

## Engineering professional identity practices: Investigating the use of web search in collaborative decision making

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Collaborative learning and problem solving are important aspects of engineering professional practice that need to be addressed in preparing competent engineering graduates and forming their professional identities. Taking the *learning as becoming a professional* perspective, we illustrate the diversity of engineering practices in a collaborative decision-making episode, where students' participation in the activity is mediated by their use of web search. We present how our development of the *implied identity* approach could help to understand how technology mediates collaborative sense making in relation to professional practices and identities. We illustrate this by providing examples of ways in which students use web information to justify their decision making.

Keywords: Collaborative learning, Engineering education, Implied identity, Professional identity, Sense making, Web search

### Introduction and background

Higher education is expected to prepare globally competent professionals in different areas, such as engineering, teaching, and medicine. In other words, learning in higher education should be oriented towards becoming a professional and the development of one's professional identity. In this paper we explore professional engineering identity practices during collaborative work.

Identity is a central aspect of learning from a situative perspective (Wenger, 1998). From this perspective, identity formation and learning practices are inseparable and jointly accomplished between individuals through their interaction with context, tools, and cultural norms. Therefore, understanding learning practices requires looking at joint accomplishments through engagement and participation in particular activities (Greeno, 1998; Lave & Wenger, 1991; Rogoff & Lave, 1984; Wenger, 1998; Gresalfi, 2009; Langer-Osuna, 2011; Hand & Gresalfi, 2015; Cobb et al., 2009; Gresalfi & Cobb, 2011).

### Web search mediated collaboration and sense making

Information seeking and sense making are two important aspects of collaborative learning and problem solving. There is an increasing attention to collaborative information seeking (Twidale, Nichols, & Paice, 1997; Hansen & Jarvelin, 2005; Reddy & Spence, 2008) and sense making in different fields of studies (Jacobson, 1991; Dervin, 2003; Sarmiento & Stahl, 2006; Paul & Morris, 2011). On the importance of sense making, research has shown information-seeking practices in organizations are more influenced by participants' understanding of the information, than the information itself (Hansen, & Jarvelin 2005). Sense making plays a crucial role in collaborative learning and decision making. However, understanding how technology mediates the process is still a challenging problem and an important issue to be addressed (Whittaker, 2008).

In addition, little is known about technology mediated collaboration and sense making in relation to identity practices. Understanding collaborative practices of identity is particularly important when looking at learning in the context of higher education and more specifically in areas such as engineering education where teamwork projects are at the core of students' assignments and activities. Students' collaboration is often mediated by using different resources such as web information. Although web search engines are mainly designed to serve individuals for information seeking purposes, there is evidence of collaborative access and decision making in web search (Evans & Chi, 2008). In this paper, we explore joint accomplishments of identity in a collaborative problem solving environment mediated by web search. Following this, we briefly review approaches in identity research that may inform such inquiry.

## Sense making in identity practices

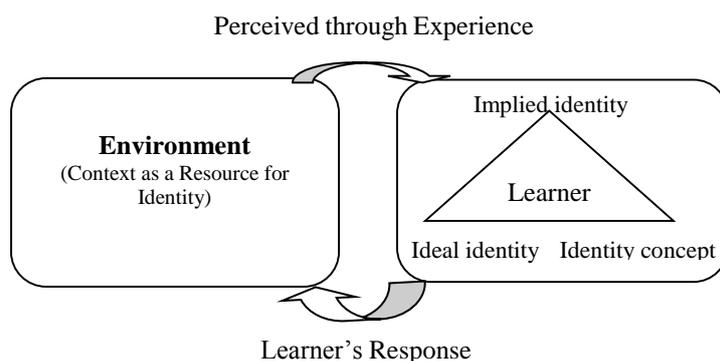
Sense making in identity research can be approached by looking at a person's (or group's) response to the affordances of the environment. Studies addressing this concern often distinguish between one's identity and expectations of *being*. Previous research have coined terms to differentiate *normative* and *personal* identity (Cobb, Gresalfi, & Hodge 2009), *actual* and *designated* (expected) identity (Sfard & Prusak, 2005), and *intended* and *implied* identity (Khosronejad, Reimann, & Markauskaite 2015). Cobb and colleagues (2009) have identified normative identity in the context of mathematics education, as "a doer of mathematics that is established in the classroom" and looked at personal identities that "individual students develop as they participate in class room activities" (p. 43). They further demonstrated that learners articulate different forms of expectation- of what it meant to participate in mathematics- in their class. Furthermore, learners have a preference for specific norms, due to the ways they perceived themselves.

