, for example, in medical-patient monitoring, and emotion-aware intelligent systems (Kyamakya et al., 2021). The development of wearable sensors, typically used for sports and health activity tracking, has in their part paved the way for the emergence of an unobtrusive measurement of physiological responses within the research field (Pijeira-Diáz, 2019). With more sophisticated and advanced technical sensors and online tools, there are numerous opportunities to collect multimodal and componential data in everyday learning situations in working life. For studying emotions, EDA has been proved to be a valid measurement of ANS; thus, it offers a promising option in conducting multimodal research on emotions and learning in professional contexts. Furthermore, such data can also be used for development purposes (with feedback to the participants) at work. When working towards this goal, we require more research-based knowledge on the possibilities and best practices of integrating different data types in investigating emotions in workplace learning. Currently, we are facing a huge variety of opportunities that are waiting for exploration and implementation in real-life settings. This, we believe, will be one path towards a more coherent understanding of professional learning processes and the research methodology applied in learning sciences.

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References

Al-Machot, F., Elmachot, A., Ali, M., Al-Machot E., & Kyamakya, K. (2019). A Deep-Learning Model for subject-independent human emotion recognition using electrodermal activity sensors. *Sensors*, *19*(7), 1659. https://doi.org/10.3390/s19071659

Azevedo, R., Taub, M., Mudrick, N., Farnsworth, J., & Martin, S. A. (2016). Interdisciplinary research methods used to investigate emotions with advanced learning technologies. In M. Zembylas & P. Schutz (Eds.), *Methodological Advances in Research on Emotion and Education* (pp. 231-243). Dordrecht: Springer.

Barrett, L. F., & Russell, J. A. (1999). The structure of current affect. Controversies and emerging consensus. *Current Directions in Psychological Science*, *8*, 10–14. https://doi.org/10.1111/1467-8721.00003

Barsade, D., & Gibson, S. G. (2007). Why does affect matter in organizations? *Academy of Management Perspectives*, 36–59. https://doi.org/10.5465/amp.2007.24286163

Benedeck, M., & Kaernback, C. (2010). A continuous measure of phasic electrodermal activity. *Journal of Neuroscience Methods*, *190*, 80-91. https://doi.org/10.1016/j.jneumeth.2010.04.028

Benozzo, A., & Colley, H. (2012). Emotion and learning in the workplace: Critical perspectives. *Journal of Workplace Learning*, 24(5), 304–316. DOI:10.1108/13665621211239903

Billett, S., Harteis, C., & Gruber, H. (Eds.). (2014). *International handbook of research in professional and practice-based learning*. Springer international handbooks of education. Vol. 1. Dordrecht: Springer.

Boucsein, W. (2012). *Electrodermal activity* (2nd ed.). New York, NY: Springer.

Damasio, A. R. (1999). The feeling of happiness: Body and emotion in the making of consciousness. Orlando: Harcourt.

Dindar, M., Malmberg, J., Järvelä, S., Haataja, E., & Kirschner, P. A. (2020). Matching self-reports with electrodermal activity data: Investigating temporal changes in self-regulated learning. *Education and Information Technologies*, *25*, 1785–1802. https://doi.org/10.1007/s10639-019-10059-5

Ekman, P. (2016). What scientists who study emotion agree about. *Perspectives on Psychological Science*, *11*(1), 31–34. https://doi.org/10.1177/1745691615596992

Eteläpelto, A., Vähäsantanen, K., Hökkä, P., & Paloniemi, S. (2014). *Identity and agency in professional learning*. In S. Billett, C. Harteis and H. Gruber (Eds.), International Handbook of Research in Professional and Practice-based Learning. Vol.2. Dordrecht: Springer, 645–672.

Eteläpelto, A., Kykyri, V-L., Penttonen, M., Hökkä, P., Paloniemi, S., Vähäsantanen, K., Eteläpelto, T., & Lappalainen, V. (2018). A multi-componential methodology for exploring emotions in learning. *Frontline Learning Research*, 6(3), 6–36. https://doi.org/10.14786/flr.v6i3.379

Fredrickson, B. L., & Branigan, C. (2002). Positive emotions broaden the scope of attention and thought-action repertoires. *Cognition and Emotion*, *16*, 313-332. https://doi.org/10.1080/02699930441000238

Gendolla, G. H. E. (2017). Do emotions influence action? Of course, they are hypo-phenomena of motivation. *Emotion Review*, *9*(4), 348-350. https://doiorg/10.1177/1754073916673211

Goller, M., & Paloniemi, S. (Eds.). (2017). *Agency at work: An agentic perspective on professional learning and development*. Cham: Springer.

