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Deep and Surface Processing of Instructor's Feedback in an Online Course

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ABSTRACT

This study investigated the characteristics of deep and surface approaches to learning in online students' responses to instructor's qualitative feedback given to a multi-stage, ill-structured design project. Further, the study examined the relationships between approaches to learning and two learner characteristics: epistemic beliefs (EB) and need for closure (NFC). Four emerging themes were identified where the students' approaches to learning spread along a spectrum of deep to surface learning: *number of feedback items addressed, understanding of feedback, quality in addressing feedback,* and *holistic thinking.* In addition, the maturity of EB was likely to be associated with students' understanding of feedback and the systematic and relational thinking demonstrated in their responses to feedback. The relationship was unclear between NFC and deep/surface learning characteristics. The findings provide implications for the design of feedback to scaffold deep learning in ill-structured problem solving.

Keywords

Approaches to learning, Deep learning, Epistemic beliefs, Feedback, Need for closure, Problem solving

Introduction

Providing feedback to students is an important instructional means in online learning. To facilitate online learning through feedback, we need to first understand how students process feedback. Using the theoretical lens of approaches to learning (Marton & Säljö, 1976a), this study examined online students' deep and surface approaches to address instructor's feedback, which was a complex, ill-structured task (Jonassen, 1997). Further, the study explored the possible relationships between students' processing of feedback and two learner characteristics that might influence their approaches to feedback – epistemic beliefs (EB; Hofer & Pintrich, 1997) and need for closure (NFC; Kruglanski, 1990). We hoped that the findings would help researchers and online educators to recognize patterns of surface and deep processing of feedback, thereby helping learners of different EB and NFC to move towards deep learning.

Literature review

In this section, we first present theories related to approaches to learning. Next, we introduce ill-structured problem solving as a unique learning context in which approaches to learning need a greater depth of understanding. Subsequently, we review EB and NFC, which are likely to play a role in individual learners' approaches to learning.

Approaches to learning

Ever since the seminal work by Marton and Säljö (1976a), approaches to learning have been characterized as a surface-to-deep continuum (Biggs, 1993; Marton & Säljö, 1976a). Departing from a mere cognitive account, Biggs (1987) conceptualized approaches to learning as both motives and strategies. At the deep level, learners are driven by an intrinsic interest in the subject matter of the task (Biggs, 1993). Accordingly, they adopt strategies to seek meaning and maximize understanding, including *holistic* (e.g., relating ideas; looking for principles) and *serialist* strategies (e.g., using evidence; examining the logic of argument; monitoring one's own understanding) (Entwistle, 2000). Comparatively, surface learning is characterized by a motive to cope with the task, i.e., to meet requirements minimally, with reproductive strategies such as rote learning and concentration on procedures and isolated details (Biggs, 1987; Marton, 1983). Bigg (1987) accounted for learning with 3Ps: *Presage, Proces*s, and *Produc*t. While approaches to learning are shown in *Process*, they are affected by *Presage* factors, such as learners' prior knowledge and personality. Together, *Presage* and *Process* lead to *Product*, which refers to learning performance.

Upon the development of quantitative instruments (e.g., Biggs, 1987; Entwistle & Ramsden, 1983), researchers have investigated approaches to learning in terms of their impact on achievement, effects of interventions, interactions with other constructs, or factors leading to deep or surface learning (e.g., García, Rodríguez, Betts, Areces, & González-Castro, 2016; Greene & Miller, 1996; Vos, der Meijden, & Denessen, 2011). Yet, research often yielded ambiguous or even contradictory findings regarding the effects of instructional strategies for deep learning (e.g., Dolmans, Loyens, Marcq, & Gijbels, 2016; Struyven, Dochy, Janssens, & Gielen, 2006). A few reasons have been given: first, while context-specificity is an assumption of approaches to learning, few studies examined learning approaches within a specific task; second, learners of different characteristics may exhibit different patterns in approaches to learning (Asikainen & Gijbels, 2017; Dinsmore & Alexander, 2012; Dolmans et al., 2016). Consequently, Dinsmore and Alexander (2012) called for the consideration of *who, where, when*, and *what* in investigating approaches to learning.

Adopting Biggs' (1987) 3P model, this study responds to Dinsmore and Alexander's (2012) call by examining approaches to learning in a particular learning context – ill-structured problem solving, and by investigating the roles of two learner characteristics or *presage* factors – EB and NFC (Figure 1). While the initial research on approaches to learning was conducted in the context of text recall or comprehension (e.g., Marton, 1983; Marton & Säljö, 1976a; Marton & Säljö, 1976b), little is known about the approaches learners undertake in solving ill-structured problems. As a complex process that involves qualitatively distinct yet interrelated stages, ill-structured problem solving may require learners to employ additional strategies that have not been accounted for in previous studies. The next section provides a review of ill-structured problem solving.