According to the recent study of identity practices (Khosronejad et al. 2015) such differences in perceived normative identities can be explained through the concept of *implied identity*- as the mediator between the social environment and people. The concept refers to interpretations of normative identities. In the current study, we apply the implied identity framework, as we are interested in understanding how aspects of identity are perceived and put into practice through a group's interaction and use of resources including web information. Therefore, we build on previous research to unpack technology mediated collaborative practices and sense making in relation to aspects of professional identity.

## Theoretical approach

*Implied identity* is a theoretical approach (Khosronejad, Reimann, & Markauskaite 2015) to study professional identity practices. The framework looks at the individual's or a group's sense making of available resources through the concept of implied identity. It refers to the interpretation of either an individual, or a collective group of people from resources, about what it means to be a professional. The context of experience is identified as a resource with suggestions of *becoming*. As an example, a team work activity at the university is a resource with a potential suggestion that collaboration is an aspect of one's identity in the field of its inquiry. In addition, assigning students tasks that require writing implies that having writing skills is an essential part or at least a dimension of being a professional. However, the student's implied or perceived identity depends on the individual's interaction with the resource and what s/he brings to the experience. Not all students may perceive and accept, in a direct sense, that team work activities are indications of the collaborative nature of their future work. The perception may be in contrast to their ideal image of being a professional who works individually.

The implied identity perspective argues that differences between *perceived identity* and *ideal identity* or perceptions of self (*what one thinks about her own abilities and ways of being*), lead to reflections and internal dialogues towards decision making (Figure 1). Therefore, sense making processes involve the negotiation between different perceived identities and is mediated through reflection.



**Figure 1. Implied identity: A framework to study professional identity practices (Khosronejad et al. 2015)**

The framework provides tools needed for the description of collaborative sense making and participants' response to intended aspects of designed learning activities. In the current study, we look at the emergence of engineering identities during a collaborative decision making environment and explore the interaction between individuals as well as individuals' interactions with different resources including task description and web information. We further investigate how dispositions brought to the situation by individuals may influence such interactions.

## Method

We take a qualitative approach to take an in-depth look into one participant group's collaboration and address the following research questions:

1. How do engineering identities emerge as a joint accomplishment in response to identities intended by educational design?
2. How are web resources used for collaborative sense making in relation to professional practices and identities?

## Participants and setting

Participants of the study were Chemical Engineering students from one of the leading universities in Australia located in a metropolitan area. Participants were purposefully invited among enrolled students in a course about sustainability and the recruitment process was facilitated by the unit coordinator for ethical considerations and maximizing students' participation. A selected group for this paper consisted four international exchange students including Alex, Sam, Sally, and Mandy, who voluntarily participated in the study (we use pseudonyms here to protect the participants' anonymity). The collaborative session was two hours long, conducted at a special studio designed for studies of group collaboration, and was video and audio recorded. Participants had access to shared platforms for communication including writable walls and a compute.

## Task

A task was assigned to facilitate all dimensions of engineering work based on Figuerdo's (2008) four dimensional model and engineering graduate attributes. To this end, a *wicked* problem on sustainability was selected for participants to provide solutions for air pollution in mega cities. Wicked problems have no definitive and clear right or wrong answer and no immediate test of their resolution or possibilities for trial and error. There are consequences to every solution given to the problem (Rittel & Webber, 1973). Working on wicked problems about sustainability promotes the inclusion of different perspectives in the discussion, and facilitates decisions that consider environmental, social and economical concerns.

The task was designed in consultation with an academic expert in sustainable design and engineering. Participants were asked to provide solutions for air pollution in mega cities, prioritize their solutions based on their proposed criteria, and prepare a report.

