Supporting Metacognition in Online, Professional Graduate Courses

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Abstract

This paper presents a model for metacognitive learning evaluation in a community of inquiry and discusses how it may be used to incentivize effective learning in online graduate courses. We identify patterns of behavior and peer-learner interactions that indicate social engagement in community model building, based on an extensive, qualitative analysis of online course discussions and student interaction data. We explore how metacognitive learning develops through socially-situated knowledge construction and demonstrate how community interactions result in deep learning. An extrinsic reward structure is suggested, in the form of a grading rubric that appears to encourage students to experiment with behaviors that provide the intrinsic rewards of metacognitive learning.

1. Introduction

The last few years have increasingly seen calls to support metacognition in online learning environments [8, 40]. Metacognition ensures deep learning by providing students with the ability to reflect upon and gauge their learning progress. This allows learners to adjust their interactions with course resources in specific ways that achieve progress in areas they perceive as weak. As a result, learners are able to achieve deep learning outcomes, as they develop more accurate mental models of their own learning goals and outcomes – and as they experiment with strategies to achieve these. Failure to manifest this behavior is so damaging and yet so common that it even has its own syndrome – the Dunning-Kruger effect[10].

There is growing evidence that metacognition can exist not only at an individual level but also *within* groups engaged in collaborative learning [14, 19]. Most educational research employs a distinction between behaviorist, cognitive, and constructivist theories of learning, derived from the psychology literature [2, 23]. But these are epistemological distinctions, based on experimental studies of individual learning activities. Scardamalia and Bereiter [27] argue that educators have failed to understand the social structures and dynamics required for progressive knowledge-building, by focusing on individuals in isolation rather than in the context of learning. This position is supported by the community-of-inquiry research, which has demonstrated the need for interactions between social, cognitive, and teaching presence [1]. But we actually have very little information about *how* students develop strategies to assess sources of information and how they evaluate and direct their learning as part of a community of learners [11]. "Learning styles" that relate to preferences for interacting with content in specific formats (i.e. visual, auditory or written) appear to have less effect upon learner participation and collaboration than intrinsic rewards, such as enjoyment [13]. Reflective, peer- and vicarious learning [21] result from different modalities of interaction with course materials and the learning community. Each modality provides intrinsic rewards that reinforce social engagement with the community of learners. We will argue below that providing extrinsic reward structures to encourage social engagement in reflective, peer- and vicarious learning provides the basis for a successful learning community.

This paper presents a review of socially-situated learning community engagement, exploring the modalities of reflective, peer- and vicarious learning. We start with a conceptual model of social engagement in online learning, then explore the modalities of student engagement in Information Systems and Information Science courses by means of examples from an extensive qualitative analysis of student participation in professional graduate, online courses. We end with a revised model of social engagement based on our findings and a framework for the evaluation of metacognitive learning in the context of professional graduate online education.

2. Conceptual Underpinnings

2.1 Models of Learner Engagement: Reflective, Peer and Vicarious Learning

Building a sense of community and fully utilizing the socio-technical capital imbued in that community are obviously of key importance to deep learning outcomes [1, 25]. Students will not enjoy the maximum benefit from a learning community if they feel themselves to be outsiders [38]. Reflective

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Learning (reflection-in-action) requires that learners construct an abstract mental model of how things work, test that model – either through structured exercises accompanied by instructor feedback, or through proposing new examples and analogies that are critiqued in community debate – and develop the model according to the feedback that they receive [29].

This requires that the learner engage in conscious cycles of constructivist learning, internalizing knowledge from information resources that have been situated in a specific context of action to provide a learning-structure or "scaffold" [24]. This may be achieved through peer learning, where students provide contextualized examples and stories for each other's benefit. Learners internalize and conceptualize peer-supplied knowledge by building mental models or abstractions of how similar situations may work, externalizing this knowledge in the form of analogies or examples that allow their understanding to be tested by peers. In this way, the ideas, suppositions, or theories of other students take on an objective reality of their own – a process known as "objectivation" [6, 33].

