Abstract—This Research Full Paper presents a case study where university students (N=13) use a paper diary called EmoForm to self-track their emotions over a ten-week-long design-based learning course. Design-Based Learning (DBL) is a learning approach that enables students to learn through a sequence of design activities in a project-based learning or problem-based learning environment. Student's emotions are known to play an essential role in learning settings. We argue that students engaging in DBL will benefit from self-tracking of emotions. Such self-tracking will enable students to identify and control their emotions during the DBL process. The results of this study confirm that self-tracking with EmoForm enabled students' emotion awareness in DBL. In particular, our results illustrate how self-tracking with EmoForm impacted on students' DBL from three major aspects. We discuss design challenges regarding tools to support emotion awareness in DBL, and we present a summary of strategies conducive towards emotion awareness in DBL and the implications for future research.

Keywords—Design based learning, emotion awareness, self-tracking, tool

I. INTRODUCTION

Design-Based Learning (DBL) is a pedagogical approach that enables students to learn through a sequence of design activities. In general, DBL inherits the tenets of Design Thinking [1] and situates in a problem-based or project-based learning context, which involves open exploration, learning from trial and error, reflection, teamwork, and supportive tools [2]. Other terms are analogous to DBL, such as Learning by Design [3], Design-based Science [4], and Maker Education [5]. Research has shown that this type of DBL approach is promising in preparing students with the twenty-one century skills such as problem-solving and collaboration [3].

DBL has been applied in diverse subject-oriented contexts; the core of DBL stands consistent across subjects that students actively engage in their learning driven by the process of design and inquiry. Given that design is a core element in engineering, DBL has been particularly regarded as a promising educational concept for engineering education [6]. The motivation for applying design activities in engineering and science education is to engage students in learning better, considering that traditional courses often fail to engage students' interest and make meaningful connections to their everyday lives [3]. Besides, previous research has noted a positive effect of DBL on students' interest and awareness of engineering [7], as well as on their intention to pursue an engineering career [8].

Emotions, in general, can reveal students' underlying cognitive processes, commitments, and concerns in learning [9]. In the context of DBL, previous research has already argued that students' emotions play a big part in their participation in DBL activities [2], [10]. In the current paper, we argue that it is essential for students to be self-aware of their emotions experienced during DBL, for two reasons. First, DBL is an emotional place where situations such as collaboration, negotiation with peers, or conflicts in teamwork may frequently evoke students' emotions [2], [10]. Consequently, students need to develop the ability to identify their emotions timely during the process. Second, students following such an active learning approach have to take responsibility for their projects [11] and develop skills to control their own emotions. However, little is known yet on how to facilitate emotion awareness during DBL. Resolving this deficit became the motivation of the inquiry in the present study. The contribution in this paper is to show how emotion awareness can be supported in DBL and to demonstrate how it influences a DBL activity.

In the following sections, we present our theoretical framework and review related works on emotion awareness. The subsequent section describes the methodology used in the present study in terms of exploring and evaluating EmoForm [12] as an emotion awareness tool in DBL. Finally, we report the findings and discuss the implications for future research.

II. RELATED WORKS

A. A theoretical view of emotion awareness

Emotion awareness refers to the ability to perceive, identify, and understand emotions [13]. Emotion awareness occurs in an attentional process in which emotions become the center of the attention of a person [14]. During this process, the awareness of emotions is interconnected with interpretative and evaluative functions [14]. Previous research has explained some functions of emotion awareness in this attentional process [15]. For instance, these functions contain (a) differentiating between various emotions; (b) locating the antecedents of emotions; (c) monitoring emotions; (d) appraising the value of emotions; and (e) acknowledging the physiological correlates of the emotion experience.

Emotion awareness is a necessary step for self-regulation of learning [16], which can play an essential role in students' learning process. Specifically, the information provided by emotion awareness influences the usage of adaptive emotion regulation strategies [13], [17], [18]. Some have argued that improving students’ emotion awareness helps their self-regulation, which can, in turn, have a positive implication on their learning performances and outcomes [16].