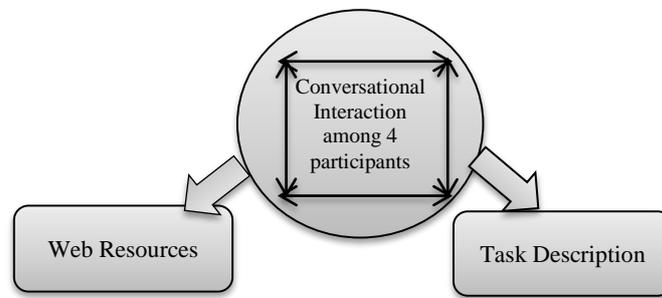
## Data collection and data analysis

Students' collaboration was video and audio recorded. Each group of students was asked to use one computer, whose screen activity was also recorded.

In the first round of analyzing the video data, the aim was to investigate practices of professional identity. Audio transcriptions were analyzed qualitatively applying both inductive and deductive approaches to find practices of engineering identities. We applied Figueiredo's (2008) four dimensional model of engineering to guide our deductive analysis and find episodes of collaboration that draw on engineering as a) basic sciences, b) design, c) practical realization and d) social sciences. Respectively these dimensions were supported by examples such as the use of statistical information, drawing on intuition and personal experience in decision making, suggestions for creating artefacts, and paying attention to the needs of end users and society.

The analysis was conducted using NVivo software. More specific sub categories were added according to the description of each dimension. A new category was added for the engineering as environmentalist to highlight concerns about environment and sustainability (Khosronejad, Reimann, & Markauskaite, 2015).

In the second phase of the analysis, we applied the implied identity framework to investigate the emergence of identity practices as the group progressed through the activity and made decisions. We used interaction analysis (Jordan & Henderson, 1995) to study participants' interaction, with one another as well as with the task and web resources (Figure 2). We investigated the perceived identities that mediated participants' responses to identity resources.



**Figure 2: Participants’ interaction during collaboration**

In the analysis of group interaction, we followed what each participant suggested in relation to the four dimensions of engineering identity. These suggestions were made through talk and were either the result of their interpretations of the task and web resources or were manifestations of their beliefs about legitimate practices. We further looked into how different suggestions were picked up or refused by a group as a joint accomplishment.

**Result**

Findings suggest that group’s main practices of engineering identity include engineering as design and engineering as practical realization through different phases of decision making (Table 1). In the first two phases of decision making, the group relied on intuition, and drew on participants’ personal experience and knowledge to make decisions. Therefore, their practice was interpreted as engineering as design.

The third phase of decision making is to provide solutions for the problem of air pollution. The group was mainly focused on the creation of artefacts such as filters and therefore their practice was indicative of engineering as practical realization.

**Table 1: Identity practices in different phases of decision making**

Decision Phase	Dimension of Engineering Practiced
Phase 1: Choosing a city	Engineering as design: Having personal experience and knowledge of the selected city
Phase 2: Finding sources of air pollution	Engineering as design: Relying on intuition and personal experience
Phase 3: Finding possible solutions to the problem	Engineering as practical realization: Creating artefacts

To answer the research questions, we now take an in depth look into the first episode of collaboration where the group decided to select a specific megacity in approaching the task. Our focus is only on the sequence of talk and turn taking. We illustrate how the group began collaboration and moved towards decision making by practicing engineering as design. We further examine how web resources were used to guide or justify group’s decisions.

**Contextual thinking and “engineering as design”**

- L1. Sally: Should we pick a city maybe, like it could be easier to, if you focus on a specific place?
- L2. Sam: Yeah, because they mention culture somewhere here. Oh yeah, also address ethical considerations as well as technologies as part of your discussion. So I think we should pick a country.
- L3. Sally: I need to have a context.
- L4. Sam: New Delhi.
- L5. Sally: Could be. I know nothing about it but... in India.
- L6. Mandy: That could be tough

At the beginning of the collaboration, Sally suggests it is easier for the team to select a specific city before continuing to work on the problem (Line 1). Sam supports her suggestion by referring to the task description (Line 2) and explaining later that a consideration of “cultural aspects” is required and so it will be helpful to think contextually. The task as a resource is used to justify the decision of contextual thinking.