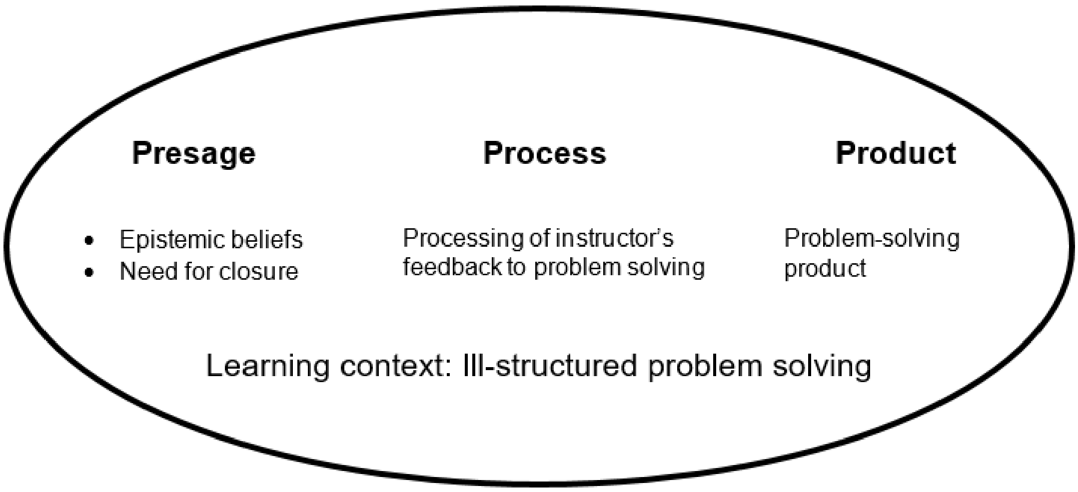

Figure 1. The key framework under investigation based on Bigg's (1987) 3P model

Ill-structured problem solving

Ill-structured problems are complex and ill-defined (Jonassen, 1997; Sinnott, 1989; Voss & Post, 1988). They do not have clear goals or definitive information. There may be multiple solutions, multiple paths to solutions, or no solutions at all. Ill-structured problems require problem solvers to go through iterative cycles between two essential stages (problem representations and problem solutions) while constructing arguments during the process (Ge & Land, 2003; Jonassen, 1997). Problem representation refers to defining features of a problem situation, identifying goals and subgoals, and figuring out a path from the initial state (i.e., initial situation of the problem) to the goal state (i.e., the desired condition, or the ultimate goal, to be reached through solution-searching activities) in the problem space. A problem space consists of various problem states, while a state is a representation of the problem in some degree of solution (Anderson, 2015). Due to the complexity of ill-structured problems, learners have to navigate across various problem spaces in order to identify the most relevant space (Sinnott, 1989). Frequently, the solver needs to go through an iterative process of redefining and re-representing the problem until an optimal solution is identified (Ge, Law, & Huang, 2016).

This study operationalized ill-structured problem solving in dual layers: (1) students worked on a semester-long instructional design project, which was an ill-structured problem itself; (2) students responded to instructor's qualitative feedback to their projects, which was another layer of ill-structured problem solving.

Epistemic beliefs

EB refers to individuals' conceptions of the nature of knowledge and knowing (Hofer & Pintrich, 1997). An individual who holds less mature EB may believe, for example, that knowledge is certain and principles in a field do not change over time; on the other hand, an epistemologically more mature learner may question the authority of a textbook. EB has received an increasing attention in recent years due to its recognized importance in cognitive engagement, learning strategies, and achievement (e.g., DeBacker & Crowson, 2006; Muis, 2007; Schommer, Crouse, & Rhodes, 1992). It is reasonable to postulate that learners' EB may have certain relationship with their approaches to learning manifested in the process of ill-structured problem solving, or in addressing instructor's feedback as investigated in this particular study. Indeed, several authors have suggested such propositions (Chin & Brown, 2000; Entwistle, 2000; Marton & Säljö, 1976b), yet empirical research is needed to investigate the relationship between EB and learning approaches.

Need for closure

NFC refers to the desire for a firm answer to a question to avoid any forms of ambiguity (Kruglanski, 1990). The desire to reach closure is manifested in (1) *seizing* - arriving at a quick solution or using superficial processing, and (2) *freezing* - protecting prior knowledge or established solutions with only superficial scrutiny of new information (Kruglanski & Webster, 1996). NFC was found to be associated with learners' cognitive engagement (DeBacker & Crowson, 2006; Harlow, DeBacker, & Crowson, 2011). DeBacker and Crowson (2006) projected that high NFC "compels students to accept the first reasonable solution they encounter, in order to end the ambiguity of problem solving" (p. 539). Because of the ambiguous nature of ill-structured problem solving, it is reasonable to anticipate that NFC may play a role in learners' approaches to an ill-structured task. In this study, the task was to address instructor's feedback to project.

Research questions

This study investigated approaches to learning in the process of ill-structured problem solving, operationalized in learners' handling of feedback to their projects. Two research questions were asked:

- What characterize deep and surface approaches in students' responses to instructor's qualitative feedback to their problem-based projects?
- What are possible links between characteristics of deep/surface approaches and learners' EB and NFC?

Methods

Both quantitative and qualitative methods were adopted in this study. Specifically, quantitative questionnaires served to identify learners' EB and NFC profiles, and qualitative data were collected and analyzed to understand learners' approaches to learning and their relationships with EB and NFC.