The Control-Value theory [19] proposes the concept of achievement emotions that points to the emotions that directly related to achievement situations and their outcomes. According to the Control-Value theory [19], three types of students’ awareness are identified as helpful for emotion regulation:

- **A1: Emotion-oriented awareness**
Emotion-oriented awareness pertains to information for differentiating students’ emotions. This theory defines the achievement emotion along three dimensions, including valence (i.e., positive or negative), arousal (i.e., activating or deactivating), and object (i.e., activity-related or outcome-related). According to this theory, students’ emotion-oriented regulation can be enhanced by being aware of various emotions, e.g., whether they are positive or negative (valence and arousal dimension) and whether they relate to the activity or its outcomes (objective dimension).

- **A2**: Appraisal-oriented awareness

Appraisal-oriented awareness pertains to information for appraising and locating the antecedents of emotions that students are aware of. An appraisal is crucial in educational processes, as it can mediate the impact of situational factors and can foster positive emotional development [19]. The Control-Value theory highlights two types of antecedents relating to students’ achievement emotions. For example, the individual personality antecedent which refers to the control and value beliefs underlying students’ situational appraisal; and the environment antecedents, which may influence students’ own control and value beliefs in a broader social-historical context. The environment includes the classroom elements, e.g., feedback and consequences of achievement, quality of instruction, anatomy support, as well as goal structures and expectation [20]. In this sense, students’ appraisal-oriented regulation can be enhanced by, e.g., being aware of their learning environment that affects emotions and their sense of control over learning tasks as well as task value.

- **A3**: Problem-oriented awareness

Problem-oriented awareness relates to being aware of the information about the effect of students’ emotions on their academic learning and achievement, which can be reflected as students’ cognitive resources, motivation to learn, learning strategies, or learning performance. Correspondingly, according to the control-value theory, students’ problem-oriented regulation can be enhanced by, e.g., being aware of their learning environment that affects emotions and their sense of control over learning and achievement.

**B. Tools for emotion awareness**

Emotion awareness tools can capture information about student’s emotions and associated environmental and situational cues. Emotion awareness tools in learning situations differ in terms of what emotion-related information is recognized and correspondingly what technique is used. Overall, they have used several techniques that include:

1) **Emotional behavior recognition.** This type of technique identifies the patterns of emotional behavior by observing motor-behavioral activity [21]. These observable behaviors can be varied, e.g., from facial expressions, voice intonation, to sentiment analysis. Related tools include, e.g., Emodash [22] and affective AutoTutor [23]. Emodash is an interactive dashboard designed for supporting teachers’ retrospective awareness of student’s emotions in an online language learning setting. The mechanism of Emodash is based on Microsoft Emotion Recognition API to interpret and analyze students’ facial expressions in video recordings, which enables teachers to explore their past teaching sessions from the lens of students’ emotions. While affective AutoTutor is a dialog-based intelligent tutoring system that not only detects but also responses to students’ emotional states.

2) **Subjective self-report.** This type of technique bases on students’ self-reporting their subjective feeling on either a mobile application, web platform application or paper-based questionnaire. Related tools include both app-based self-reporting and paper-based self-reporting tools.

For instance, the Live Interest Meter App [24] is a mobile application tool designed to quantify students’ emotions and to provide teacher insights on fostering learning. The meter component of this tool enables students to vote the level of their interest in a topic. Similar to Live Interest Meter, ClassMood App [25] is a web-based application tool that provides teachers with data of students’ emotions and helps them guide students to emotions that are more conducive to learning. Both of these tools can provide nearly real-time insight and feedback on students’ feelings and thoughts in the classroom. Differently, the Emotion Awareness Scale [15], [26], and Levels of Emotional Awareness Scale [27] both are retrospective paper-based questionnaires that contain questioning items describing how students feel and think about their feelings.

Although these tools above are well suited to evaluate students’ emotion awareness and regulation strategies in traditional learning situations, they are not designed for the context of DBL. Ensuring emotion awareness in the DBL classroom is challenging. As an illustration, given the opportunistic nature of the design process [28], DBL engages students in an opportunistic sequence of tasks rather than a standardized sequential learning process. Consequently, emotion awareness in DBL demands extra effort to locate the antecedents of their emotions from the intricate design and inquiry process.

