Utilizing Natural Language Processing (NLP) to Evaluate Engagement in Project-Based Learning

Sarah Priscilla Lee
School of Education and Social Policy
McCormick School of Engineering
Northwestern University
Evanston, Illinois, United States
spl@u.northwestern.edu

Marcelo Bonilla Worsley
School of Education and Social Policy
McCormick School of Engineering
Northwestern University
Evanston, Illinois, United States
marcelo.worsley@northwestern.edu

Melissa Renae Perez
School of Education and Social Policy
McCormick School of Engineering
Northwestern University
Evanston, Illinois, United States
melissaperez2019@u.northwestern.edu

Bobbie Dlan Burgess
School of Education and Social Policy
McCormick School of Engineering
Northwestern University
Evanston, Illinois, United States
bobbie@u.northwestern.edu

Abstract—**In a time of rapid development, 21st century learning emphasizes innovative thinking and making. This has heightened interest in STEAM subjects and its implementation in traditional classrooms through project-based learning (PBL). However, assessment is difficult for open-ended, PBL activities. This work-in-progress study utilizes natural language processing (NLP) tools to analyze content produced in a middle-school media arts classroom. The authors examine student engagement and excitement along dimensions of tone and authenticity. We discuss the results of NLP vis-a-vis feedback that 1) determines student engagement and excitement and 2) improves the implementation and display of project-based learning in traditional classrooms.**

Keywords—natural language processing, project-based learning, blogs, social media

I. INTRODUCTION

As the maker movement and interest in STEAM education continues to grow, educators in traditional classrooms seek to incorporate more project-based learning activities that use previously inaccessible digital fabrication tools such as laser cutters, CNC milling machines, and 3D printers [4]. However, the implementation and execution of project-based learning can elicit uncertainty and problems for education administrators, policymakers, and facilitators because it is difficult to measure or assess learning [2]. Furthermore, teachers that may be open to project-based learning encounter problems with time, class management, control, scaffolding student learning, using the technology as a cognitive tool, and again, assessment [5] [6] [7]. Some teachers experience conflict with deep-seated beliefs and the new instructional approach in project-based learning [6]. NLP tools offer a possible feedback channel for the assessment and improvement of project-based learning in classrooms.

In this paper, we present a project-based activity at a public middle school media arts classroom in the midwest and use Linguistic Inquiry and Word Count 2015 (LIWC2015) [12] to analyze the written content from students' blogs. The project (i.e. a picture frame project) took place over four weeks and was documented through field notes taken by researchers and content produced by students and the teacher. In keeping with documentation practices seen in authentic engineering classes, students were encouraged to document their process on individual blogs that was then shared on a public classroom webpage. Images as well as video recorded reflections accompanied blog posts as well. Video reflections were completed by some students at the end of the project and were based on interview questions created by the teacher. At the end of the project, all students were asked to fill out a survey that asked them about their experience in the class overall and on the project specifically. Over the course of the project, the teacher shared students' progress and products through a public classroom Instagram and Twitter account. The blogs were a key component in the teacher's final assessment of student work, therefore, in this paper we use LIWC2015 to analyze the written content from the blogs.

II. BACKGROUND

Prior work utilizing natural language processing (NLP) has examined student engagement through semantic features [8] as well as using more sophisticated linguistic measures to develop multi-feature models of linguistic predictions of student affect through interaction-based affect detection [9]. Additionally, affective research in education has focused on constructs such as boredom, confusion, engaged concentration, and frustration to predict when learners come to an impasse in learning [4] [10]. Other work that builds on affective research and learning in open-ended environments has investigated engagement as captured by multimodal data sensors and emerging through sentiment, gaze, drawings, gestures, and speech [11] [13] [14]. Thus, feedback from affective research in education holds useful implications for professional development and critically shapes the pedagogy and implementation of project-based learning in traditional classrooms.

While the features found in previous work lend support to the relationship between learner engagement and motivation (a key component of meaningful learning and making), they do not determine the merits of using NLP tools to analyze student- and teacher- produced content. In this study, we seek to better understand how NLP tools--specifically LIWC2015--can be leveraged to analyze learner engagement as captured at two levels of content: 1) student-produced content and 2) teacher-produced, public-facing media content. Student content includes online blogs, video interviews and surveys. Public-facing content consists of Twitter and Instagram, which enabled feedback from the public.

III. Objective

The objectives of this study are:

- To leverage LIWC2015 [14], a natural language processing tool, to assess written content produced by students.
- To assess the level of student engagement along dimensions of tone and confidence as determined by LIWC2015.
- To determine the extent to which feedback from LIWC can equip teachers with necessary feedback for improving the implementation and display of hands-on curriculum.