Goodwin, C. J. (2008). Research in psychology: Methods and design (5th ed.). John Wiley & Sons.

Gooty, J., Connelly, S., Griffith, J., & Gupta, A. (2010). Leadership, affect and emotions: A state of the science review. *The Leadership Quarterly*, 21,979–1004. DOI:10.101016/j.leaqua.2010.10.005

Harmon-Jones, C., Bastian, B., & Harmon-Jones, E. (2016). The discrete emotions questionnaire: A new tool for measuring state self-reported emotions. *PLoS One, 11*(8), 1–25. https://doi.org/10.1371/journal.pone.0159915

Harteis, C. (Ed.). (2018). *The impact of digitalization in the workplace*. Springer.

Homan, A.C., Van Kleef, G.A., & Sanchez-Burks, J. (2015). Team members' emotional displays as indicators of team functioning. *Cognition and Emotion, 30*(1), 134-149. https://doi.org/10.1080/02699931.2015.1039494

Hommel, B., Moors, A., Sander, D., & Deonna, J. (2017). Emotion meets action: Towards an integration of research and theory. *Emotion Review, 9*(4), 295-298. https://doi.org/10.1177/1754073916689379

Hökkä, P., Vähäsantanen, K., & Paloniemi, S. (2020). Emotions in learning at work: a literature review. *Vocations and Learning*, 13(1), 1–25. https://doi.org/10.1007/s12186-019-09226-z

Hökkä, P., Vähäsantanen, K., Paloniemi, S., Herranen, S., & Eteläpelto, A. (2019). Emotions in leaders' practice of professional agency. *Journal of Workplace Learning*, 31 (2), 143–165. doi:10.1108/JWL-07-2018-0086

Järvelä, S., Malmberg, J., Haataja, E., Sobocinski, M., & Kirschner, P. A. (2019). What multimodal data can tell us about the students' regulation of their learning process? *Learning and Instruction*. https://doi.org/10.1016/j.learninstruc.2019.04.004

Järvenoja, H., Järvelä, S., Törmänen, T., Näykki, P., Malmberg, J., Kurki, K., Mykkänen, A., & Isohätälä, J. (2018). Capturing motivation and emotion regulation during a learning process. *Frontline Learning Research, 6*(3), 85–104.

Järvenoja, H., Malmberg, J. Törmänen, T., Mänty, K., Haataja, E., Ahola, S., & Järvelä, S. (2020). A Collaborative Learning Design for Promoting and Analyzing Adaptive Motivation and Emotion Regulation in the Science Classroom. *Frontiers in Education, 5*: 111. doi:10.3389/feduc.2020.00111

Kagan, N., Krathwohl, D. R., & Miller, R. (1963). Stimulated recall in therapy using video tape: A case study. *Journal of Counseling Psychology, 10*, 237–243. https://doi.org/10.1037/h0045497

Karvonen, A. (2017). *Sympathetic nervous system synchrony between participants of couple therapy*. Jyväskylä Studies in Education, Psychology and Social Research 599. University of Jyväskylä. https://jyx.jyu.fi/bitstream/handle/123456789/55925/Karvonen_Anu_screen.pdf?sequence=1&isAllowed=y

Kreibig, S. D. (2010). Autonomic nervous system activity in emotion: A review. *Biological Psychology*, *84*(3), 394–421. https://doi.org/10.1016/j.biopsycho.2010.03.010Get

Kyamakya, K., Al-Machot, F., Haj Mosa, A., Bouchachia, H., Chedjou, J.C., & Bagula, A. (2021). Emotion and Stress Recognition Related Sensors and Machine Learning Technologies. *Sensors, 21*, 2273. https://doi.org/10.3390/s21072273

Kärner, T., & Sembill, D. (2022). Multimodal stress assessment in working and learning contexts: Using physiological, observational and experience-based data. In M. Goller, E. Kyndt, S. Paloniemi, & C. Damşa (Eds.), Methods for researching professional learning and development: Challenges, applications, and empirical illustrations. Springer.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge university press.