**III. METHODOLOGY**

It is a widely held contention that self-tracking and its ensuing data-based insights foster positive behavioral change [29]. Inspired by experience sampling approaches [30], prior research has developed EmoForm [12], a paper-based self-reporting tool, to capture students’ emotions and learning experiences in DBL. However, our understanding of whether and how a self-tracking tool facilitates emotion awareness in DBL is still lacking. This paper reports on a case study of evaluating students’ experience of self-tracking with EmoForm in a DBL program in an applied science university. Specifically, this study intends to address the following three research questions.

- **RQ1**: How did students experience using EmoForm for self-tracking emotions in DBL?
- **RQ2**: Whether and how does the EmoForm facilitate students’ emotional awareness during DBL?
- **RQ3**: What are strategies perceived by students for facilitating emotion awareness in DBL?

**A. EmoForm in DBL**

The original version of EmoForm [12] was developed for application in secondary education, so it was adapted for the university context. The adjustments the current version has made include four aspects. First, the modified version of
EmoForm uses a 7-point Likert scale instead of a 5-point Likert scale to enable university students to have a finer grain expression on the intensity of their emotions. Second, the original version of EmoForm presents ten DBL activities in the first section (including empathize design user, define design problem, ideate design solution, make prototype, test prototype, presentation, design documentation, planning, get support from teacher, and get feedback from others). Based on the implications on the further development of EmoForm suggested in [12], the modified version adds five more activities to the first section of EmoForm, including design documentation, planning, ask or offer help, review other’s task, and chat with peers. Besides, the current version adds one open-ended option in the first section of EmoForm to encourage students to fill in any project-related activities other than the thirteen stated in the form. Third, the current version categorized DBL activities in the first section of EmoForm into three groups, namely, (a) design thinking process, (b) management, and (c) social interaction. This adjustment is to ease students’ cognitive load for recalling and retrieving their involved activities. Four, the current version asks students to rate their achievement emotions (in sections 2 & 4), learning performance and concentration (in section 3), and involved activities (in section 1) every 20 minutes.

The underlying design principles (P1-3) of EmoForm adhere to the information intendedly provided for emotion regulation (A1-3) in the control-value theory. In this study, we hypothesize these three design principles of EmoForm that are formulated as follows (P1-3) can support students’ emotion awareness in DBL. We aim to explore these design principles in the case of EmoForm to inform future development of tools for supporting emotion awareness in DBL.

- **P1**: Support emotion-oriented awareness by differentiating and quantifying emotions

As seen in Figure 1, EmoForm asks students to differentiate their achievement emotions. For example, students need to differentiate and rate (a) their positive feelings (e.g., enjoyment, relaxation, contentment, and pride) from negative feelings (e.g., boredom, frustration, anxiety, and hopelessness). (b) their activity-focused achievement emotions (in section 2) and outcome-focused achievement emotions (in section 4); and (c) the level of their emotions from not at all (scored as “1”) to very much (scored as “7”). By responding to these three aspects of information that EmoForm asks (P1), student’s awareness of different emotions would be triggered (A1).

- **P2**: Provide DBL situational cues for awareness by documenting involved activities and collaboration

In the first section of EmoForm, students are asked to identify the DBL activities, which happens in the same time frame as their scores of associated achievement emotions. In addition to the involved activities, students need to indicate whether they work individually or collaboratively. This DBL-specific situational information can provide students cues of their associated emotions. Thus, students’

**Fig. 1.** The current version of EmoForm for adult students in the present study. (adapted from the original version of EmoForm)
awareness of situational cues, namely, functioning as one of the antecedents of students’ emotions (A2) would be activated by recalling and filling in their involved activities (P2).

- **P3:** Enable learning performance awareness by self-rating perceived concentration and learning

In the third section of EmoForm, students are required to rate the level of their perceived learning performance, which includes self-perception of learning and self-perception of concentration, respectively. These perceptions of learning are measured in the same time frame as their experienced achievement emotion. By rating the level of their perceived learning performance (P3), students would be aware of some of the potential effects of their emotions (A3).

**B. Intervention and implementation**

This intervention situates in a ten-week-long DBL course that is a part of an entire DBL educational program lasting 20 weeks. During this ten-week-long DBL course, students work on a design challenge entitled “Future Solution” that addressing a real-life problem through an iterative design process. Students’ design projects can be either a group project or an individual project, which is open to students’ free choice. Students who enrolled in this course are majoring in diverse subjects. Consent forms were signed before data collection. To be mentioned, the current study was implemented in a research project with dual goals. In addition to addressing ways of supporting students’ emotion awareness in DBL presented in this paper, another goal of that research project was understanding what elements are crucial to be considered in DBL (relevant findings can be found in [31]).

