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Use of Communities of Practice to Analyze and Improve Graduate Engineering Education.

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I am a Fulbright Scholar, currently in a program towards a Ph.D. in Learning and Teaching in STEM- Science Education at NCSU. I received a bachelor's and M.Sc. in Chemistry at the University Federico Santa María Technical University (UTFSM). I was very proud to receive a Trajectory Sport Award for athletes who have demonstrated leadership and highlighted sports careers at UTFSM and Undergraduate Research Grant from the Center of Ionic Liquids (CILIS- University of Chile). My interests are focused on studying the pedagogical theories that are linked to teaching-learning strategies. I am especially interested in understanding the linkages between the different learning styles and skills of engineering students and their success in pursuing the goals that they had set for themselves when they entered the University.

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Abstract

This work-in-progress paper reports on pilot testing of instruments for an NSF-funded research project that aims to bridge the gap between professional engineering work and engineering graduate education, in accordance with a recent National Academies of Sciences, Engineering, and Medicine [NASEM] policy document (2018). The project will apply, research, and develop communities of practice (CoP; Wenger, 1998) theory in three graduate classes from three different engineering departments. A community of practice is a group of people who share purposes and methods, which emerge from the needs of a context, with the negotiation of shared meaning and forms of participation. The project will investigate how CoPs form, how CoPs in different disciplines learn to interact and collaborate, and what conditions foster equitable participation by all members of a CoP. Prior research shows that highly diverse communities have optimal team performance and creativity, but only if members feel psychologically safe. Data sources contemplated include personal interviews, classroom observations, a psychological safety survey, survey on perceptions of class, and a CoP-specific instrument, the Community Assessment Toolkit (CAT). In this paper we report on our piloting of the instruments.

Introduction.

A recent National Academies report notes the need for changes in graduate STEM education: "Recent surveys of employers and graduates and studies of graduate education suggest that many graduate programs do not adequately prepare students to translate their knowledge into impact…" (National Academies of Sciences, Engineering, and Medicine [NASEM], 2018) (p. 1). In particular, students need to develop abilities for working in collaborative and team settings, to communicate to diverse audiences, to acquire pedagogical skills (p. 96), and to deal with diverse opinions, ideas, and backgrounds (p. 3). Similarly, research indicates that employers recognize a gap between their expectations and the skills of graduate students in engineering (Markes, 2006; Ramadi E, Ramadi S and Nasr., 2016; Saeki and Blom 2011), and recent graduates recognize that communication skills, as well as broad analytical and technical knowledge, are important for success in the professional world (Michalaka and Giogli, 2020). These policy documents, in conjunction with the perspectives of employers and students, point to the need for a transformation in teaching-learning that puts students at the center of the process and focuses on developing skills essential for the workplace.

To achieve this transformation in the training of engineers, a promising strategy is to design learning contexts that are similar to real professional engineering environments (Chen, Kolmos, and Du, 2021). Controlled immersion in engineering communities challenges students to work and interact with multidisciplinary teams and develop knowledge, skills, procedures, and language prevalent in the world of engineering practice. In the process of participating in these communities, students need to negotiate, transfer, and adapt their knowledge and skills to achieve full participation. This process of incorporating novices into a community of professionals is described as “legitimate peripheral participation" in the Community of Practice (CoP) theory (Lave and Wenger, 1991; Wenger, 1998) This theoretical framework strongly emphasizes collaboration, groups, knowledge as doing, and communication across disciplinary and cultural backgrounds.

The goal of the research project is to bridge the gap between professional engineering work and engineering graduate education. The project will apply, research, and develop communities of practice (CoP; Wenger, 1998) theory in three graduate classes from three different engineering departments. A community of practice is a group of people who share purposes and methods, which emerge from the needs of a context, with the negotiation of shared meaning and forms of participation. The project will investigate how CoPs form, how CoPs in different disciplines learn to interact and collaborate, and what conditions foster equitable participation by all members of a CoP.

In this article, we will describe the piloting process of the instruments and protocols to be used in the research project. In the next section, we will describe in greater depth the theory of CoP.