Lehtonen, E., Puhakka, I., Pylväs, L., & Nokelainen, P. (2020). Asiantuntijuuden kehittyminen, tunteet ja työpaikka oppimisympäristönä. [Emotions and development of expertise in the workplace]. The Finnish Work Environment Fund Report no 118083. Tampere. https://oma.tsr.fi/api/projects/20a33852-4761-4a08-9831-dece09ce66e8/attachment/baae2065-0f81-4a58-91d8-f19b9a1f332e [In Finnish]

Levenson, R. W. (2014). Autonomic nervous system and emotion. *Emotion Review, 6*(2), 100-112. https://doi.org/10.1177/1754073913512003

Manolov, R., & Onghena, P. (2017). Analyzing data from single-case alternating treatment designs. *Psychological Methods, 16* (March), 1–25. https://doi.org/10.1037/met0000133

Mauss, I. B., Levenson, R. W., McCarter, L., Wilhelm, F. H., & Gross, J. J. (2005). The tie that binds? Coherence among emotion experience, behaviour and physiology. *Emotion, 5*, 175-190. https://doi.org/10.1037/1528-3542.5.2.175

Mauss, I. B., & Robinson, M. D. (2009). Measures of emotion: A review. *Cognition and Emotion, 23*, 209-237. https://doi.org/10.1080/02699930802204677

Meijers, F. (2002). Career learning in a changing world: The role of emotions. *International Journal for the Advancement of Counselling, 24*(3), 149–167. https://doi.org/10.1023/A:1022970404517

Milstein, N., & Gordon, I. (2020). Validating measures of electrodermal activity and heart rate variability derived from the Empatica E4 utilized in research settings that involve interactive dyadic states. *Frontiers in Behavioral Neuroscience, 14*:148. https://doi.org/10.3389/fnbeh.2020.00148

Mäkikangas, A., Bakker, A.B., & Schaufeli, W.B. (2017). Antecedents of daily team job crafting. *European Journal of Work and Organizational Psychology*, 26(3), 421-433. DOI: 10.1080/1359432X.2017.1289920

Noroozi, O., Pijeira-Díaz, H. J. Sobocinski, M., Dindar, M., Järvelä, S., & Kirschner, P. A. (2020). Multimodal data indicators for capturing cognitive, motivational, and emotional learning processes: A systematic literature review. *Education and Information Technologies, 25*, 5499–5547. https://doi.org/10.1007/s10639-020-10229-w

Parong, J., & Mayer, R. E. (2021). Cognitive and affective processes for learning science in immersive virtual reality. *Journal of Computer Assisted Learning, 37*, 226–241.

Pekrun, R. (2016). Using self-report to assess emotions in education. In M. Zembylas, M. & P. A. Schultz (Eds.), *Methodological advances in research on emotion and education.* Springer International Publishing.

Pekrun, R., Elliot, A. J., & Maier, M. A. (2006). Achievement goals and discrete achievement emotions: A theoretical model and prospective test. *Journal of Educational Psychology*, *98*(3), 583-597. https://doi.org/10.1037/0022-0663.98.3.583

Perry, D.P. (2006). Fear and learning. Trauma-related factors in the adult education process. *New Directions for Adult and Continuing Education, 110*, 21-27. https://doi.org/10.1002/ace.215

Pietarinen, T. (2021). *Affect in collaborative and virtual inquiry learning*. Insights into small student groups and teachers in the classroom. Annales universitatis Turkuensis. University of Turku. https://www.utupub.fi/bitstream/handle/10024/152012/Annales%20B%20540%20Pietarinen%20DISS.pdf?sequence=1&isAllowed=y

Pijeira-Díaz, H. J. (2019). *Electrodermal activity and sympathetic arousal during collaborative learning*. Acta Universitatis Ouluensis E184. University of Oulu. http://jultika.oulu.fi/files/isbn9789526222196.pdf

Rausch, A., Goller, M., & Steffen, B. (2022). Uncovering informal workplace learning by using diaries. In M. Goller, E. Kyndt, S. Paloniemi, & C. Damşa (Eds.), *Methods for researching*

professional learning and development: Challenges, applications, and empirical illustrations. Springer.