![Fig. 2. Example of the DBL environment in the present study.](image)

We organized a session to introduce EmoForm to students prior to the intervention. In this study, the intervention involved students using EmoForm for five times during the DBL course. Students were free to choose when and on which days of this DBL course to fill EmoForm in. A total of thirteen 3rd year undergraduate students completed the intervention of using EmoForm and participated in a one-on-one semi-structured interview after this intervention. These involved students are from a diverse background who are majoring in, e.g., ICT and software engineering (N=4; including S1, S5, S7, S13), computer science (N=1; i.e., S6), civil engineering (N=1; i.e., S12), mechanical engineering (N=2; including S3, S8), mechatronics (N=3; including S4, S9, S11), international business (N=1; i.e., S10) and industrial product design (N=1; i.e., S2).

**C. Data collection and analysis**

This study uses qualitative data gathered from semi-structured in-depth interviews with students. Students were first asked to review their EmoForms for the past days and think-aloud. This exercise was intended to help students recall their use of EmoForm for the subsequent parts of the interview vividly. Questions asked in the follow-up interview include (a) students’ experience of using EmoForm, e.g., “How does it feel to use it?”; “How would you use the information from it?”; “What conclusion do you get from it”; (b) the effect of using EmoForm on students, e.g., “Did it help you in dealing with emotions?”; “How did it influence you in dealing with emotions?”, and (c) strategies for dealing with emotions, e.g., “How to deal with the emotions in a similar project in the future?”

All interviews were audio-recorded and transcribed verbatim. Data analysis of interviews followed the thematic analysis approach [32]. Specifically, data were coded from a research-driven perspective (e.g., themes of information display, themes of behavioral adaption).

**IV. RESULTS**

**A. Experience of using EmoForm**

As a part of the design principle P1, the EmoForm uses a 7-point Likert scale to engage students in self-rating the intensity level of their emotions and learning. Regarding this closed format of rating, many students felt it is comfortable to use this scale. In contrast, just several students (e.g., S1-2, 4, 9) expressed that it is a challenge to rate their emotions in a quantifiable manner. This finding is in line with our previous knowledge that rating might involve additional workload and potential distraction from the learning task [33]. However, some students (e.g., S8, 11) who found it hard to evaluate the level of their feelings at first got used to it soon. They mentioned that rating became easier by using the scores for the first 20 minutes or the first day as a baseline. Some participants (e.g., S2, 7) showed a clear preference on a 7-point Likert scale over either 5-point or 9-point Likert scale.

Furthermore, some useful emotion-oriented awareness information (as a part of P1) for students was highlighted from the interviews include emotions such as enjoyment, boredom, frustration, pride, and contentment. It is important to note there might be a vast individual difference in temperament and in experiencing personal feelings. Research has pointed out that different students can experience varied emotions, even in the same situation, as emotions involve subjective experiences that vary between individuals [34]. For example, this study found that one student (S6) said she seldom feels relaxed while another (S5) said she seems like an anxious person in general. Moreover, a few students (e.g., S6, 10) mentioned anxiety is not their primary emotion as it does not frequently take place in their cases during DBL. This finding is in line with earlier findings that anxiousness and hopelessness remain considerably low in DBL [12].
Situational appraisal-oriented awareness information is in an open and multi-choice format displayed in the first section of EmoForm, in which students are asked to state the activity they are involved in and to indicate whether it is teamwork or individual work (P2). Some students (e.g., S2, 10) favored this display format and thought it is clear to fill in and useful for them to track what they have done or even plan what they need to do next. Interestingly, student S2 stated that reviewing the combined information of activity and emotion is especially useful, while S8 liked examining the combination of learning information together with emotion information. This divergent finding is logical: some students pay more attention to the potential causal relationship between their emotions and activities while some others pay more attention to the effect of their emotions on learning. Besides, some students (e.g., S2, 11, 13) mentioned a scenario in which they can use this awareness information further to share what they feel and what they do with their coach or peers in a team. However, results also showed that the current visualization of three sets of information on EmoForm did not work well for all students. One student (S7) commented that it is hard for them to draw an overall conclusion without analyzing their reported information. Instead, generating explicit and dedicated feedback for them is preferred. This would suggest that future work is needed to explore ways of data visualization supporting explicit cross-referencing.