Participants, context, and instruments

Forty-four students were recruited from two sections of a completely online instructional technology course at a southeastern university in the United States. A major assignment of the course was a semester-long instructional design project that consisted of four progressive milestones leading to the final product – a training website for a target group of learners (Table 1). For each milestone, the instructor provided feedback using a set of grading criteria. In addition to assigning points to each criterion, the instructor provided qualitative comments (Figure 2). While most comments were on the criteria where students needed improvement, occasionally the instructor also provided "bonus" comments on future project work or on criteria in which students received full points. The comments usually did not give direct instructions, but prompted students to consider ways to improve their work. Students were required to respond to the feedback individually before working on the next milestone in the subsequent week. In their responses, students needed to (1) summarize the feedback, and (2) describe plans to address the feedback.

Table 1. Four project milestones leading to the final product (training website)

Milestones	Schedule		Requirements
	Work submission	Response to feedback	
1	Week 5	Week 6	• Identify target learners & training topics • Justify importance of the training • State general training goals
2	Week 7	Week 8	• Identify applicable standards • Describe "big ideas" taught in the training • Identify learning objectives (target knowledge and skills) • Describe potential learning challenges • Start developing website (the *About* page)
3	Week 9	Week 11	• Design an engaging *Home* page, with website introduction • Develop the *Home* page
4	Week 13	Week 14	• Design instructional content supported by digital tools • Develop instructional content page(s) of the website

Feedback to Milestone 1 (Project Proposal)

Team 7

Components	Points Received	Comments
1. Team number and members' names (2 pts)	2	
2. Synchronous online meeting (3 pts)	3	I am very impressed that you've had two synchronous meetings.
3. Target learners (10 pts)	8	You have narrowed down the target learners, which is great. But what are some details or characteristics of the learners that may affect how you design the website for them?
4. Target teaching topic (10 pts)	10	Just to be sure, the main topic is "proper use and etiquette on social media website," while "use online tools to research, discuss and collaborate" describes the learning activities to study the topic, correct?
5. Importance of the target topic (5 pts)	5	You have made a good case for the importance of the topic.
6. Goal of the instruction (10 pts)	10	I like your idea of using a video to demonstrate knowledge gain.
7. Coherence and logic (10 pts)	10	All the parts are indeed coherent.
Total	**48**	You have picked a worthwhile topic, and the learning activities/assessments reflect active learning. I look forward to seeing how you move forward with the project. Meanwhile, I would like to remind you that this project requires students to learn from the website without an instructor on the side. So consider how you can design the website to complement the F2F ICT I course, and how to support students to learn by themselves online.

Figure 2. An example of instructor's feedback

At the end of the course, the students completed two surveys (Table 2): an 18-item Discipline-Focused Epistemic Beliefs Questionnaire (Hofer, 2000) and a 15-item NFC survey (Roets & Van Hiel, 2011). Students' EB and NFC scores were calculated and ranked. Following the maximum variation principle (Creswell, 2007), we purposefully sampled only those whose EB and NFC were *both* ranked at the top or bottom 10, thereby retaining nine students distributed across the four EB-NFC quadrants. Figure 3 depicts the relative positions of all the 44 students in the quadrants while highlighting the nine selected students. While the High NFC-Naive EB and Low NFC-Mature EB quadrants had four and three students respectively, the other two quadrants had only one in each. This uneven distribution is consistent with the positive EB-NFC correlations reported in the literature (DeBacker & Crowson, 2006).

Table 2. Subscales, sample items, descriptive statistics, and Cronbach Alphas for the EB and NFC instruments

	Subscales	Example items	Mean	*SD*	Cronbach *α*
Epistemic beliefs	Certainty of knowledge	Principles in this field are unchanging	3.09	.40	.78
	Source of knowledge	If you read something in a textbook for this subject, you can be sure it is true			
	Justification of knowing	Correct answers in this field are more a matter of opinion than fact			
	Attainability of truth	Experts in this field can ultimately get to the truth			
Need for closure	Order	I enjoy having a clear and structured mode of life	3.93	.79	.88
	Predictability	I dislike unpredictable situations			
	Decisiveness	When I have made a decision, I feel relieved			
	Ambiguity	I don't like situations that are uncertain			
	Close-mindedness	I dislike questions which could be answered in many different ways			