Then the group starts brain storming about possible cities. Sam proposes New Delhi first. This is followed by Sally’s statement that she doesn’t “know about it” (Line 5) which implies her preference of selecting a city that she has personal knowledge and experience about. Sally’s turn in talk has a suggestion of implied identity to practice “engineering as design” because it draws on the use of personal experience in decision making. This is inferred via a comparison with alternative ways of engineering practice such as when engineers rely on statistical information for decision making and practice engineering as “science”.

The group continues with brain storming, naming Beijing and Santiago as other options while Sally starts using the computer to search for “most air polluted city”. Sam guides the group’s decision to use the first link among suggested Google responses, a link to a CNN article. In approaching the article, the group mostly attends to the visual map of cities (Figure 3).

- L7. Alex: Do we really have to choose one city?  
 L8. Sally: I think you have to talk about the environment  
 L9. Sam: Have to talk about culture  
 L10. Alex: It would be good if we chose one ((place)) that we know.  
 L11. Sam: Well all of them are in Asia ((refers to online information- Figure 3)).  
 ((group looks through the page))  
 L12. Sam: Oh it’s a map. Really are the most polluted cities over here, in that region?  
 L13. Alex: Because I don’t know so much about these cities, you know, to talk about them.  
 ((group discusses about the cities))  
 L14. Mandy: scroll up please. Cities with greatest annual mean blah blah ((referring to the content of the article)) which is one of the most dangerous pollutant for human health. See if you can get a website for this air pollution database, the data source for the picture ((referring to the map)).
- Note: Double parentheses contain transcriber’s descriptions rather than, or in addition to, transcripts of talk in interaction.

As they look through the webpage, Alex challenges the idea of choosing one city in approaching the task (Line 7). Sam and Sally defend the idea of contextual thinking one more time by referring to the task requirement of talking about “environment and culture” (Line 8 and 9). Consequently, Alex agrees with them (Line 10).

Sam suggests the current (CNN) article is drawing on examples from Asia only, implying that it may not be a good resource (Line 12). Following the group’s further reflection on the illustrated map, Mandy suggests they track down the “Ambient Air Pollution Data Base WHO 2014” resource cited in the article (Line 14).



**Figure 3: Web search to assist brain storming**

- ((Sally initiates the search by opening the new window))  
 L15. Alex: Don’t you think you can talk about like Rio or Sao Paulo?  
 L16. Sally: We can  
 L17. Alex: Because we know, like better... about the culture.  
 L18. Sally: We can even talk about Sydney.

However, before the search for the new resource is complete, Alex’s suggestion to select Rio or Sao Paulo interrupts the process (Line 15). Alex has now accepted the implied identity of “engineering as design” as his suggestion is following the idea of having personal knowledge and experience about the selected city. He is building on previous turns in conversation in the favor of this dimension of engineering identity. Sally re-builds on the idea (Line 16) and suggests “Sydney” (Line 18).

## Being specific: Setting stage for “engineering as science”

L19. Sam: But is Sydney that pollutant?

L20. Sam: And actually it’s saying mega cities. Is that a specific concept or any city that’s big? What is the concept of a mega city, can you check that, please?

((group searches for “megacity” and opens the page as shown in Figure 4, they agree to select a city with more than 10 million people in its population, and they continue brainstorming))

Sam asks if Sydney is polluted (Line 19) and if the team should have a look into the concept of megacity (Line 20). Therefore, Sally searches for “megacity” in Google and clicks on the Wikipedia link (Figure 4) explaining the concept. As the group is looking over the list of mega- cities, they encourage one another to come up with a decision and move to the next phase to continue discussing sources of air pollution with references to the task description.



Figure 4: Search to find exact definition

## Reminder for a facilitator: Towards engineering as “social practice”

L21. Alex: So first have to choose the facilitator

L22. Sally: I don’t think we have to choose the facilitator. I think we’ll be fine.

L23. Alex: The problem is she asks for her work, you know. I think she wants someone. Who wants to be... who wants to be the facilitator? But this person will always get to discuss as well.

L24. Sally: So Alex, because you’re worried about it so  
((group chooses Alex as a facilitator, he agrees, and the topic is changed to the selection of the city))

Alex reminds the group about choosing a facilitator (Line 21). Sally rejects the idea (Line 22). The group discusses whether the facilitator can also engage in decision making. Alex emphasizes that selecting a facilitator is an important part of their collaboration with references to the task description and researcher’s request (Line 23). Sally suggests that “the one who is concerned should” take the position (Line 24). Therefore, Alex accepts to be a facilitator and starts taking notes of group’s discussion using the writeable wall. Despite the intended aspects of “engineering as a social practice” in the design of the task and the perceived implied identity to position one member as a facilitator, all members except Alex are reluctant to accept the suggestion. This means that “engineering as a social practice” is rejected by the majority.

