Annotating discussions centred on an unseen artefact using an extended version of the ICAP framework

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2 September 2020

1   Introduction

The annotation guidelines presented in this document were developed to inform the labelling of student discussion forum messages using an extended version of the **ICAP framework** (Chi and Wylie, 2014), particularly in the context of an artefact, such as a video presentation, that is not available to the annotators. The extended ICAP framework has been used to label messages from MOOC discussion forums and annotated textbooks (Wang et al., 2016b; Yogev et al., 2018). The guidelines in that earlier work were adapted here to allow the framework labels to be applied to a discussion where each message thread is a response to a video presentation that is not available to the annotators (Farrow et al., 2020).

The ICAP framework defines cognitive engagement based on observable behaviours. It looks at individual learning activities and how they relate to students' cognitive engagement with the learning materials. Four modes of cognitive engagement are identified, and the framework predicts that higher modes will be correlated with greater learning gains. In descending order, these modes are **I**nteractive, **C**onstructive, **A**ctive, and **P**assive. Each mode represents a qualitatively different *kind* of growth in knowledge, not simply a bigger or smaller change. Nevertheless, each mode subsumes the modes below it (Figure 1). Off-task behaviours do not constitute any sort of cognitive engagement.

The lowest mode in the framework, *Passive* engagement, corresponds to the least taxing on-task activities; for example, watching a video or reading a discussion forum post. *Active* engagement covers activities that demand the student's attention, such as taking verbatim notes or reworking previous content. To qualify as *Constructive* engagement, novel output must be generated; for example, summary notes that link together concepts, or a list of relevant external resources. *Interactive* engagement requires interaction with a partner, and both partners must be engaged constructively. Off-task behaviours do not constitute cognitive engagement at all.

Prior work has demonstrated the feasibility of applying a modified version of the ICAP framework to MOOC discussion forums (Wang et al., 2016b) and to student comments on an annotated electronic course text (Yogev et al., 2018). In common with Yogev et al. (2018), this work looks at the case where the discussion centres around a pre-existing artefact. In the earlier work, that artefact was an electronic course text. Participants highlighted sections of
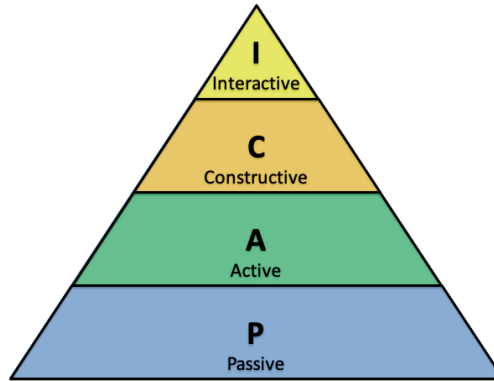
Figure 1: The hierarchical modes of cognitive engagement in the ICAP framework.

the text and added their own comments, questions, and answers, such that the discussion was grounded in the text. Here, we present guidelines for assigning labels to a data set where the relevant artefact is a video presentation, prepared by one of the discussion participants, and not available to the annotators. Annotators must therefore judge based on context whether a comment is simply paraphrasing, repeating, or requesting clarification about content from the recording (*Active* mode); or whether it introduces something new beyond what was already given (*Constructive* mode).

2 The extended label set

We build on the extended cognitive engagement taxonomy used in Yogev et al. (2018). This allows for finer-grained distinctions between messages within two of the original modes: *Constructive* mode is divided into *Constructive Reasoning* and *Constructive Extending*, while *Active* mode is divided into *Active Targeted* and *Active General*.

Like Yogev et al., we also treat affirmation messages as a special case. However, we differ in the way we handle these messages during the labelling process. In that earlier work, messages of agreement or thanks expressed in response to an earlier message had a label assigned to them that depended on the label of that earlier message. If the earlier message was labelled as *Interactive* or *Constructive Reasoning*, then the affirmation message was labelled as *Constructive Extending*; in all other cases, the affirmation message simply inherited the earlier label.