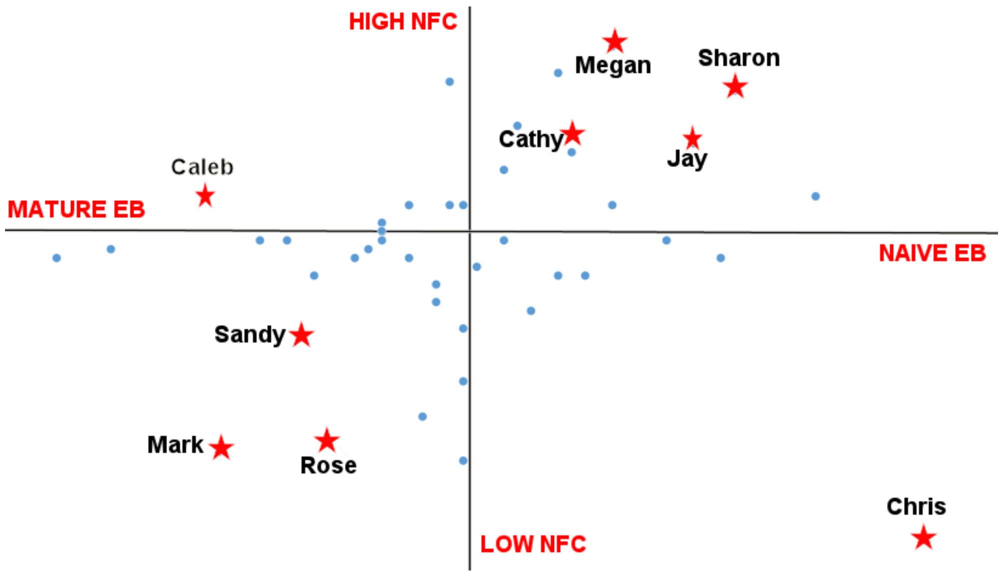

Figure 3. Relative positions of all the 44 students in the EB-NFC quadrants (stars represent the nine sampled students)

Data sources and analysis

In addition to the EB and NFC data, there were three data sources: (1) instructor's feedback to the four milestones, together with students' responses to feedback, (2) students' end-of-semester reflections describing their perceptions of the instructor's feedback, and (3) students' project work.

To articulate the subtleties of approaches to learning as a general construct manifested in the context of ill-structured problem solving, we followed a bottom-up approach in coding: while being guided by principles of the approaches to learning in the literature, we allowed constructs to emerge from data (Biggs, 1993). In the first stage of data analysis, two researchers coded the nine students' responses to feedback and their reflections, without the knowledge of the students' EB-NFC profiles. Open coding was conducted, followed by axial coding to characterize distinct themes emerged from the data (Strauss & Corbin, 1990). Once the main themes were identified, the researchers then conducted the second round of coding within each theme to identify sub-patterns emerged from the data. While the levels of processing exhibited in students' responses ranged along a continuum, we identified those that showed salient deep or surface learning patterns, given the focus of this study. In the second stage, the students' EB-NFC profiles together with their respective quadrants were revealed, which were subsequently cross-examined with the deep and surface learning patterns demonstrated from their data. A linkage was identified when the data showed a clear association between a deep/surface learning pattern and EB or NFC. Throughout the coding, the researchers went through an iterative process of discussing interpretations and inferences, until consensuses were reached. Students' reflections and project work were used to triangulate and provide necessary background information.

Results

Question 1: Characteristics of deep and surface approaches to addressing feedback

Before reporting the findings, we provide an overview of the nine students' approaches to feedback. Among the nine students, Mark was the "poster" student who demonstrated deep processing in almost all aspects in his responses. On the other end, Chris' responses demonstrated mostly surface approaches. The other seven students exhibited a mixture of deep and surface approaches.

The analysis of the students' responses to feedback revealed four themes where students' levels of processing spread along a spectrum (Table 3). In this section, we present each theme and report the most salient patterns that characterized deep and surface learning within the theme. It should be noted that the unit of analysis in this section is not individual learners, but the aggregated behavioral and thinking patterns exhibited in their responses and reflections.

Table 3. Themes and sub-patterns that characterize deep and surface processing of feedback

Themes	Deep processing ⟵⟶	Surface processing
Number of feedback items addressed in responses	• Addressing most feedback • Addressing "bonus" feedback that did not require responses	• Addressing minimal or limited feedback • Addressing only feedback that required responses
Understanding of feedback	• Accurate understanding; appropriate problem representations • Elaborations that showed internalization and enriched problem representations	• Misunderstanding or simplistic understanding; inappropriate problem representations • Mere (or no) restatement of feedback
Quality in addressing feedback	• Application of general feedback to specific situations, with elaborations • Integration of feedback into existing understanding or project work • Actual work on solutions beyond requirements	• "Will do" • Explaining causes of an issue without suggesting solutions • Addressing feedback to a limited degree • Fixing the obvious while leaving deeper issues unaddressed
Holistic thinking	• Solutions driven by explicit problem representations • Mindful navigations between two problem spaces (feedback and project), leading to transformed problem representations	• Solution-orientedness without a clear link to problem representations • Addressing feedback without holistic considerations of the project

Theme 1: Number of feedback items addressed in responses

Across the four milestones, each team received a total of 11-17 feedback items from the instructor. Deep learning was demonstrated by two patterns within this theme. The first pattern was an attempt to address most or all feedback. For example, Mark explicitly responded to all of the 11 feedback items. The second pattern was regarding the aforementioned "bonus" feedback. Although responses were not expected, students such as Megan responded to both of the two future suggestions given to her project.

Surface learning within this theme was the most evident in Chris' responses. Among the 14 feedback items given to his project, Chris responded to only two. Regarding the "bonus" feedback, half of the students did not acknowledge or address them.

Theme 2: Understanding of feedback

The students varied in their understanding of feedback, which was shown in two patterns. The first is the extent to which students demonstrated accurate understanding of the feedback. The second is the extent to which students internalized the feedback.