Theoretical Framework

Communities of Practice

Wenger defines CoP as a group of people who share purposes and methods, which emerge from the needs of a context, with the negotiation of shared meaning and forms of participation including tools, symbols, concepts, procedures, criteria, etc (1998). Wenger’s CoP theory is based on four premises: the social nature of humans, the idea that knowledge is competence (doing), knowing is participating, and learning produces meaning (1998). One consequence of this view is that a core goal of educational programs must be to help novices move from being outsiders to engaging in “legitimate peripheral participation” (Lave & Wenger, 1991) to becoming core members of a professional community.

According to Wenger (1988), diverse CoPs often need to interact. Wenger proposes that the interaction between two communities of practice is generated by "brokers" and "boundary objects." A broker is defined as a participant in two communities who can introduce elements from one community to another, while boundary objects are artifacts, documents, terms, concepts, etc., through which COPs organize their connections and lay the foundation for their practice. For example, engineering graduate students in a class with their instructor(s) form part of a community of practice revolving around education while practicing engineers form their own communities of practice. Opportunities for the interaction between these two CoPs can support students in making the transition between their graduate studies and actual engineering work settings, ideally becoming true brokers that disseminate ideas across the groups. Classes with students from different fields of engineering, or from engineering and a different field, also require brokerage.

CoP theory originally contemplated voluntary communities that developed organically (Lave & Wenger, 1991), and which were often fairly homogeneous. CoP has since been expanded and refined for use in existing formal organizations with specific goals and assigned membership, resulting in the concept of "organizational communities of practice" (OCoP; Cox, 2005). OCoPs may have much higher diversity (of nationality, culture, norms, values, geographical location, etc.). OCoP research has found that high diversity leads to unified community culture (Earley and Mosakowski, 2000) and strong contributions from the varied knowledge and experience bases represented (Cramton and Hinds, 2005). A key contributor to effective functioning of a diverse OcoP is psychological safety (Edmondson, 2003), meaning that members feel free to contribute ideas and information, take risks, and value other members' skills and experience. Studying global OCoPs that meet virtually, Kirkman et al. (2013) found a J-shaped relationship between diversity and performance: high diversity along with psychological safety led to optimal performance; low diversity led to cohesive groups but with less potential for novel ideas to emerge; and medium-diversity groups often led to formation of sub-groups and low cohesion, performing least well. Thus, CoP theory and its refinement, OCoP, hold great promise for the incorporation and leveraging of diversity in graduate engineering education

Methodology

Context and Setting

Our project is researching three graduate classes from three different engineering departments:

1. Building information modeling (BIM) in Construction, which features an internship in construction companies. The immersion in construction companies will allow us to examine how students become brokers, transferring elements of practice between communities.
2. Design of a Robotic Computer Vision System for Autonomous Navigation course. In this course students work in teams, each team working on a robotic component. The components need to work together seamlessly. develop their own CoP around their team's subsystem, and some must function as "brokers" in order to coordinate the efforts of their own group with those of another group, in pursuit of an integrated system.
3. Educational Data Mining (EDM). In this class, students from Computer Science and from Education work in small heterogeneous teams to propose, plan, and implement an EDM

project. We will study how students can develop as brokers representing their primary academic community to others, and "legitimate peripheral participation" as students join a new community of practice (EDM) by working in it and interacting with data mining professionals and literature.

Instruments and Protocols

To conduct the research, we need instruments and procedures to assess the functioning of and interaction between communities of practice, to measure and track psychological safety, and to capture students' perceptions of the class.