## Engineering as science to justify engineering as design decision

L25. Mandy: Ok do we want to talk about Sao Paulo then?

L26. Alex: Is Sao Paulo that pollutant?  
((searching for “Sao Paulo air pollution”, and reading through the first article, Figure 5))

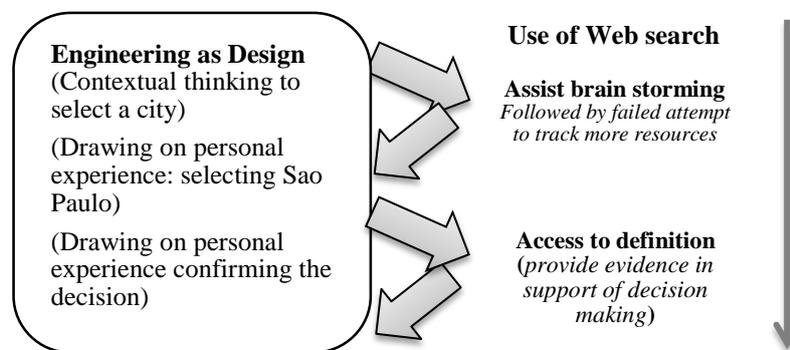
L27. Group: So, Sao Paulo is the chosen city.

The group gets back to the previous topic of choosing a city, with Mandy suggesting Sao Paulo as an option (Line 25). Alex asks if Sao Paulo is “that polluted”, a question that builds on the previous turn in talk to be “specific” in terms of the definition of “megacity” (Line 26). Sally searches for “Sao Paulo pollution” in Google to answer the question. She clicks on the first link “Air pollution in Sao Paulo kills more people than car accidents...” (Figure 5). As Sally reads through the title, everyone agrees to select Sao Paulo (Line 27), and Alex stands up to take notes using the main wall. Alex’s taking up the position of a facilitator is reinforced by team members calling out “Go facilitator!”



**Figure 5: Search to confirm decision made based on personal knowledge**

As the details of the collaboration show, the group’s use of web resources in phase 1 is influenced by their initial decision to rely on personal experience in tackling the problem. Sally’s initial suggestion of selecting a context that they have personal experience about (Line 1) offers the implied identity of engineering as design, which is further accepted and practiced in next turns in talk. The group builds up on the idea irrespective of the information they read on the web. A summary of the group’s transition between different dimensions of engineering identity practices and their use of web resources is shown in Figure 6. In this phase of collaboration, web resources are used to justify and assist group’s practices of “engineering as design”.



**Figure 6: Phase 1 decision making practices in relation to dimensions of identity**

## Discussion and conclusion

This paper looked at the emergence of engineering identities in relation to local affordances of the collaborative environment including the use of online information retrieved through web search. The result builds on previous research to show that local practices of identity are inseparable from activities (Hand & Gresalfi, 2015), with an emphasis on how one participant’s ways of being acts as a resource for others during collaboration and influences joint accomplishments of identity in relation to both the task and the online information. Therefore, the individual’s way of being becomes part of the context shaping other individuals’ interaction with resources, in a dynamic and non- neutral sense to guide the group’s interpretations and practices of identity. Similar insights are pointed out by research looking at interpersonal aspects of communication in relation to the use of resources (Greeno & MMAP, 1998; Gresalfi, 2009).

The *implied identity* framework conceptualizes online information as a potential resource for identity practices with suggested ways of being. However, our result shows that, in one episode of collaboration, web information is used only to justify decision making practices. This is an example of accommodative use of web search, meaning the search of information is meant to accommodate the decisions made rather than guide the group to different decisions and new ways of professional practice.

We conclude that collaborative sense making in web search and the use of web information was mediated by implied identities initially perceived through interpersonal interaction. Future research may further explore how online information is played out in the group’s decision making in relation to the practices of identity.

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