In a group setting this reflection-in-action requires conscious support by instructors and can be reinforced and supplemented in structured interactions with peer-learners. Not all forms of interaction are valuable – student participants will frequently respond with superficial or content-free posts such as "LOL" or "good idea" but otherwise add little to the discussion. The reward structure for participation in peer debate must be designed to encourage forms of interaction that provide stories, examples, and analogies, and forms of interaction that critique and complicate the abstractions of others.

While computer-mediated communication may make it easier to cooperate at a distance, it also makes it easier to benefit from the contributions of others while not contributing oneself [17]. Learners can appear to be passive but may be actively constructing knowledge as demonstrated by the "vicarious learner" phenomenon, where students learn from the experiences of their peers, internalizing the stories, analogies, and examples provided in discussions, even when they do not interact directly with peers [22]. Although lurkers do not engage in overt collaboration, they may still be using the community effectively for their purposes, as they engage in vicarious learning [4, 9]. In the context of online discussion these vicarious learners do not need to participate in debate as they can observe the knowledge-building debate and internalize the results. This is an especially notable strategy in professional, graduate courses, where the goal is to situate professional knowledge and methods in the context of transferable competencies and procedures.

2.2 Achieving Metacognition

Empirical studies emphasize that students need to take control of their own learning for a successful outcome, especially in an online environment [3]. Online environments must permit students to construct and to test their knowledge, as they learn. Students must develop strategies to recognize what they understand and when they need more information [8]. Instructors must develop course scaffolding structures that support this endeavor [26, 31]. Sustained interactions with a community result in "perspective-taking", where the individual internalizes the method and rationale of community practices, thus acquiring expertise[15]. The individual applies this understanding to new problems, developing new understandings that are in turn externalized back into the community through the processes of "perspective making", involving debate that develops a new community view of expert knowledge or practice [7]. Deep learning results from repeated cycles of perspective-making and perspective-taking, to develop the understanding of both the individual and the community in tandem [7, 33]. Individuals only possess a partial understanding of the problem, so group problem-solving is akin to assembling a jigsaw puzzle. Each person must contribute their part of the picture without being able to comprehend the whole, which is gradually constructed through sustained debate. A community of inquiry builds a joint, yet distributed understanding of their domain of practice [7, 20, 28]. Social engagement in joint knowledge construction appears to rely on serendipity. A diverse and often unpredictable set of peer-learners guide community knowledge-building according to individual areas of expertise. The potential for positive outcomes is high in graduate, professional courses, as these communities encompass a wider range of expertise and situated knowledge than can be provided by the instructor alone. But peer knowledge construction also engenders high levels of ambiguity, so the potential for conflicts and disagreement can also be high [27].

2.3 A Framework for Social Engagement

We have based successive versions of our model of metacognitive learning in a community of inquiry upon concepts from the literature on user-participation in systems development. This literature has a long history of research into participatory involvement in the core processes of inquiry and learning that underpin information system design. It can therefore be transferred to the processes of inquiry and learning that underpin online education. Building on the Behavioral-Attitudinal model of user engagement in systems design [5, 16], and developing our earlier model [37]

significantly, we present the metacognitive model of online learning, shown in Figure 1. We distinguish between *participation* in a process, typically assessed by the degree to which individuals play an observable part in community activities, and *involvement* in the process, which requires a psychological state of identification with process outcomes. But while Kappelman and McLean [16] define user *engagement* in system design as the superset of participation and involvement, we prefer to employ a more socially-situated definition that is relevant to community engagement. Wenger argues that mutual engagement is required to bind community members together into a social entity that constructs a repertoire of shared resources, such as collective understandings and expertise [39]. *Social engagement* denotes active commitment to the social facilitation and structuring of the community learning process and the ability to understand who-knows-what. We have previously argued that students rapidly develop the ability to identify *thought-leaders*, those peer-learners who possess expertise in various application domains (the instructor may also be viewed as a thought-leader). This leads to an awareness of from whom the learner may obtain knowledge that is valuable to the learning task in hand [37]. The process of social engagement in community debate provides a community-oriented form of metacognition, through which individuals can evaluate their state of knowledge against that demonstrated by thought-leaders and can interact with thought-leaders to engage further where necessary – asking questions or exploring concepts that others seem to understand. Deep learning does not end simply with social engagement. Students must engage in cycles of internalization, externalization, and objectivation, for reflective learning to take place [6, 33]. But social engagement is crucial in linking individual, psychological involvement with community knowledge building, because it places specific knowledge in context [35]. It is social engagement that allows students to make sense of – and therefore evaluate – the successive interactions and debates that enable *community knowledge building.* A socially-engaged community of students can construct collective understandings that persist as deep learning. These provide participants with a resource to challenge and refine "accepted wisdom." It is this, vicariously-situated understanding that accomplishes deep learning outcomes, as the community of learners evaluates which knowledge is valuable in various contexts and contingencies, providing a jointly-constructed set of knowledge resources which can be drawn upon in future work. We conclude that social engagement and community knowledge building are related in an iterative cycle that eventually produces metacognitively deep learning outcomes.