IV. Data

Data were gathered from 49 students in a media arts classroom at a public middle school situated within a district that serves students from a mix of socioeconomic backgrounds. The 49 students were split between two classes by grade level. The first period class consisted of 22 seventh grade students and the third period consisted of 27 eighth grade students. The classes were not self-selected, therefore, students that enrolled in the class did so to fulfill a school requirement. This also means that the students that enrolled in the classes did not have to"try out" for the class either, as students in the advanced class are required to do.

We differentiated student-produced content from teacher-produced, public-facing media content. Student content included online blogs, video reflections and exit surveys. Public-facing content consisted of Twitter and Instagram, which allowed feedback from the public. The four major sources of content that we analyzed are explained in detail below.

A. Written Blogs

Students were instructed to respond to questions posed by the teacher in the form of a written blog. Students were also instructed to include pictures of their artifact, updates on the process and progress of making, and content from past projects that were done in the media arts class. Written blogs were highlighted by the teacher as a practice that authentically mirrors the documentation practices in engineering. Blog updates were not always framed by questions given by the teacher, therefore, the level of detail and focus presented in blog posts varied from student to student.

B. Video Reflections

Once the students were satisfied with their projects, they would go out into the hallway in pairs to record video reflections. Students talked about the artifact they made and described their process of making, including challenges or issues they encountered. These video reflections were aided by a list of optional questions that the teacher provided.

C. Survey

Students were given an online survey by the teacher to fill out in class at the end of their project. The prompts were: "My favorite thing/s we did in Media Arts this trimester was.... because…", "The most important skills I learned in Media Arts this trimester are…", "Something I wish we could do in Media Arts in the future is…", "Things I would change or suggestions I have for future 7th grade Media Arts classes are…", "Did you work with the Northwestern students? How did they help you?", "Write a description of this class for incoming 7th graders", and "What advice would you give to incoming 7th graders for Media Arts next year?".

D. Social Media

Public accounts on Twitter and Instagram were used to share and promote classroom content. Instagram was the main platform that the teacher used to post pictures of the students and their work accompanied by captions and hashtags..

E. The Project

This study focuses on content produced for a picture frame project (artifact), which was one out of three other projects completed that trimester.. Other class projects included making posters that addressed a social issue, animated introduction videos for their student page, customizing headbands and T-shirts, and building in Minecraft. The projects utilized the laser cutter, 3D printers, a Carvey machine, vinyl cutter, and heat press.

V. Methodology

Since the different forms of data were differentiated, the method of collecting and analyzing it also varied by type. For the purposes of this work-in progress paper, we have limited our analysis to the student-produced blogs and survey responses.

A. LIWC2015

The following dimensions are examined:

- Clout—a high number suggests that the author is speaking from the perspective of high expertise and is confident; low Clout numbers suggest a more tentative, humble, even anxious style.
- Authentic—higher numbers are associated with a more honest, personal, and disclosing text; lower

numbers suggest a more guarded, distanced form of discourse.
- Emotional tone—a high number is associated with a more positive, upbeat style; a low number reveals greater anxiety, sadness, or hostility. A number around 50 suggests either a lack of emotionality or different levels of ambivalence [11].

B. Written Blogs

First, we extracted text data from student blogs regarding the frame project. Once the data were collected, LIWC was used to analyze the student-produced written blogs. Specifically, we wanted to see what measures of "Tone" and "Clout" emerged from the blog data [11].

TABLE I.   Written Blog Data

Class Period	LIWC Data		
	Category	Average	Standard deviation
1st[a]	Tone	74.21	26.01
1st[a]	Clout	58.93	26.51
3rd[b]	Tone	49.17	31.28
3rd[b]	Clout	21.70	17.34

[a]Data from 22 blogs
[b]Data from 25 blogs

C. Survey

The data from the survey were collected in a Google Form for one of the media arts classes and then run through LIWC2015. Since the questions from the instructor focus more on feelings toward the class, we look at "Tone" and "Authenticity". Higher numbers are "associated with more honest, personal, and disclosing text while lower numbers suggest a more guarded, distanced form of discourse" [11].

TABLE II.   Survey Data

Class Period	LIWC Data		
	Category	Average	Standard deviation
1st[a]	Tone	77.59	30.56
1st[a]	Authenticity	15.73	14.61

[a]Data from 18 surveyed

VI. Discussion

The data display overall values for clout, tone, and authenticity that are very low (average clout for first period 58.93 and third period 21.70; average tone for the third period 49.17). In the case of the surveys, this means that while the tone is overall "upbeat" (indicated by a high average value, first period average tone was 74.21), the text is ultimately more distant than honest. Similarly to the blog posts, the first period class contained numbers that were higher overall; however, the average for clout, or the confidence of the text, is still low compared to the tone—the same can be said for third period. This could be because the students did not have much confidence in what they were working and reporting on in the blogs, but possessed an overall interest in the activity.

LIWC categories serve as a useful tool for teachers to better understand their students' engagement. The four main categories it measures—analytical thinking, emotional tone, clout, and authenticity—just scratch the surface of the values LIWC can provide, and combined with others, can give instructors access to data that capture student engagement while learning.