For the purpose of developing an automated classifier that can label future data reliably, it is preferable to assign each label based only on attributes of the current message. Otherwise, two affirmation messages with identical content (*e.g.*, *"Thanks for your helpful reply"*), and appearing in the same position within a discussion thread, could receive different labels depending on the labels of the earlier messages. Therefore, our guidelines do not assign the derived label to affirmation messages directly. Instead, the *Affirmation* label is used as a placeholder for messages that affirm what another user said about the current topic in an earlier message (*e.g.* an agreement or thank you). Once all the messages in the data set

have had labels assigned (manually or using an automated classifier), a simple rule-based transformation can be applied to relabel all *Affirmation* messages, based on the labels that were assigned to the messages they are affirming.[1]

The full extended ICAP label set is presented in Table 1. All of the labels are described in more detail in Section 4, and positive and negative examples are given for each label based on messages exchanged in an online Software Engineering course where students were responding to video presentations.

Table 1: The extended ICAP labelling scheme, adapted from Yogev et al. (2018).

Cognitive engagement mode	Label	Example behaviour
Off-task	**O**	Commenting without any relation to the current topic or the course content
Interactive	**I**	Displaying explanation or reasoning about the current topic in response to an earlier message
Constructive Reasoning	**C1**	Displaying explanation or reasoning about the current topic
Constructive Extending	**C2**	Introducing new content about the current topic to the discussion
Affirmation	**F**	Affirming what was said in an earlier message
Active Targeted	**A1**	Referencing specific previous content
Active General	**A2**	Showing other signs of being engaged with course content
Passive	**P**	Reading messages without responding

3   The labelling process

Every message is assigned a single label: either the *Off-task* label, or else a specific label from the extended ICAP label set. On-task messages can relate to the *current topic* for a particular discussion thread, or can address the *course content* more generally (see definitions below). A message that does not relate to either course content or the current topic is *Off-task*. The definitions of *current topic* and *course content* presented below are also used in the label definitions for on-task messages in Section 4.

If a message includes evidence of multiple on-task behaviours, the label corresponding to the highest mode of cognitive engagement that was identified in the message is chosen. For example, if a message demonstrates both *Interactive* and *Affirmation* behaviours, it is labelled as *Interactive*. The flow chart in Appendix A represents the labelling process visually[2].

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[1]See Farrow et al. (2020) for further discussion on this point.

[2]In the flow chart text, each message is referred to as a discussion 'post'

3.1   Current topic

The current topic is defined by the content of the video presentation, where a research paper is presented. The current topic includes the academic content discussed in the presentation; the concepts, frameworks, tools, experiments, results, and theories described in the paper; and the paper itself as an object of study.

However, technical and stylistic aspects of the video presentation – such as comments on presentation skills, the clarity of the audio, or the design of the slides – are *not* considered part of the current topic; they belong, instead, to the broader course content.

3.2   Course content

Course content includes course logistics; lectures, presentations, reading lists, and assignments; and relevant personal experience. Course content does *not* include personal introductions or motivation for taking the course (these are considered off-topic).

4   Label definitions and constraints

There are two general constraints on the use of certain labels. The first is that messages can only be labelled as *Interactive* or *Affirmation* if they are responding to the *content* of a previous message in the discussion – to build on it or to affirm it, respectively. In particular, this means that where a message simply presents a link to a video presentation or a research paper and has no substantive textual content itself, the replies to that message cannot be labelled as *Interactive* or *Affirmation*.

The second important constraint is that *Interactive* and *Constructive* messages must relate to the current topic (Section 3.1), and not only to general course content (Section 3.2). In this, we follow Wang et al. (2016a), who say, *"If the student is reasoning about scoring rubric, that's categorized as active behavior, because that only shows the student is paying attention to course materials, but not that he/she is engaged in constructive behavior for the purpose of learning."*

In the rest of this section, we define each of the labels and give positive and negative examples from an English language data set to illustrate the definitions and constraints.

4.1   Off-task messages (O)

Off-task messages only talk about content that is totally unrelated to both the current topic and the course content. For example, *"Ah yes the beach boys. I should have gotten that one"*. Blank messages sent in error will also get this label, as will truncated messages that have no relevant content (for example, *"Hi [NAME]"*).