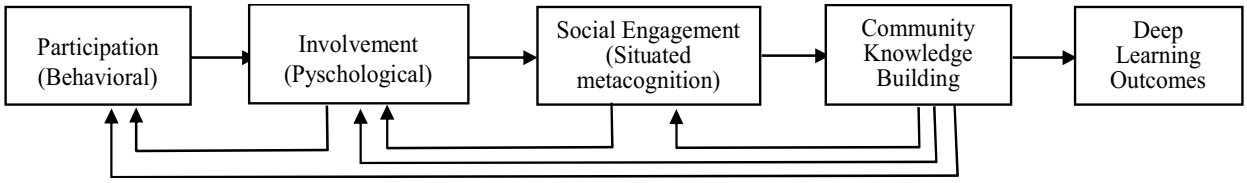

Figure 1: A metacognitive model of online learning

3. Research Method

This paper presents findings from studies conducted over a period of eight years, analyzing 17 professional graduate courses in information systems and 5 in information science. Data were gathered from the asynchronous online discussion boards from online graduate Information Systems and Information Science courses at a north American university. The data was arranged into discussion threads and analyzed qualitatively, to identify student posting, interaction, and information reuse strategies. A grounded theory approach was used to extract and iteratively refine categorization of the message content and uncover emerging patterns in student interaction and community knowledge construction [12]. We supplemented the analysis of discussion texts with activity data from course logs, to infer how students accessed ideas from other students. This provided valuable insights into our analysis that are discussed elsewhere [12, 36]. The examples demonstrate the centrality of peer-learning [32] and vicarious learning in encouraging social engagement with online courses. We therefore present evidence that includes not only active participants but also those who appear to be peripheral participants in this community of [vicarious] practice [20]. Students are actively learning behind the scenes, becoming engaged and enculturated into the community of information professionals [12, 36].

4. Findings

This section presents a set of examples of different discussion thread arcs taken from asynchronous threaded discussion board discussions. The arcs are discussed in terms of the type of cognitive and socio-

cognitive content expressed and the development of knowledge construction and sharing.

4.1 From participation to deep learning

The discussion described here was seeded by the instructor question posing the question "*does requirements analysis ever end?"*. The first four posts in the thread basically say the same thing following the orthodox line that requirements analysis never ends.

Hi everyone - Requirements analysis never really ends because it is a necessary maintenance feature for the lifetime of a system. Requirements analysis involves the management of a process to "submit proposed changes to requirements for a system."
Requirements analysis never really ends for a project because it cannot be defined in the traditional sense but instead it serves as an outline that will "frame your thinking as you proceed.
The Requirements Analysis Phase never ends because "there remains an ongoing need to continuously manage requirements through the course of the project and the lifetime of the system"
The requirements analysis never ends for a project because system improvement projects are dynamic.

This "requirements are ongoing" theme is canon in many systems development environments.

The next few posts all include segments stressing the importance of full/open communication during the systems development lifecycle of which requirements is a key phase, again a common theme. These posts fall into the category of involvement showing a definite identification with the topic such as in the example below

I couldn't agree more with the idea of communication between all stakeholders being vital to the success of any system. I have also had the opportunity to work where there was communication and it was very beneficial.

Then an interesting change occurs. Two students (S1 and S2 below) start to question their position regarding the importance of communication and by inference the consensus group position this broadens the discussion. Two more students add refinements to the question of open communication and at this point the groups appears to have reached a new consensus that open communication is compromised by practical issues. This illustrates students applying metacognitive approaches, challenging their individual understanding and that of the group.