At the deep-learning end, across the four milestones, Caleb, Mark, and Sandy showed an accurate understanding of all but one feedback item. Figure 4 illustrates an example of the instructor's feedback to Mark's team project Milestone 1, and Figure 5 shows Mark's responses to the feedback. Deep learning was further shown in the second pattern, when students went beyond an implicit acknowledgement of feedback by demonstrating internalization. A representative case was Jay's response to Milestone 1 feedback. A requirement of Milestone 1 was to describe the target topics each team planned to teach with their proposed training website. The proposal of Jay's team indicated their misunderstanding by mixing target topics (social media etiquette) with intended learning activities ("Student will use online tools to research, discuss, and collaborate"). When the instructor pointed out this issue, Jay responded that the instructor "wants to be sure that we clearly set the learning goals (topics) separately from the means of teaching (activities)." In his own words, Jay demonstrated internalization of the feedback, which helped to construct an appropriate problem representation conducive to a solution.

Components	Points Received	Comments
1. Target teaching topic (10 pts)	8	You seem to have a good idea about what the *teaching/learning activities* will be like. *Teaching topics*, on the other hand, have a somewhat different meaning. It is the main concepts students learn from learning activities. So, what are the main topics you plan to teach?
2. Importance of the target topic (5 pts)	4	Learning how and why electricity works is certainly important, but why is there such a need for your students to learn? Is it because the topics are on the curriculum, or perhaps the students have difficulties to grasp some of the concepts? More elaboration will strengthen the argument.

Figure 4. Instructor's main items of feedback to Mark's team project Milestone 1

On the other end of the spectrum, regarding the first pattern (i.e., demonstrating accurate understanding), two students, Jay and Megan, demonstrated complete misunderstandings of a considerable amount of feedback. Slightly better along the spectrum, there were cases of superficial or simplistic understanding. For example, Sharon's team received seven items of feedback to their Milestone 1. In her response, Sharon did not address any specific feedback, but attributed all the issues to her team's not being able to select a "teach-able" topic. This understanding was further confirmed in her later response to Milestone 2 feedback, where she felt that her team had done a better job ever since to make their project more "teach-able." As shown, instead of trying to understand feedback at a deeper level, Sharon resorted to constructing a simplistic problem representation, and continued to stay in this problem space. The narrow and mis-conceptualized problem space might have prevented her from navigating appropriate paths to solutions. Regarding the second pattern (i.e., internalizing feedback), most students did not show internalization but merely restated feedback or did not restate at all. In fact, Mark was the only exception who routinely rephrased instructor's feedback in his own words to show his understanding (Figure 5).

1. **What are the main items of feedback provided by Dr. Huang?**

   The main items of feedback provided by Dr. Huang includes target teaching topic and importance of the target topic. Within the target teaching topic we need to breakdown what concepts will be covered while teaching learners about how electricity works. Within the importance of the target topic we need to better explain why learning how electricity works is important.

2. **For each feedback item, how do you think it should be addressed? Do not simply restate Dr. Huang's suggestions. Respond in some details, e.g., provide specific examples**

   To better explain our target teaching topic of how electricity works we should give the learners the overall objectives of our topic instead of stating everything the students will do while working on our project. Some example topics are:

   - Students will learn how an electrical current is created.
   - Students will learn what household materials can be used as electrical conductors.
   - Students will learn what household materials can be used to insulate electrical currents.
   - Students will learn how to predict and test electrical circuits using household materials.

   To help students better understand why learning how electricity works is important and why they should learn about this topic we should go into more detail to further intrigue the students. Doing so will make them gain interest in the project and better retain information while teaching takes place. For example, electricity is a part of our everyday lives that you may take for granted, without electricity you wouldn't be able to watch television, have a telephone, play electronic games, use the internet, or even use hot water in your home easily. Before we advance to learning about voltage, amperage, and the atomic structure of electricity that will take place in a future lesson, students will gain better understanding of how electricity works overall by drawing upon prior knowledge of positive and negative electrical currents and use problem solving and critical thinking skills to create their own electrical current using household materials.

Figure 5. Mark's responses to instructor's feedback shown in Figure 4

Theme 3: Quality in addressing feedback

While Theme 2 is about understanding of feedback, this theme is about how well students actually addressed feedback. Deep learning was evident in three patterns. First, some students were able to apply the instructor's general feedback to specifics of their project, elaborating with details, examples, or questions. An illustrative example was Caleb's response to Milestone 4 feedback. When the instructor pointed out that the stated learning objectives were not aligned with the instructional content on his training website, Caleb responded, "After thoroughly reviewing (the instructional content) and comparing it to (the learning objectives) on my website, I can CLEARLY see the misunderstanding that was taking place on my part." In what followed, Caleb identified three specific learning objectives that were not addressed in the instructional content and discussed how he would address the issue.

The second pattern of deep learning was demonstrated in the investment of effort to actually work on addressing feedback, which was beyond the requirement of discussing plans to address feedback. Mark and Megan routinely did extensive work in their responses. For example, in Milestone 3, Mark's team added a real-life scenario to their homepage to draw learners' attention and introduce them to the website, but the instructor pointed out that the scenario was too lengthy to keep learners' attention. In addition to recognizing the issue, Mark rewrote the entire scenario in his response.