Despite the increased use of CoP as a theoretical framework in research, there is still a need for instruments and procedures to assess CoP effectiveness and impact on participants (Boughzala, 2011; Han et al., 2021, Lie, 2009). A 2011 systematic literature review found that "*empirical evidence supporting the effectiveness of CoPs remains limited, and even fewer analyses investigate the mechanisms that determine effectiveness* " (McKellar et al., 2011, p. 2). Our own literature review revealed that the gap still exists. The only quantitative instrument identified by Mckellar and our own literature review is Verburg and Andriessen's (2006) Community Assessment Toolkit (CAT). The reliability of each of the 17 sections of the CAT (each consisting of 2-8 items) was assessed by calculating Cronbach's alpha and found to be acceptable, based on data from 277 participants of 7 different CoPs in a large multinational corporation. However, there is no discussion of the validity of the test, and some sections are unrelated to CoP theory (e.g., information and communication technology).

Research has established that highly diverse CoPs have the best and most innovative performance, when members feel psychologically safe. Edmondson (1999) developed the Team Learning and Psychological Safety Survey. The survey's validity and reliability were established through Cronbach's alpha and factor analyses; the paper presenting the survey has been cited over 10,000 times.

In addition to the TLPSS, we have developed interview protocols and course perception surveys based on the dimensions discussed in the introduction and theoretical framework of this paper. The construct validity of the interview protocol and survey stem from their development guided directly from theory.

To study the relevance and results collected by the instruments, we will carry out a pilot evaluation with a small group of students from the three courses. In the next section, we will describe this group and the findings found.

Piloting

Pilot testing involves using a research instrument ahead of its full-scale use (Baker, 1994). The purpose behind pilot testing is to assess whether the instrument may be inadequate, too complicated, to identify logistical obstacles, for training purposes, and to identify problems (van Teijlingen and Hundley, 2002).

We recruited students from previous semesters of the three classes to pilot the instruments. We decided to pilot with around 10% of the number of participants expected for the full study, i.e., around three or four per class. Our participants were five past participants in the BIM course, three from EDM, and three from Robotics. Each participant was interviewed via ZOOM using the protocol; they also they completed the surveys during the Zoom meeting, and were asked about the clarity of the surveys and any questions they might have. We also kept track of the time required for each survey or interview protocol. The interviews were conducted by the first and second author of this paper. Each student was interviewed individually for about 1 hour. The research was conducted under IRB Protocol # 24313. Participants received a $25 gift card BRAYAN: Add any necessary details to this section.

Results and Discussion

CAT

The CAT measures functioning of CoPs. It was developed in environments other than classrooms (the corporate world), and this posed a challenge for their application in our project. All participants commented on very large differences between the questions and the classroom environment. In particular, the CAT inquires about: Clients, Team, Organization, Company, and uses terms such as “non-work related” and “cost savings”. While we provided guidance to students to make connections across CAT terms and their experience these continued to be confusing to the students. Furthermore, a single CAT term might have different meanings depending on the particular question; e.g., “organization” could mean the classroom, the department, or the university.

In addition to this empirical data, our analysis of the CAT also revealed serious deficiencies. While the CAT authors report reliability metrics for various sections, it is not entirely clear what questions belong in each section. As mentioned earlier, there is no discussion of the validity of the test, and some sections are unrelated to CoP theory (e.g., information and communication technology). We concluded that the CAT is not adequate for our research study.

TLPSS

The TLPSS measures group psychological safety. The TPLSS was straightforward for the students. Three terms had to be defined to ensure that students were referring to the same thing. These terms were Team, Organization, company, and Team Leader. This was necessary because different teams are formed within the courses, so it was important to define which team we were referring to. By giving these clarifications prior to taking the test, the students confirmed the consistency and coherence of the questions. The average duration of the test was 15 minutes. We concluded that the TLPSS is useful and appropriate, requiring only the clarification of three terms.

Interview protocol

The interviews (one per class) lasted between 30-45 minutes. The students felt comfortable with the questions, and it was only necessary to clarify one question. At the end, the students were asked if they recommended any additional question and 100% of the participants agreed that the protocol covered all important aspects of the experience. We concluded that the protocol is useful and appropriate and have made the recommended clarification.

Course Evaluations

The students found the course evaluations clear and relevant. They had no recommendations for the course evaluations. The application time is 15-20 minutes.