Rausch, A., Schley, T., & Warwas, J. (2015). Problem solving in everyday office work - a diary study on differences between experts and novices. *International Journal of Lifelong Education*, 34(4), 448–467. https://doi.org/10.1080/02601370.2015.1060023

Rausch, A., Seifried, J., & Harteis, C. (2017). Emotions, coping and learning in error situations in the workplace. *Journal of Workplace Learning, 29*(5), 374–393. http://dx.doi.org/10.1108/JWL-01-2017-0004

Russell, J. A. (2003). Core affect and the psychological construction of emotion. *Psychological Review, 110*(1), 145–172. https://doi.org/10.1037/0033-295X.110.1.145

Russell, J. A. (2005). Emotion in human consciousness is built on core affect. *Journal of Consciousness Studies, 12*(8-10), 26-42.

Silvennoinen, M., Parviainen, T., Malinen, A., Karjalainen, S., Manu, M., & Vesisenaho, M. (2022). Combining physiological and experiential measures to study adult learning. In M. Goller, E. Kyndt, S. Paloniemi, & C. Damşa (Eds.), *Methods for researching professional learning and development: Challenges, applications, and empirical illustrations*. Springer.

Seifried, J., & Rausch, A. (2022). Applying the experience sampling method to research on workplace learning. In M. Goller, E. Kyndt, S. Paloniemi, & C. Damşa (Eds.), *Methods for researching professional learning and development: Challenges, applications, and empirical illustrations*. Springer.

Storbeck, J., & Maswood, R. (2015). Happiness increases verbal and spatial working memory capacity where sadness does not: Emotion, working memory and executive control. *Cognition and Emotion, 30*, 925–938. https://doi.org/10.1080/02699931.2015.1034091

Sung, B., & Yih, J. (2015). Does interest broaden or narrow attentional scope? *Cognition and Emotion, 30*(8), 1485-1494. DOI: 10.1080/02699931.2015.1071241

Tynjälä, P. (2013). Toward a 3-P model of workplace learning: A literature review. *Vocations and Learning, 6*(1), 11–36. https://doi.org/10.1007/s12186-012-9091-z

Villanueva, I., Campbell, B. D., Raikes, A. D., Jones, S. H., & Putney, L. G. (2018). A Multimodal exploration of engineering students emotions and electrodermal activity in design activities. *Journal of Engineering Education, 107*(3), 414–441. DOI:10.1002/jee.20225

Vähäsantanen, K., Paloniemi, S., Hökkä, P., & Eteläpelto, A. (2017a). Agentic perspective on fostering work-related learning. *Studies in Continuing Education*, 39(3), 251–267. http://www.tandfonline.com/doi/full/10.1080/0158037X.2017.1310097

Vähäsantanen, K., Hökkä, P., Paloniemi, S., Herranen, S., & Eteläpelto, A. (2017b). Professional learning and agency in an identity coaching programme. *Professional Development in Education,* 43(4), 514-536. https://doi.org/10.1080/19415257.2016.1231131

Vähäsantanen, K., Hökkä, P., & Paloniemi, S. (2020). University Teachers' Professional Identity Work and Emotions in the Context of an Arts-Based Identity Coaching Program. In L. McKay, G. Barton, S. Garvis & V. Sappa (Eds.) *Arts-Based Research, Resilience and Well-being Across the Lifespan*. Cham: Palgrave, 233–256.

Watzek, V., Anselmann, V., & Mulder, R. H. (2019). Team learning and emotions during teamwork: a qualitative study. Research papers in education, 34 (6), 767–789. https://doi.org/10.1080/02671522.2019.1568525

Winkler, I. (2018). Identity work and emotions: A review. *International Journal of Management Reviews, 20*(1), 120–133. http://dx.doi.org/10.1111/ijmr.12119

Zelenski, J. M., & Larsen, R. J. (2000). The distribution of basic emotions in everyday life: A state and trait perspective from Experience Sampling data. *Journal of Research in Personality, 34*(2), 178–197. https://doi.org/10.1006/jrpe.1999.2275

Zwart, R.C., Korthagen, F.A.J, & Attema-Noordewiever, S. (2015). A strength-based approach to teacher development. *Professional Development in Education, 41*(3), 579–566. https://doi.org/10.1080/19415257.2014.919341