The third pattern, which emerged as the deepest level of processing, was demonstrated in the students' integration of feedback into their existing understanding. The pattern was evident in Mark's response to Milestone 2 feedback. Milestone 2 required students to review and identify from three given sets of standards the ones applicable to their project. Originally, Mark's team identified standards from one of the three sets. The instructor suggested that another set of standards might be more relevant to Mark's project (i.e., electricity concepts for elementary students). Mark responded, "we originally decided ... the (first set of) standards ...

because the project does show creativity and innovation and also contains critical thinking, problem solving, and decision making (which was what the first set of standards was about). On the other hand with the (first set of) standards primarily associated with digital learning, the project will be better suited to follow (the suggested set of) standards." As shown, Mark did not take the feedback at the face value by simply adopting the suggested standards. Rather, he reflected on and justified the reasoning behind the original decision and discussed how both sets of standards were relevant to his project. Through reconstructing his initial mental model, Mark updated his problem representation, which went beyond the scope of the feedback to the project level.

Towards the other end of the spectrum, four patterns characterized surface learning. The first pattern was shown in many responses as some variations of a "will do" statement. For example, Milestone 3 feedback requested Rose's team to revise their learning objectives. Rose responded, "After speaking with the rest of my group, we will be updating our (learning objectives) accordingly." However, no specific revision plan was proposed.

The second pattern, which showed a somewhat deeper level than a mere "will do," was a tendency to explain the cause of an issue without attempting to suggest solutions. In her responses to both Milestone 3 and 4 feedback, Sandy discussed the causes (i.e., division of labor among team members) that had led to the issues pointed out in instructor's feedback (i.e., crowded home page or inconsistencies across different pages), yet there was no discussion on how she planned to resolve the issues.

In the third pattern, students did attempt to discuss solutions, but to a limited degree. For example, Milestone 1 feedback requested Caleb to give more considerations to his target learners' characteristics. In his response, Caleb described only one aspect of his learners (seniors) by referring to them as "the generation that never grew up with technology." This limited scope of addressing feedback was quite common among the students' responses, which was not conducive to successful problem solving.

In the last pattern, the students attempted to fix obvious issues while leaving deeper ones unaddressed. For instance, in Milestone 2, Jay's team identified two *big ideas* they expected learners to take away from their training. The feedback asked the team to rephrase the first big idea from the learners' perspective, and justify why they believed the second one to be a big idea, which was in fact a learning activity. In his response, Jay rephrased the first big idea, yet left the deeper issue (i.e., justifying the second big idea) unaddressed. Sandy's response to Milestone 1 feedback showed a different approach to fixing obvious issues. The instructor suggested her team to consider their target learners' characteristics, such as prior knowledge, motivation, and interest. Sandy responded, "We were instructed to take into consideration our target group's prior knowledge … we could eliminate this issue if we narrowed in on a more specific group of students." As shown, instead of trying to understand the learners, Sandy opted for a shortcut solution by narrowing down target learners to "eliminate" the issue.

At this juncture, it is important to point out that Sandy's quick-fix solution was likely to be rooted in her narrow understanding of the feedback. Instead of interpreting the feedback as a prompt for considerations of a key instructional design principle – thorough learner analysis to inform the design of training, Sandy's understanding of feedback focused on isolated details – learners' prior knowledge only. Consequently, her solution was to narrow down learners to eliminate the "prior knowledge issue."

Sandy's case revealed a new dimension, problem space, in conceptualizing approaches to learning in the context of ill-structured problem solving. When learners did not gain a clear understanding of feedback and operated in a different problem space, they might not be able to reach appropriate solutions despite exhibiting certain patterns of deep learning. Megan was such a case – she invested extensive efforts in addressing feedback through elaborations, examples, and actual work, yet her solutions or plans for solution were often judged unsuccessful due to her misunderstandings of the feedback.

Theme 4: Holistic thinking

As shown in Theme 3, the close connection between problem representation and solution is a manifestation of holistic thinking, that is, taking into consideration the relationships among different components while solving a problem. Emerging from the data, two salient patterns demonstrated holistic thinking, or lack thereof: solutions driven by explicit problem representations, and mindful navigations between feedback and project.

At the deep-learning level, students' solutions were clearly driven by explicit problem representations. Mark was a representative case. In addition to establishing an accurate understanding of most feedback, Mark turned problem representations into explicit goals for his solution, demonstrated in statements like, “To help students better understand why learning how electricity works is important … we should …” As shown in Figure 5, Mark’s solutions routinely used these goal-setting statements, which were built upon his understanding of the feedback. Consequently, his description of the feedback, solutions, and actual work were all logically and cohesively aligned.

The second relational pattern of deep learning was shown in students’ mindful navigations between two problem spaces, the feedback and the project, in their responses. When deciding whether to keep a visual element on his website in response to feedback, Mark reasoned that he might remove it “unless it greatly improves the project during final review.” It is clear that Mark went beyond the problem space of the feedback and entered into the problem space of the project, by anchoring his planned solution in the project. Mark’s end-of-semester reflection corroborated the finding, “When reviewing feedback I would make sure to ... look back at what we had originally done.” An even deeper level of processing was shown in Mark’s response to Milestone 4 feedback, where the instructor suggested moving an instructional video from one page to another on their website, in order to make the website structure clearer. Mark responded that he would move the video as suggested, and then completely delete the original page that contained only the video, “so that learners have the opportunity to learn (from the video) about how a circuit works before reviewing the material (on the new page).” In this example, Mark considered the instructor’s general feedback in light of the project itself. Through mindful navigations between the problem spaces of the feedback and of the project, Mark was able to transform his problem representation from “moving the video to a new page” to a more holistic level, with the consideration of causal relationships of various instructional design components. Indeed, Mark stated in his end-of-semester reflection that the feedback “made us think more thoroughly and gave us the opportunity to give clarity to our work.”