The idea of communication with the users is a big one for me, probably because I worked at a company where lack of communication seemed inherent in the system, and I was often the user who was not being heard...
I think that you are completely correct about the importance of communication, ***I do have some rather practical concerns about such theoretical and general ideas of communication remaining*** *open. I guess my concern is that one is limited by the structure and tone of the organization itself.*
You know, as I was posting my answer, I thought to myself, ***"I wonder how practical this idea is?" I definitely understand your thoughts.*** *Would "underlings" even use it? Would they be worried about losing their jobs if they "complained" too much? ...*
Does all management respond to the need for communication as complaining? *...Just because someone might see an inefficiency with a level of their software, or hardware,* ***doesn't necessarily mean they are complaining.***
From S5 responding to S4 *I think that it is very important for members of a project to voice their opinions concerning business requirements. However, this does remind me of last week's discussion.* ***I think we noted that while communication is vital, one does not want to be swayed by excessive opinions****. ...*

The outcome of this discussion segment is a new body of community knowledge that is internalized by the participants and later brought back into other discussions. In the examples above we see a tentative pattern of initial low level (participation) contributions giving way to the kind of metacognition the model predicts.

4.2 Metacognition

The thread described here is an Example of metacognition occurring fairly early within a thread**.** Here the 1st post challenges current wisdom. The initial question from the instructor asks students to reflect on the value of the Project Managers Book of Knowledge (PMBOK) published by the Project Management Institute. The response from S5 is a first level direct response to the instructor question.

From S5 to All *...****these types of standards and best practices are often developed when there is little consensus on how various processes within professions are best conducted. Oftentimes, guidelines such as the PMBOK arise out of a desire to create formal terminologies for fields that have defined few standards and best practices. Such fields sometimes are characterized by failures at a systemic level*** *...While best practices and standards help professionals develop management techniques that are established within a field,* ***one could argue that such guidelines homogenize management techniques within industries. This could hinder creative management approaches, blocking breakthrough management strategies that do jive with existing paradigms***
From S6 to S5 *"This could hinder creative management approaches, blocking breakthrough management strategies that do jive with existing paradigms."* *This is a very unique and interesting point that I didn't see in any other posts.*

I think the hope of best practices is to give a person a set of guidelines so that they can learn and develop their skills while minimizing failures. Hopefully, experienced PM's will continue to experiment and evolve the next set of "best practices".

From S7 to S6
Although I think a PM should have autonomy with his/her project, ***I think the BOK is just a basis in which to follow to ensure you're meeting the needs of a customer. I'm certainly not condoning a PM that follows the BOK as a set of rules, I just think it can be helpful to assure you're going about things the right way. Especially for those that may not have a lot of experience in PB.***

From S8 to S6
To add to your point... you may be given freedom in what you're allowed to do as well.

From S10 to S5 " one could argue that such guidelines homogenize management techniques within industries. This could hinder creative management approaches, blocking breakthrough management strategies that do jive with existing paradigms". ***This is a fair argument but the benefits of having guidelines such as the PMBOK probably outweigh the cons.*** *The question I'd like to ask you is this -* ***how would you see the PMP work with , or be altered to facilitate the acceptance and entertainment of new and creative techniques****?*

From S5 to S10 ***I think that many guidelines and standards that deal with management issues allow companies and professionals to tailor processes to specific needs. Many of our classmates have taken the same side in their posts and say that "best practices" should be used as a sort of guideline that can be tweaked or changed****.*

In the above segment not only are there challenges to orthodoxy but each respondent adds a unique perspective and several critically evaluate the added perspectives which adds to the group knowledge. As these contributions are framed within an active discussion they can be used (observed) by vicarious learners on the periphery.

4.3 Community knowledge building.

As discussion proceeds through the stages in the model we hope to arrive at some kind of synthesis. In this case we are looking for posts that wrap-up the discussion. We might consider these posts as *closers*, attempts to synthesize a group understanding from the discussion. From our prior research these represent fairly rare occurrences and tend to end threads. Below are a few examples, with each quote (cell) representing a closing statement in a separate discussion.

How does this impact project management? Well, in many ways I don't think it does. However, it does suggest that project managers should have a strong understanding of the fact that work phases will be greatly intertwined. It is likely that work will need to be done on previously developed components to accommodate changing requirements. Project managers should anticipate these modifications and schedule time for them into the resource plan.