Students exhibited variable timing and frequencies of self-tracking with EmoForm. Most students (e.g., S3, 5-6, 10, 13) felt comfortable about recording their emotional experience on EmoForm every 20 minutes. Some of them (e.g., S6, 10) appreciated the moment of their self-recording every 20 minutes as which triggers them to reflect on their ongoing experience. For example, S10 mentioned that “I thought about what I was going to do, and I put a point [on EmoForm] before everything so that I could see, ‘This is my plan. This is what I want to do today.’ Sometimes after a while, I just saw, ‘I didn’t get any support from a teacher. Oh, I have to do that still,’ so then I could do it, it was kind of a reminder.” However, other students (e.g., S4, 7, 8) thought it is too intrusive to record every 20 minutes choosing to record what they have done after completing a two-hour activity or after a whole day of learning. However, a few of them (e.g., S4, 8) found it difficult to recall their memories even after just two hours had elapsed. Interestingly, one student (S10) mentioned that she fills in EmoForm without following a fixed schedule, and she usually fills in when her learning was distracted by something, or she was on a break. These findings suggest that future works should put a boundary on retrospective self-reporting. This observation shows the tension that arises in obtaining reliable on the moment self-report and avoiding disrupting the immersed flow of learning in DBL.

B. EmoForm on facilitating emotion awareness

Overall, most students (e.g., S2-3, 5-6, 8-10) stated that EmoForm was fun and useful to use. Results illustrate that all students acknowledged the impact of EmoForm on students’ emotion awareness. This finding confirms that self-tracking with EmoForm facilitates emotion awareness, which is consistent with known results relating to behavior tracking [35]. More specifically, results in this study reveal the following three major effects of EmoForm, which underlines the potential for emotion awareness to support DBL.

First, our results show that self-tracking with EmoForm encouraged communication and accountability of students’ internal states. For example, some students (e.g., S2, 4, 6, 11) acknowledged that it is useful for confirming their impression regarding their involvement in different activities (P2) and their emotions (P1). Some of them (e.g., S6, 11) furtherly mentioned that they communicated such information with others, which resulted in an increased awareness of themselves as well as their peers. For example, S11 said that “Well, I did once with someone else. You can then wake up to talk about, ‘Oh, hey, you like that. I didn’t like that or something like it.’” Likewise, S6 envisioned that “It could be nice if it [self-tracking with EmoForm] applies with many of us, [saying that], ‘Okay, we’re going to do this. How do you feel?’” Similarly, S2 commented that the awareness and communication of these emotions between peers could be useful, as it can help students find out who likes and dislikes doing something so that they can locate the right person to offer help or receive help from. Besides, one student (S10) explained that “I think the support [of self-tracking with EmoForm] is really important that I see that I did some things.” In this case, S10 thought self-tracking activities she participated in on EmoForm helped her realize she had done more than what she had in impression, which made her feel much better about herself.

Second, the findings demonstrate that self-tracking with EmoForm increased students’ awareness and understanding of self. Such an effect are varied to a different extent for students. For example, almost all students (e.g., S2-7, 9-13) commented that self-tracking on EmoForm made them aware of their emotions (P1), and realize what they did right (P3) as well as what motivated them to do (i.e., associated activities, P2). This is something that they had not taken into account before. For example, S5 mentioned that “[I think it made me more aware of the concentration level because it’s something I would never look at. I just think I’m concentrated, but if you actually have to discuss with yourself, e.g., was I fully focused, or was I half-focused? It actually gives insight into the quality of your work].” Besides, S3 reported that “It was a good learning experience for me in a way that you become more aware of your emotions. [...] Besides, for me, it was also a realization that I was experiencing more extreme emotions when working together with other people.” Similarly, S6 said that “I think that it’s very useful because I didn’t do this before. [...] I realized that I can program and make some designs. I can relax when I’m doing it.” This finding echoes the perception that being required to self-track concerning emotional or cognitive categories might serve as a meta-cognitive prompt that helps to reflect on a task [33].