The two aforementioned relational patterns were lacking in the case of surface learning. A frequent pattern in the students’ responses was solution-orientedness, that is, jumping quickly to solutions without a clear link to problem representations. Megan and Jay were two representative cases whose responses often leaped prematurely into lengthy solutions. For example, when the instructor asked Megan’s team to consider the characteristics of their target learners (14-16 years old), Megan’s response did not describe how she understood the feedback but discussed extensively how graphic content, animations, sound, etc. might benefit teaching her target learners. Without explicit problem representations to drive her solutions, Megan often appeared to be approaching feedback by fixating on the solution, and volunteering extensive, yet often irrelevant and incoherent, details.

The second surface learning pattern was shown in a considerable number of responses that focused mostly on addressing feedback without a holistic consideration of how related components, at both the feedback and project levels, might be affected by a solution.

Question 2: Links between deep/surface approaches and learners’ EB and NFC

Regarding the second research question, we first provide an overview of the four EB-NFC quadrants, highlighting salient deep and surface learning characteristics of each, and then connect the characteristics to EB and NFC respectively.

The Mature EB-High NFC quadrant had only one student, Caleb, who exhibited both deep and surface learning patterns. He addressed only half of the feedback. However, in the feedback he chose to address, Caleb did show a good understanding of the feedback and proposed reasonable solutions, although his responses often lacked elaborations and details. Caleb’s understanding of and plans to address feedback showed cohesiveness and logical connections in general.

The Naive EB-Low NFC quadrant also had only one student, Chris, who had the lowest scores in both NFC and EB maturity among the 44 students. Chris addressed only two out of 14 feedback items, the least among the nine students. Most of his responses lacked understanding of the feedback. Although the lengths of his responses were comparable to others, he appeared to be operating in his own problem space. While his plans to address feedback did show some relation with his own, albeit inaccurate, understanding of the feedback, his responses generally lacked logic and cohesiveness.

The Mature EB-Low NFC quadrant had three students, Mark, Rose, and Sandy. Among them, Mark was the “poster” student whose responses exhibited almost all of the deep learning characteristics. Despite variations, this group generally exhibited good understanding of the feedback, although not all of them chose to elaborate their responses. Their holistic thinking was demonstrated in the alignment between their solutions and understanding of the feedback, although sometimes implicitly.

The Naive EB-High NFC quadrant had four students, Cathy, Jay, Megan and Sharon. Despite variations, this group showed misunderstandings or simplistic understandings of a considerate portion of feedback. Similar to Chris in the Naïve EB-Low NFC quadrant, this group's responses generally lacked logical connections and cohesiveness.

Relating the EB-NFC profiles of the four quadrants to their respective approaches to addressing feedback, we first examined the possible links between EB and approaches to learning. The two quadrants of mature EB and the other two of naive EB appeared to differ in the following patterns: (1) understanding of feedback, and (2) logical connections and cohesiveness shown in students' understanding of feedback and plans to address it. Compared with those with naive EB, the students in the mature EB quadrants generally exhibited better understanding of feedback, and showed better alignment and coherence in their responses.

Regarding the possible links between NFC and approaches to feedback, we were unable to identify any clear patterns that could distinguish the two high-NFC quadrants from the low-NFC ones. The only plausible link was regarding students' responses to the aforementioned "bonus" feedback. Among all the seven (out of nine) students who received such feedback, all of the three students in the two high-NFC quadrants responded, yet none of the four low-NFC students did so. The final reflection of Caleb, a high-NFC student, may provide some insight into this phenomenon, "Paying attention to feedback ahead of time will save you in the long run."

Discussion and implications

Utilizing both qualitative and quantitative methods, this study sought to develop a context-based conceptualization of different learning approaches while taking into consideration of individual learner characteristics (Dinsmore & Alexander, 2012). The study extends our understanding of the approaches to learning in a number of ways. First, this study investigated deep and surface learning patterns in students' responses to instructor's feedback, which represented an important, ill-structured learning task with multiple layers of problem spaces. While the existing literature identifies general characteristics of deep and surface learning (Biggs, 1993; Entwistle, 2000), the current study showcases how learners' deep and surface approaches manifest in the particular processes of addressing feedback. The contextualized themes and sub-patterns correspond to what was suggested in the deep or surface learning literature. For example, deep learning was characterized as an intention to extract meaning (Entwistle, 2000) and an intrinsic motive to actualize interest and competence (Biggs, 1993). In the current study, the attempt to address most feedback was a manifestation of an intrinsic motive to understand the status of the project to further improve it. Comparatively, surface learning is characterized in the literature as an attempt to meet requirements minimally (Biggs, 1987), as well as a conceptualization of a task or situation as unrelated bits of information (Entwistle, 2000). In the current study, these characteristics were manifested in students' simple restatements of feedback without elaborating their understanding, and in their focus on addressing isolated details in feedback while leaving out deeper issues.