There will always be conflicts as long as the project is intended to server a multi-culture society. It is usually the skill of the feasibility team that will determine the success or failure of the feasibility analysis and ultimately the success or failure of the project. thanks, S17

If I were to develop a system where each item had to have an identification number, I would assign them each a barcode, that way if there were multiple copies with the same ISBN, or the same call number the barcode could serve as an individualized primary key. This could also solve the issue of the absence of a call number or ISBN which happens.

4.4 Persistent deep learning

A key goal is to achieve deep learning that follows students across course topics and weeks, not simply vanishing at the end of the week's discussion. The segment below shows students making references to prior material.

As we have mentioned from week to week, people that control budgets do not like the idea of total agility, as they perceive it as a money pit. It is important to be prepared with traditional methods, but follow an agile approach in a more internal way.

A few weeks ago, I would've been on-board with that statement, but through our discussion and research I've come to realize/understand that certain TPM approaches do have validity, I used bridge building as an example a couple of weeks ago.

4.5 Vicarious learning and transitioning through levels of discussion.

We have shown groups of students moving between different levels of participation. Is it possible to see similar patterns from individuals?

Student S18 from our 2011 dataset was an archetypal lurker or freeloader , the least involved student for the cohort posting exactly 1 rather superficial message per week, nevertheless by week 8 this peripheral participant had clearly been enculturated by the preceding discussions as shown when she answers a question by drawing upon themes discussed in earlier weeks.

I think we can definitely be adaptive within the guidelines of the PMBOK. Learning and knowing that the phases detailed within the PMBOK, especially the planning stage, never actually end goes a long what toward this goal. In order to be adaptive within the PMBOK, I believe you must understand that none of the phases end and they are constantly in progress until the project finishes. You aren't ever finished planning or finished development, but have only gotten it to a point where it can be presented.

As weeks went by, many students showed a more gradual transition to different modes of participation. The segment below shows selected posts from one student changing over time from superficial in week 1 but moving to deeper levels of interaction in later weeks.

Participation (Week 1) *(Student presents a superficial answer as a contractual obligation)*	***What do you see as the key project management skills?*** *As a generic list of important skills, budgeting, planning, time management, motivating and managing a team of employees effectively. The priority list depends on the project and the organization you are working with.*
Involvement (Week 3) *(Student shows a state of psychological involvement)*	*It's not a matter of one or the other. It's important to understand the business as well as the development of various components. If you can't understand the core business , then , complications in development become much harder to address..*
Social Engagement (Week 5) *(Student is engaged in iterative set of contributions, acknowledging a contribution but challenging it and presenting a scenario of community interest)*	*Yes but like I said, the promoted person was from a completely different department so she had no directly relevant experience in the field. The fact that she was 20 years younger is just an additional slap in the face... The biggest deciding factor was that the promoted person had a degree while the woman with 10 exp did not. I realize that not everyone should be promoted just because their next in line- but if you're next in line and get passed over, it still hurts and needs to be taken into account by management.*
Community Learning (Week 10) *(Student attempts to synthesize an answer to the question showing the impact of different vendor approaches)*	*A lot depends on who is doing the installation and customization. I've had COTS products you cut the vendor a check, then they dump this monstrous piece of software on your server, hand you a few instruction booklets and say "call us if you need help!" A lot of the onus is on your in-house staff to develop the software to adequate use. I've also seen the opposite where the vendor is extremely helpful.*
Persistent Deep Learning (Week 8) *(Student shows that her opinions have been changed by discussions)*	*A few weeks ago, I would've been on-board with that statement, but through our discussion and research I've come to realize/understand that certain TPM approaches do have validity*

5. Discussion of Findings

5.1 An Extended Model of Metacognition in Online Learning

When constructing the original model in Figure 1, we argued that each of the model behavior-constructs builds on the preceding one, to achieve deep learning outcomes. Social engagement requires ongoing involvement in learning, while community knowledge building is enabled by the situated (within the community of inquiry) metacognition that is achieved through ongoing social engagement. Social engagement leads to various forms of community knowledge-building, which in turn leads to the deep learning outcomes explored in this study. The thread in Section 4.1 demonstrates movement from the most basic participation all the way to deep learning. The thread in section 4.2 shows extensive self-evaluation (metacognition), conducted across and between students, rather than simply at an individual level. Section 4.3 provides examples of how students synthesize new knowledge for others, as a result of metacognitive learning. Section 4.5 demonstrates that even lurkers (non-participants in the discussion) can be engaged in an enriching experience and suggest that vicarious learning is an important mechanism for knowledge exchange.