Third, this study found self-tracking with EmoForm stimulated behavior change for some students. Specifically, students (e.g., S5, 6, 10) became aware of the emotions they recorded on EmoForm, which resulted in some positive behavioral changes, e.g., taking control of emotions. For example, S5 mentioned that “Normally I feel like I would let myself have some boredom and some frustration like a person asks you the same question three times. But I was like, ‘I’m just here for them. I have to take it away from myself.’ It [self-tracking with EmoForm] did make me control my emotions a little bit more, I think.”

Many students (e.g., S3, 5-6, 9-10, 13) felt it was useful to review what they recorded on EmoForm and believed that
it helps in finding when they feel some emotions, and opens the possibility to deal with these emotions in the future. For example, S9 mentioned that “It helps in finding when you feel some emotions, and then you can deal with them. [...] It gets you on the right track to eventually deal with your emotions.” Some other students envisioned the effect of using EmoForm in this study on their future activities, just as S6 reported that “I just focus on the programming part. Now, I know that this gets me so frustrated, [...] Maybe I can work with other projects and [asking myself], ‘Okay, how I feel? Did I feel frustrated? Do I really enjoy what I’ll be doing?’ Because maybe I can improve my work, depending on how I feel.” Similarly, S8 mentioned that “Maybe if I would reflect on what I did using this [EmoForm] and using the emotions, then I might be able to do something about it. For instance, if I see that I’m frustrated and my work is bad so that I know that if I’m frustrated, I need to take a break or something to get less frustrated. I think in that way, I could be able to use it for dealing with emotions.”

To conclude, these findings above confirm that applying the design principles (P1-3) displayed on EmoForm, to a different extent, facilitated students’ emotion awareness in DBL.

C. Perceived emotion regulation strategies

Self-awareness of emotions was seen as a strategy for emotion regulation in DBL for some students. This finding echoes with the theoretical claim that encouraging students to identify their feelings may be viewed as a step towards emotion-oriented management (A1) [19]. For example, S10 commented, “I also think the frustration part is good so that I can be more aware of what I don’t like to do or what frustrates me. It’s easy to implement it maybe later if something doesn’t work out, and I get frustrated, that I maybe can change it and do it differently.” Besides, one student (S5) mentioned a strategy of steering her process, taking into account of emotions. Especially, she described, “I would say that you have to plan your process. Taking into account what you already know about yourself. For example, I might start the next project by going around and asking people about their ideas to get this positive emotion rush. Only then, I’m going to go into documentations and sketching because if I start with that, it’s like taking my motivation away at the very first step of the project.” In particular, some of the students in this study especially mentioned that awareness tools like EmoForm could help them in regulating their emotions. For example, S8 stated that “Maybe using a form like this and then actively reflecting on it. That is probably how I could deal with it, I think, which I don’t really think [in the past].”

As one step further, sharing emotions within a group is also seen by some students as a strategy to regulate emotions in DBL. For example, S9 stated, “it’s good to have a review of that day and to chat with each other, like how everyone felt of things. Maybe if someone says like, ‘I didn’t really feel good about that,’ or ‘I didn’t feel any enjoyment,’ then you can talk about it and change it for next time. [...] Because when you’re working alone, I think it’s really hard to deal with emotions. It’s easier if people help you with that.” Likewise, S11 has a similar opinion as S9, saying that “[if you know the emotions of the other people in your group, you can connect to it and see, maybe they can pull you up or you can pull them up to get more motivation in the group. [...] I think it is way more helpful if you know the emotions of other people as well because it’s often hard to make the first step to talk about emotions.”

Furthermore, one student (S1) argued that the teacher’s intervention (e.g., having a regular meeting with the coach) might help him deal with emotions in DBL. This type of strategy points to a problem-oriented emotion regulation strategy (A3). Previous studies [36], [37] have already shown an influential role of the teacher in students’ learning and emotions. This finding suggests that future work may consider teacher intervention in developing students’ emotional awareness in DBL.

Some students (e.g., S1-4, 7, 13) think having an open-minded mindset to both positive and negative emotions has also been seen as a strategy for emotion regulation (A2) in DBL. For example, S2 mentioned that “[I guess instead of trying to hold back of them you get positive or negative emotions], just get it out and then work with it. If it is negative emotions, try and distract yourself from them, if it’s positive, ride that positive wave and get as much of them as you can.” And S3 also described, “I try to keep positive because, in that way, you’re way more open for meaningful learning experiences.” This finding reflects the adaptive emotion regulation strategies previously proposed in literature like reappraisal or acceptance of emotions [17].