Further, this study revealed the complexities inherent within deep and surface learning in ill-structured problem solving. Consistent with Marton and Säljö's (1976a) work, the study suggested that deep and surface approaches were not dichotomous. The two approaches did not exactly mirror each other in an opposite way; rather, they each had their own patterns that spread along a spectrum. An additional complexity was evident in the simultaneous exhibition of both deep and surface approaches by the same individual such as Caleb, who showed deep learning patterns such as accurate understanding of feedback, while in the meantime demonstrated surface processing in responding to only half of the feedback and in lacking elaborations in responses. Chin and Brown (2000) reported similar findings that learners who were labeled as surface approach might exhibit deep strategies. Different from Chin and Brown (2000) who argued that learners have a predominant learning mode, we found it often hard to label a learner as predominantly deep or surface in the ill-structured problem-solving context.

The third contribution of the study was the identification of *problem space* as an important additional dimension of deep and surface learning in the context of ill-structured problem solving. In this study, the students were supposed to learn instructional design through working on an instructional design project (a broader problem space) and responding to feedback (an immediate problem space). In the case of deep learning, the feedback not only prompted Mark to address immediate issues in the feedback, but also pushed him to explore the broader space of the design project. He had to navigate between the two problem spaces (the feedback and the project) to construct meaning and reach new understanding of instructional design. However, many students were unable to expand their understanding from the immediate to the broader space despite the instructor's scaffolding through feedback. Consequently, they continued to stay in a limited problem space (i.e., a shallow representation of the feedback). For those students, even though they exhibited deep learning approaches, such as elaboration and self-questioning (Chin & Brown, 2000), their approaches failed to lead to fruitful solutions because they were not solving the "right problem." At an even more surface level, students chose to narrow down their problem space, which led to a quick and tangible solution to close the case. For instance, instead of trying to understand more about target learners, Sandy opted to narrow down the learner group to eliminate the "prior knowledge issue." For this approach of narrowing down problem spaces, we coin the term *degenerative thinking*.

This study further revealed how learners of different EB and NFC might show different approaches in processing feedback. The students with mature EB who believed in the changing nature and personal construction of knowledge were more likely to invest effort in meaning making to establish a genuine understanding of feedback. Such beliefs might explain their more accurate understanding of feedback, which led to logical solutions. On the other hand, different from expected, NFC seemed to have played a less influential role in processing feedback, with its only linkage to high-NFC students' attempt to address bonus feedback. This phenomenon might be explained by the *seizing* aspect of NFC (Kruglanski & Webster, 1996), that is, to handle and clear everything out of the way early in the process in the hope of a smooth closure. However, a controversial case seems to be Caleb, a high-NFC student – while responding to bonus feedback, he only addressed half of the other feedback. More empirical studies are needed to clarify the roles of NFC and EB in learners' approaches to ill-structured problem-solving tasks.

This study offers valuable implications for instructional designers and online instructors. By identifying issues and weaknesses as learners progress along problem-based projects in online learning environments, we can develop effective tools and strategies for diagnosis, formative evaluation, and scaffolding. Online instructors may use students' responses to feedback as a strategy to pinpoint exactly the learning issues (e.g., causes of misconceptions) and follow up with appropriate scaffolding. Researchers and instructional designers may work together and apply the findings of this study to develop robust instruments for measuring students' learning-in-progress along the continuum of deep and surface learning. It follows that a self-regulated scaffolding system should be developed to intentionally target on known weak areas, prompt learners to reflect on their learning process, and engage them in deep learning activities, such as checking their understanding of feedback, examining their problem spaces, elaborating responses, integrating feedback holistically into the project, mindfully navigating between different problem spaces, and taking appropriate actions to move from inappropriate into appropriate problem spaces for productive and feasible solutions.

Moreover, this study helps us to understand motivational antecedents such as EB and NFC that underlie learners' problem-solving processes, which allows us to anticipate and address individual learners' surface approaches and foster deep learning with appropriate strategies. With further validation of empirical studies, we may use such motivational antecedents as EB and NFC to predict deep and surface learning so that appropriate strategies can be devised to help learners move towards deep learning as they gain competence in the problem-based learning environment.

Conclusions

Due to its qualitative nature and the small sample size, this study was unable to yield generalizable findings. Further, this study chose to focus on learners at the top or bottom of both EB and NFC, while leaving out those with moderate EB-NFC profiles. While recognizing the limitations, we believe that this study makes a meaningful and practical contribution to online learning. As increasing numbers of courses are offered online, it is highly important that we understand how students process feedback, which is an essential strategy for online instruction. In doing so, we are able to optimize the process in which the instructor provides constructive feedback and students respond effectively to feedback. Lastly, this study is unique in utilizing learners' EB and NFC as lenses to examine their deep and surface learning approaches in problem solving. The results of this study have generated further questions for future research. More quantitative or mixed-method studies can be conducted to verify the relationships between EB, NFC, and approaches to learning. Future studies can also examine learners with moderate EB-NFC profiles. Finally, instruments can be developed to measure deep and surface learning in the context of ill-structured problem solving.

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