The examples shown above demonstrate that this movement is not just in one direction. Community knowledge building leads back to an increase in low level participation where students simply want to get on board. For instance in section 4.2 a lurker (S8) gets drawn into the discussion albeit at a low level. Similarly Social engagement encourages students to be more *involved* in the community. Thus we argue that there are multiple reinforcement mechanisms (the various feedback loops) that result in metacognitive learning outcomes. The revised model, presented in Figure 2, summarizes these mechanisms. It illustrates how deep learning in one context can find its way back into active discussions, both as canon (community knowledge) and as a source of discussion by others.

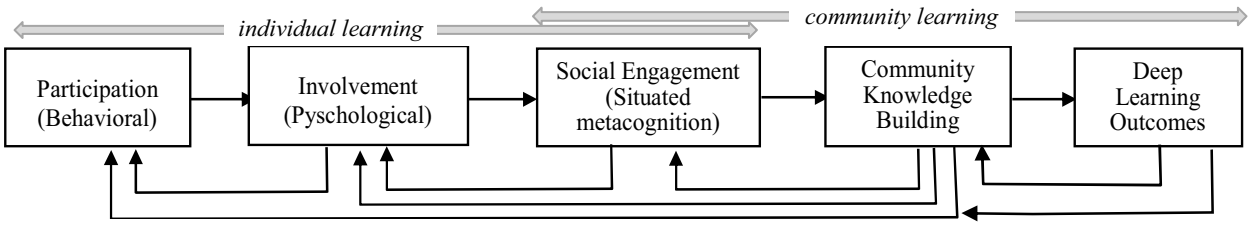

Figure 2: The extended metacognitive model of online learning

In the findings above, we have demonstrated how social engagement and community knowledge building may help us to define a reward-structure that would reinforce the desired behaviors. These rewards may be intrinsic or created by other motivating factors such as higher grades for higher quality student contributions. The model in Figure 2 suggests that situated metacognition is achieved through constant feedback loops between collective and individual learning evaluation. Our data indicates that students who engage in three behaviors which we refer to as Thought-Leader, Complicator and Synthesizer are central to this socially-situated, deep learning:

"*Thought-Leader*" posts provide examples that are situated in a specific context of application, explaining how and why specific processes, methods, or activities led to various consequences, within that context of action;

"*Complicator*" posts reframe and challenge group understanding, by questioning, critiquing and/or extending the underlying model suggested by analyst posts.

"*Synthesizer*" posts (which are rare), articulate and make obvious the underlying abstraction, enabling others to learn from the conceptual structures (mental models) underpinning the debate. This is a role that the instructor can play towards the end of the debate.

The objectified community knowledge that results from one context, such as a discussion, can find itself reused in other contexts - this feeds back to individual learning stages of the model. Even deep learning does not represent a final stage of knowledge. Socially-constructed, joint knowledge becomes accepted community wisdom, which in turn provides both a foundation for discussion and a suitable source of challenge during the metacognitive learning stage. Deep learning from one context feeds into subsequent cycles of knowledge development, for application in new contexts and learning tasks.

The model above represents a slightly idealized view. When using this as a theoretical lens for analyzing online discussion we found that not all discussions followed the arc described in Figure 2. Some discussions did not rise above superficial "me too" responses indicating the lowest level of participation. On the other hand we were able to find examples where rich discourse happened from a cold start with multiple participants complicating or reframing the discussion and challenging orthodox thinking. Elements which may have affected the arc of discussions included personal relevance to students, the extent of instructor moderation, the nature of scaffolding materials and question design, we have explored these issues elsewhere [35, 36].