VII. Future Work

A multimodal analysis of content produced by students and teachers can elucidate levels of engagement and excitement—promising indicators for learning—among many others. There is potential for NLP tools like LIWC2015 to analyze written content in addition to transcribed speech from video and audio recordings to track learning and engagement levels over time. Changes in these levels could provide useful feedback for teachers to revise project-based learning curriculum accordingly. Because LIWC2015 is unable to identify specific, technical words, future work should incorporate a multimodal approach for data collection. Finally, the implementation and development of project-based learning could benefit from comparisons between student-produced content and teacher-produced public-facing content for a more complete narrative of learning in open-ended environments.

VIII. Conclusion

This paper presents preliminary findings from a text-based analysis of student learning artifacts and reflections from a four week, Maker-focused activity. The initial findings point to noticeable differences in how two different classes enrolled in the same course evidenced variable amounts of confidence and connectednes with a digital fabrication project. Importantly, this work aims to surface the potential affordances of using natural language processing to better understand student experiences. As a retrospective tool, natural language processing can help teachers consider how to redesign their courses. Additionally, teachers could use such a tool in real-time to consider variations in how students tone and confidence change over the course of project. Accordingly, we hope that this work will encourage more practitioners to consider using natural language processing tools to support their learning and their students' learning.

References

[1] R. S. Baker, S. K. D'Mello, M. M. T. Rodrigo, & A. C. Graesser, "Better to be frustrated than bored: The incidence, persistence, and impact of learners' cognitive–affective states during interactions with three different computer-based learning environments," *International Journal of Human-Computer Studies (IJHCS)*, vol. 68, no. 4, pp. 223-241, 2010.

[2] N. B. Hertzog, "Impediments to a project-based and integrated curriculum: A qualitative study of curriculum reform," presented at the Annual Meeting of the American Educational Research Association (AERA)., New Orleans, LA, 1994.

[3] B. G. Ladewski, J. S. Krajcik, & C. L. Harvey, "A middle grade science teacher's emerging understanding of project-based instruction," *The Elementary School Journal*, vol. 94, no. 5, pp. 498-515, 1994.

[4] L. Martin. (2015). *The promise of the maker movement for education* [Online]. Available: https://doi.org/10.7771/2157-9288.1099

[5] R. W. Marx, P. C. Blumenfeld, J. S. Krajcik, M. Blunk, B. Crawford, B. Kelley, & K. M. Meyer, "Enacting project-based science: experiences of four middle grade teachers," *Elementary School Journal*, vol. 94, pp. 517-538, 1994.

[6] R. W. Marx, P. C. Blumenfeld, J. S. Krajcik, & E. Soloway, "Enacting project-based science: challenges for practice and policy," *Elementary School Journal*, vol. 97, pp. 341-358, 1997.

[7] S. M. Sage, "A qualitative examination of problem-based learning at the K-8 level: preliminary findings," presented at the Annual Meeting of the American Educational Research Association (AERA)., New York, NY, 1996.

[8] S. Slater, R. Baker, J. Ocumpaugh, P. Inventado, P. Scupelli & N. Heffernan, "Semantic features of math problems: relationships to student learning and engagement," *In: Proceedings of the 9th sInternational Conference on Education Data Mining,* pp. 223-230, 2016.

[9] S. Slater, J. Ocumpaugh, R. Baker, M. V. Almeda, L. Allen and N. Heffernan, "Using natural language processing tools to develop complex models of student engagement," ACII, San Antonio, TX, pp. 542-547, 2017. Available: DOI: 10.1109/ACII.2017.8273652

[10] S. McQuiggan, S. Lee, & J. Lester, "Early prediction of student frustration," Affective Computing and Intelligent Interaction, pp. 698-709, 2007.

[11] J.W. Pennebaker & Y. Tausczik, "The psychological meaning of words: LIWC and computerized text analysis methods," *Journal of Language and Social Psychology*, pp. 24–54, 2010.

[12] J.W. Pennebaker, R. J. Booth, R. L. Boyd, & M. E. Francis. (2015). *Linguistic inquiry and word count* [Online]. Available: www.LIWC.net

[13] M. Worsley, "Multimodal learning analytics: enabling the future of learning through multimodal data analysis and interfaces," *In: Proceedings of the 14th ACM International Conference on Multimodal Interaction*, pp. 353-356, Santa Monica, CA, October 2012.

[14] M. Worsley & P. Blikstein, "Towards the development of multimodal action based assessment," *In: Proceedings of the 3rd International Conference on Learning Analytics and Knowledge,* pp. 94-101, Leuven, Belgium, April 2013.

[15] M. Worsley & P. Blikstein, "What's an expert? Using learning analytics to identify markers of expertise through automated speech, sentimeny and sketch analysis," *In: Proceedings for the 4th Annual Conference on Education Data Mining,* Eindhoven, Netherlands, 2013.