Where identical duplicate messages are sent in error, an argument could be made to treat all except the first copy as *Off-task*. However, we have decided to follow the same principle described above for *Affirmation* messages (Section 2) and label each message based primarily on its own content. Thus, we give all duplicate messages the same label, based on the message content.

4.2 Interactive mode (I)

Interactive mode applies to messages that display explanation or reasoning about the current topic in response to an earlier message, and build on what was said in that message. The earlier message must contain some substantive content (Section 3). Explanation and reasoning are defined as for *Constructive Reasoning*, below. For a message to be labelled as *Interactive*, two additional requirements must be met: the message must be a direct response to the content of another message earlier in the discussion (not just to the linked presentation); and the message must continue the discussion from the earlier message (explicitly or implicitly). For example, *"You say that since X is 40 years old there should be some laws now. But I see it this way; since X is 40 years old and there are no laws yet that must mean that they are really hard to define"*.

4.3 Constructive Reasoning mode (C1)

Constructive Reasoning mode applies to messages that display explanation or reasoning about the current topic (not simply paraphrasing or repeating). Note that reasoning does not need to be valid and explanations do not need to be correct! Explanation and reasoning includes proposing an explanation, or a cause and effect relationship; comparing or distinguishing between two or more conditions; elaborating on a point made in the linked student presentation or in a message earlier in the discussion; making a statement about the current topic and justifying it with evidence or personal examples; making a statement or asking a question about the current topic, giving reasons why the commenter thinks this way. For example, *"Did the authors talk about requirements engineering in the context of various X methodologies? Because each X treats the requirements engineering process very differently (Y versus Z) I'm wondering how the topics they covered would change in these contexts."*

Note that simply asking a question about whether A or B is the case does not count as reasoning. The commenter must also explain why they expect A to hold but not B, or why they expect behaviour under conditions P and Q to be the same (or different). Likewise, stating an opinion without justification is not enough; for example, *"My opinion is that legacy methodologies like X and Y simply do not work. In fact I have abandoned any ideas that they could work."*

In the same way, mentioning personal experience to affirm a previous contribution does not meet this criterion if there is no reasoning involved. For example, *"My experience matches the ideas presented by the authors - I've been involved in projects with too much budget and schedules - they were not completed well or ultimately failed."*

4.4 Constructive Extending mode (C2)

Constructive Extending mode applies to messages that introduce new content about the current topic to the discussion (not simply paraphrasing or repeating). New content can include a link to a video presentation; information from the presented paper that was not previously mentioned; a reference to other documents or resources about the current topic not previously mentioned; or a question, answer, or comment that is related to the current

topic, going beyond what has already been said in earlier messages, but not including any explanation or reasoning. For example, *"Traditionally requirements have been difficult to nail down upfront. Why would obtaining usability requirements have more success than obtaining business requirements?"*

When material from the presented paper is introduced into the discussion, annotators must use their judgement to determine whether is likely to be a paraphrase of the original presentation (and should thus be classified as *Active* not *Constructive*). References to other documents or resources must be specific enough that another discussion participant could reasonably be expected to identify the source. It is not enough to say, *"I did a quick search on the Web for testing best practises and found a lot of information."* In contrast, the following would be acceptable as a reference: *"[AUTHORS] referenced in Unit 3 Section 3 criticized Z along more practical lines."*

Finally, a novel question is not enough if no new content is added to the discussion. For example, *"Did the author mention anything about using A and B to improve performance at the middle layer level?"* However, a question that is introduced with context that contributes to the discussion is acceptable; for example, *"I noticed authors of the paper did not mention much about X. What are your views on this hybrid of Y and Z?"*

4.5 Affirmation messages (F)

Affirmation messages express agreement or thanks in response to an earlier message; for example, *"Yes it is possible to extend the concept of X to data warehousing/ business intelligence It is a good idea for research; I will have to look into it. If we keep in mind Y. It is an interesting idea Thanks for the comments appreciated"*. The earlier message must contain some substantive content (Section 3).