5.2 Recommendations for Course Design

We base our recommendations for course design on our finding that the use of social media platforms, blogs, WIKIs, and collaboration tools may be counter-productive for professional, part-time students, who lack the cognitive surplus [30] to engage with "disruptive" learning platforms. Instead, well-designed course scaffolds and reward-structures that promote social engagement with the community encourage students to engage in metacognitive learning. Based on our analysis, we propose a revised model for metacognition as shown in Figure 2.

Our final aim is for online collaborative learning to achieve deep persistent learning. Learning that students will internalize and can use in other discussions or other courses. We believe that sometimes this requires gently nudging the discussion. Simply providing positive feedback, while necessary is not sufficient and indeed excessive feedback frequently leads to the instructor becoming the central player. Instructor feedback that rewards students for posting challenging material but that at the same time asks them to go further for instance asking them to reconcile the opinions of others, or add a level of complexity to the discussion should keep discussion active, for example:

But when you are doing something new (which seems to be about 80% of the projects that I hear about), you don't have much of a basis for this type of approach. So - guys - how do you estimate really novel projects? How good an estimate do you think you get?)

Feedback should encourage metacognition either individually or as a group (as per Section 4.3) as this can lead to deep learning. However since metacognition is fed by involvement instructor feedback should attempt to instill a sense of psychological relevance. In section 4.1 students very quickly arrive at a consensus as to the importance of constantly reviewing requirements and from this point some are brave enough to engage in self-evaluation, but without the ownership of the topic this may not have happened.

Material should be personally relevant if possible, or at least relevant to the students' current or anticipated profession, this should led to greater involvement. Questions should be framed to encourage students to be willing to challenge orthodox wisdom (engaging in metacognition) or even the instructor's wisdom without fear, thus question wording should not imply any particular expected answers. Supporting materials should give students background information that is sufficiently structured to provide a scaffold for

abstraction without leading them to form specific models that they don't understand.

An explicit rubric that rewards reflective contributions is required to ensure that a sufficient number of students engage in the three social engagement community role-behaviors defined above – Thought-Leader, Complicator, and Synthesizer – for other members of the community to engage in reflective, peer, and vicarious learning. A rubric that we developed, on the basis of our findings, defines various levels of contribution in Table 1.

Table 1. Rubric to reward *social engagement*

Grade	Description
A+	Consistently participates, debates points, and provides unique insights from their own experience, which significantly advance the understanding of others. Provides resources and interpretations of topic from research and reading. Frequently interacts with other students in debate, adding to, complicating, and extending their insights multiple times (*at least* 3 days each week).
A	Consistently participates by attempting to explain relevant issues, providing insights and resources from own experiences or research. In addition, often interacts with other students in debate (at least 2 – 3 days in each week), and *complicates the ideas of others* at least once during that week.
A-	Frequently participates by attempting to clarify relevant issues, based on their own experience or research into the experience of others. Interacts with other students regularly, to provide examples or extend their ideas. *Thinks about issues and responds insightfully* (at least 2 different days/wk.).
B+	Joins discussion by asking questions or posting thoughtful comments to clarify issues. Interacts occasionally with other students, to provide examples or extend their ideas. *Thinks about issues and responds insightfully.*
B	"I have no experience, so I have nothing to say. Here's a summary of something that I read." (with attribution and your own summary). Responds to others with additional information.
B-	Quotes relevant parts of web articles verbatim, without adding any insights. Does not discuss the ideas in detail. *But at least they did the research ...*
C	Good observer, participates at end of week, usually only contractually by reiterating things that people have already said, or commenting on the ideas of others ("that's a good idea, Jake!").
D	Frequently takes up air time with nothing to say. Does very little to contribute to the learning of others, not even by questioning.
D-	Very little indication of cerebral activity during class discussions. Does not want to think about topic, so posts a short comment to get the grade.
F	Posts a witty one-liner and is never heard from again ("I had nothing to say that others had not already said" is just an excuse for not bothering to think about the topic – there is always something to respond to, in a *discussion*).

5.3 Instructional Metacognition Framework

Metacognition is regarded as the "holy grail" of constructivist learning. It is defined as the self-conscious or reflective ability to be aware of one's own state of knowledge and the need to learn [8]. People *guide their own learning* by thinking, exploring, and debating ideas until they understand them:

"Cognitive psychologists use the term metacognition to describe our ability to assess our own skills, knowledge, or learning. That ability affects how well and how long students study—which, of course, affects how much and how deeply they learn. Students with poor metacognition skills will often shorten their study time prematurely, thinking that they have mastered course material that they barely know." [18].