Conclusion and Future Work

In this work-in-progress paper we have discussed the design and piloting of instruments for a research project studying three courses from three different departments of an engineering school. The piloting process was very informative and resulting in discarding the CAT. We will instead evaluate the functioning of CoPs using the surveys and interviews. In addition, the piloting process was useful in developing familiarity with the instruments and in the interviewing process.

Future research will be carried out during the first 2022 with 14 students of the robotics course, 32 students of Educational Data Mining, and in Fall 2022 10 students are expected in the BIM in Construction course. A similar number of students is expected for 2023. The connection of data collected within the 2 years of the project will allow us to build pedagogical insights into graduate engineering education that follows the vision of the National Academies' report while building knowledge about sociocultural interactions specifically in graduate engineering settings

References

Baker, T., L. (1994). Doing social research (2nd edn.). New York: McGraw-Hill Inc.

Blom, A., & Saeki, H. (2011). Employability and Skill Set of Newly Graduated Engineers in India American Psychological Association (APA). https://10.1037/e596532012-001

Boughzala, I. (2014). Assessing the community maturity from a knowledge management perspective. Information Systems for Knowledge Management (pp. 1-31). John Wiley & Sons, Inc. https://10.1002/9781118920664.ch1

Chen, J., Kolmos, A., & Du, X. (2021). Forms of implementation and challenges of PBL in engineering education: A review of literature. European Journal of Engineering Education, 46(1), 90-115. https://10.1080/03043797.2020.1718615

Creswell, J. W. (2009). Research design : Qualitative, quantitative, and mixed methods approaches. Sage Publications.

Edmondson, A. (1999). Psychological safety and learning behavior in work teams. Administrative Science Quarterly, 44(2), 350-383. https://10.2307/2666999

Han, F., Cheng, Y., Strachan, M., & Ma, X.Hybrid Paper-Digital Interfaces: A Systematic Literature Review ACM. https://10.1145/3461778.3462059

Lave, J., & Wenger, E. (1991). Situated learning: Legitimate peripheral participation. Cambridge University Press. https://10.1017/CBO9780511815355

Li, L. C., Grimshaw, J. M., Nielsen, C., Judd, M., Coyte, P. C., & Graham, I. D. (2009). Use of communities of practice in business and health care sectors: A systematic review. Implementation Science : IS, 4(1), 27. https://10.1186/1748-5908-4-27

Markes, I. (2006). A review of literature on employability skill needs in engineering. Null, 31(6), 637-650. https://10.1080/03043790600911704

McKellar, K. A., Pitzul, K. B., Yi, J. Y., & Cole, D. C. (2014). Evaluating communities of practice and knowledge networks: A systematic scoping review of evaluation frameworks. EcoHealth, 11(3), 383-399. https://10.1007/s10393-014-0958-3

Michalaka, D., & Giogli, E.2020 ASEE Southeast Section Conference Which skills are more important in the engineering world? Perceptions of college students, recent graduates, and employers

National Academies of Sciences, Engineering, and Medicine. (2018). In Alan Leshner, Layne Scherer(Eds.), Graduate STEM education for the 21st century. The National Academies Press. https://10.17226/25038

Ramadi, E., Ramadi, S., & Nasr, K. (2016). Engineering graduates' skill sets in the MENA region: A gap analysis of industry expectations and satisfaction. Null, 41(1), 34-52. https://10.1080/03043797.2015.1012707

Tashakkori, A., & Teddlie, C. (2022). The SAGE handbook of applied social research methods; pages 283-317. (2nd ed.,). SAGE Publications, Inc. https://10.4135/9781483348858

van Teijlingen, E., & Hundley, V. (2002). The importance of pilot studies. Nursing Standard (Royal College of Nursing (Great Britain) : 1987), 16(40), 33-36. https://10.7748/ns2002.06.16.40.33.c3214 [doi]

Verburg, R. M., & Andriessen, J. H. E. (2006). The assessment of communities of practice. Knowledge and Process Management, 13(4), 13-25. https://10.1002/kpm.241

Wenger, E. (1999). Communities of practice: Learning, meaning, and identity. Cambridge university press.