V. DISCUSSION

One argues that a necessary step towards designing tools to improve emotion regulation is understanding the extent to which and how students are aware of the emotions they experienced during learning [16]. The work presented in this paper examined whether and how self-tracking of emotions using the EmoForm can facilitate students’ emotion awareness and provide more in-depth insights on how such a tool can be developed in the future.

Our findings are illustrative of the potential benefits of repeatedly self-reporting on internal states during learning. While affective computing technologies can be used elegantly and unobtrusively to create awareness implicitly [33], this study emphasizes the advantages of explicit awareness through self-report, which is well known to be able to simulate reflection and behavior change [38]. On the other hand, self-reporting emotions, especially in response to a system-generated reminder, (as in experience sampling) can be mistimed, obtrusive, and interrupt the flow of learning. There already has been a debate about using explicit feedback or implicit feedback system in supporting students’ emotion awareness and provide more in-depth insights on how such a tool can be developed in the future.

Our findings are illustrative of the potential benefits of repeatedly self-reporting on internal states during learning. While affective computing technologies can be used elegantly and unobtrusively to create awareness implicitly [33], this study emphasizes the advantages of explicit awareness through self-report, which is well known to be able to simulate reflection and behavior change [38]. On the other hand, self-reporting emotions, especially in response to a system-generated reminder, (as in experience sampling) can be mistimed, obtrusive, and interrupt the flow of learning. There already has been a debate about using explicit feedback or implicit feedback system in supporting students’ emotion awareness in education [33]. Future research could explore the possibilities of a multimodal tool combining explicit self-assessment (e.g., the experience sampling form strategy) and implicit context awareness (e.g., system login data, wearable-enabled data collection) to balance the potentials and drawbacks of each technique, in a fashion similar to the Reconexp tool for experience sampling [39].

Interestingly, some participants wished to share their emotion-related information with others to create social awareness in DBL. Future work could investigate the acceptance and feasibility of sharing information among students in the context of DBL. On the other hand, students seemed to use the shared emotion information to adapt their strategy of learning in this study, which also raises new questions such as how to ensure comparisons between students can lead to a positive outcome. Comparisons can
triggers knowledge sharing and cooperative behavior between students but can also lead to downward comparison and diminishing efforts or withholding of information [33].

Besides, it would be interesting for future research to examine how to strengthen the guidance provided by emotion awareness tools in DBL with explicit advice without compromising the student’s feelings of autonomy. Apart from developing new tools to support emotion awareness in DBL, future research should explore systematically the underlying mechanisms that shape the relationship between emotion awareness and learning outcomes in DBL. Questions that arise for future studies pertain to identifying the conditions and situations where emotion awareness during DBL can lead to positive learning outcomes.

Most of our participants were positive about using EmoForm and found using it fun and useful. We do not know if this is the effect of novelty or a social desirability bias, but the reception was encouraging showing the potential for emotion awareness to support DBL. Clearly our findings are based on a single case study. Comparison to different cases or experimental studies may help strengthen the evidence provided here, and generalize a broader range of students.

VI. CONCLUSION
This paper attempts to explore ways of emotion awareness in DBL. Here we examined emotion awareness achieved by self-tracking using the EmoForm. Our empirical results confirm the assumed influence of self-tracking with EmoForm in facilitating emotion awareness, which are in line with established approaches to self-tracking behavior in previous research. In particular, the effect of EmoForm in this study reflected on three aspects: (a) it encouraged communication and accountability of students' internal states; (b) it increased students’ awareness and understanding of self; and (c) it stimulated behavior change. This above empirical evidence also underlines the potential for emotion awareness to support DBL. Moreover, this study identified some design choices to be taken into account in related emotion awareness tool development in DBL: (a) exploring strategies for choosing appropriate timing for self-report of emotions to avoid disruption; (b) exploring ways of data visualization supporting explicit cross-referencing. Finally, this paper has presented strategies towards emotion awareness in DBL and discussed implications for future studies.

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