Being able to recognize when students have engaged in metacognitive learning processes within the context of a course learning community, which by nature is a messy and complex learning environment, is a key instructor capability. We present our model, examples, and a conceptual framework as part of our ongoing endeavor to develop tools and frameworks by which we may improve instruction. Table 2 summarizes the various mechanisms by which adult, professional learners interact with the community of learners in online courses. This framework relies on the following definitions of constructivist learning processes, synthesized from various sources discussed in our conceptual underpinnings [6, 29, 33, 34].

Internalization: the construction of knowledge and abstractions by reading and absorbing examples and stories from others (vicarious knowledge).

Externalization: the ability to express knowledge and abstractions that you have learned (reflection in action *or* reflection in discourse).

Social objectification: the process by which knowledge and abstractions become accepted as a valid theory/model by others, so that they are independent of one's own framing and known by the community.

Thought-leaders: community members who generate "objectified" knowledge because they express group ideas in terms of exemplars and stories [37].

6. Conclusions

Our findings indicate that online discussion can be rich and multi-layered, if there is sufficient foundation and if certain types of contribution are forthcoming. Deep learning generated from metacognitive approaches can be both persistent as scaffolding material and the source of further metacognition. We presented a model that represents online learning as an arc of interactions that are progressively more cognitively-complex and socially-oriented. We presented a rubric to support complex discussions which transcend the usual "me too" responses.

Table 2. Modalities of Social Engagement in Online Communities of Inquiry

Level	Form of Activity (Process)	Conditions Required (Scaffolding)	Evaluation (Factors Observable)
Participation	Observable behavior that denotes interaction with course materials through passive activity (externalization).	Experiential learning: design of course activities and resources to support reflection-in action.	a) Frequency of posting to discussion; relevance of posts to topic. b) Evidence of contextually-situated learning, that results from the active construction of knowledge within a learning community.
Involvement	Behavior that indicates a psychological state of identification with course objects (internalization).	Vicarious learning: provision of information resources that provide an intellectual structure for domain "problem."	a) Use of frameworks and methods provided in course materials, in assignments or discussion posts. b) Use of frameworks and methods suggested by peer-learners, in assignments or discussion posts.
Social Engagement	Behavior indicating metacognitive learning (cycles of internalization, externalization and social objectification).	Reward structure (e.g. grading rubric) that encourages social interaction, peer-learning, and mediation of group debate.	a) Explication of professional knowledge derived from individual experience (reflection-in-action). b) (Inter)active co-construction of knowledge with peer learners. c) Synthesis and complication of group perspectives as part of interactive debate with peer learners.
Community Knowledge Building	Cyclical patterns of interaction that lead to metacognitive outcomes	Environment that permits ongoing, sustained interaction	a) People derive syntheses of the topic b) Learners reference their peers in other work c) People frame concepts differently following discussion
Deep Learning	Concepts are abstracted from discussions and applied elsewhere	Explicit definition of concept; Recognition of concept value	a) Similar concepts articulated in different discussions b) Concepts from discussion articulated in written work c) Concepts from discussion applied to written analysis

Future research will explore student progression through the model more widely and will investigate ways of validating the model. We plan to analyze more of our data sets or acquire suitably anonymized data sets from other disciplines. This will allow us to see how the model applies to different contexts and how it should be modified to cater for a wider set of course designs and instructional methods. We will compare the reward schema, evaluating social engagement in identical classes using our rubric vs. a generic rubric.

We have demonstrated that online discussion can rise above the superficial given sufficient impetus, good material and question design, subtle moderation and a rewards structure that does not alienate the more mundane posters but encourages them to take more chances and be more adventurous. Even "lurkers" can be drawn into making strong contributions. Certainly we have been encouraged by learners who seemingly from nowhere surprise us with insightful and challenging questions. The model and our data suggest that with sufficient incentive many more relatively passive participants can be drawn out. Our suggested grading rubric allows participants to understand how high quality contributions will be rewarded and allows moderators to judge students' social engagement.

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