It is not appropriate to use this label if the affirmation relates to the presentation itself rather than the content of a discussion message. For example, *"Excellent presentation; very well placed! Very clear and informative."*

4.6 Active Targeted mode (A1)

Active Targeted mode applies to messages that reference specific previous content (quoting, paraphrasing, repeating, linking, or questioning). This includes asking or answering clarification questions about specific points in the linked presentation or in earlier messages without adding any new content, explanation, or insight; paraphrasing or repeating something from the linked presentation or from earlier messages; or making connections between resources already mentioned. For example, *"The presentation mentions X. Could you explain this a bit more?"* and *"No unfortunately there did not seem to be any physical implementation. This was a study only comparing their model to the simulation."*

The reference to previous content must be specific, unlike this message: *"Thanks for your presentation. It was a very interesting and informative presentation. I would like to know how to start implementing such a technology into already existing systems. Has the authors mentioned anything like this??"*

4.7 Active General mode (A2)

Active General mode applies to messages that show signs that the user is engaged with course content (explicitly or implicitly). Signs of engagement can include asking general questions about the current topic (*"is it useful?"*); making non-specific references to earlier messages (*"as others said"*), the linked presentation (*"great presentation"*), or other unspecified documents (*"I read something that said"*); continuing a previous on-topic conversation (*"you're welcome"*); reporting a technical issue (*"the font was too fuzzy"*, *"background noise"*); and talking about administrative matters. For example, *"The presentation was well organized and covered the requirements for [this course]"*.

If a specific named concept technology from the presentation is mentioned, the message should instead be tagged as *Active Targeted*. For example, *"Interesting topic. Do you know of any other system which tags video with which to compare X?"*.

4.8 Passive mode (P)

Passive mode relates to passive engagement with course content, such as reading messages or watching the video without responding. We do not use the *Passive* label because our data set does not include the relevant tracking information.

References

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A   ICAP annotation scheme

Course content includes:
- course logistics
- lectures, presentations, reading lists, and assignments
- personal experience if directly related to course content
- **but not** personal introductions, motivation for taking the course (these are considered off-topic)

The current topic includes:
- the content discussed in the linked presentation of a paper
- the concepts, frameworks, experiments, results, and theories described in the paper
- the paper itself as an object of study
- **but not** technical and stylistic aspects of the presentation

Explanation and reasoning includes:
- proposing an explanation, or a cause and effect relationship
- comparing or distinguishing between two or more conditions
- elaborating on a point made in the linked student presentation or in a post earlier in the discussion
- making a statement about the current topic and justifying it with evidence or personal examples
- making a statement or asking a question about the current topic, giving reasons why the commenter thinks this way

New content includes:
- a link to a student presentation
- information from the presented paper not previously mentioned
- a reference to other documents or resources about the current topic not previously mentioned
- a question, answer, or comment that adds to the current topic, going beyond what has already been said in earlier posts, but not including any explanation or reasoning

Referencing content includes:
- asking or answering clarification questions about specific points in the linked presentation or in earlier posts, without adding any new content, explanation, or insight
- paraphrasing or repeating something from the linked presentation or from earlier posts
- making connections between resources already mentioned

Signs of engagement include:
- asking general questions about the current topic ("is it useful?")
- making non-specific references to earlier posts ("as others said"), the linked presentation ("great presentation"), or other documents ("I read something that said")
- continuing a previous on-topic conversation ("you're welcome")
- reporting a technical issue ("the font was too fuzzy", "background noise")
- talking about administrative matters

Extended ICAP annotation flow chart v1.8
Elaine Farrow 15 January 2020

Posts labelled as affirmation:
- A post labelled **F** will be post-processed later using simple rules to give it a new label based on the label of the earlier post to which it is replying
- If the earlier post is **I**, **C1**, or **C2**, the new label will be **C2**
- Otherwise, the new label will be the same as the label of the earlier post

Adapted from the interactive decision tree in Yogev, E., Gal, K., Karger, D., Facciotti, M. T., & Igo, M. (2018). Classifying and visualizing students' cognitive engagement in course readings. In Proceedings of the Fifth Annual ACM Conference on Learning at Scale - L@S '18 (pp. 1–10). New York, New York, USA: ACM Press. https://doi.org/10.1145/3231644.3231648