Friendly mentor or former consultant: peer-mentors in First Year Engineering Courses

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Introduction

In a first-year Cornerstone course at Northeastern University, students are tasked with a team-based design project spanning over 2 courses in one semester that integrates hands-on design and programming. The resulting product from this course is a tangible product, designed, built, and programmed by students who may or may not have experience in any or all of these areas. The aim of Cornerstone is to teach students a baseline of technical skills and prepare them with the universal problem-solving and teamwork skills they need to enter any major within the College of Engineering.

Beginning in 2017, undergraduate peer-mentors were employed to better support the first-year students in developing some institutional knowledge and achieving the tasks required of them in Cornerstone. A peer-mentor usually took the class with the same professor that they work for. They are brought on to assist the students in achieving their project goals. This practice has been adopted by 3 professors in the program and 2 implementation techniques have been established. The high-level purpose of this program is to provide a more positive experience for the first-year engineering students by establishing relationships with upper class students and to retain more institutional knowledge pertaining to the projects through those relationships enabling students to perform better. This is the first study in a series to begin examining the differences between those techniques as well as the effectiveness of the peer-mentor program.

In the first method studied by this work, the peer-mentors, 2 per class section, are selected first based on their availability then based on their skills and knowledge about the topics to serve as consultants during in-class group milestone presentations. In this method, there were no assigned out-of-class interactions between the peer-mentors and the students. In the second method studied by this work, individual meeting times of about 3 hours a semester with the peer-mentors are required outside of the class. Each class section had three peer-mentors as well as a teaching assistant to the instructor who also served as a peer-mentor for 2 of the student teams. There were fewer in-class interactions between the peer-mentors and the students, as peer-mentors were not required to attend all milestones. However, the students met their TA in almost every class throughout the semester. A summary of these differences is provided in Table 1.

Table 1: Summary of difference between two peer-mentor employment techniques studied by this work.

	Technique 1	Technique 2
Peer-Mentor Responsibility:	Not assigned to teams	Assigned to 2 teams
Number of Peer-Mentors	2 per class section	4 (3 peer-mentors, 1 TA-mentor)
Provides project feedback:	In-class	Outside of class
Meets with student teams:	By request only No time limit for the interaction	Mandatory scheduled meetings 3 hours total assigned interaction And by additional request

Literature agrees [1-3] that mentoring has positive effects on STEM students' college success but has contradictory evidence towards the effectiveness of assigned peer-mentor-student interactions outside of the class. Furthermore, the roles of mentors are defined differently across research. In previous work in this field [4-5], mentors were categorized as either instrumental or socioemotional. For this work, we have taken this spirit and mapped our terminology to vocabulary commonly used in industry to describe the various relationships that transpire. The mentors referenced by this work were paid for their role in helping the students to develop a project, and therefore we will be looking at interactions from this lens. To that end, instrumental relationships providing purely transactional efforts will be referred to as consultants and socioemotional relationships providing both personal and practical help will be coded as mentors.

Former students who had experienced this peer-mentor employment techniques (described in Table 1) at our institution were surveyed for this work. The results of this inquiry seek to examine the following questions:

How did the students describe their relationship with their peer-mentors?

Did peer-mentor interaction experience benefit their Cornerstone project?

How do the different peer-mentor techniques benefit Cornerstone students?

How did peer-mentoring affect Cornerstone students' first year experience?

Literature review

In recent years, the role and effect of mentorship in undergraduate education has become increasingly explored and studied [6-8]. Unfortunately, many people have found it difficult to research the topic due to the myriad of definitions and implementations of "mentorship" [9].

Despite this diversity of "mentor" definitions, Jacobi's [10] comprehensive review identified certain key components of mentoring to be similar in several programs. Based on Jacobi's findings, general mentorship could be defined as a personal relationship that includes role modeling or contributions to psychological support, career development, or professional achievement. One style of mentorship that is commonly used with undergraduate students is having a professor or faculty member as a mentor. These faculty mentor relationships have consistently been shown to have a positive correlation with grade point average and overall undergraduate academic success [11]. Furthermore, informal student-faculty interactions have been discovered to have a distinct effect on the attitudes and interests of the student and has been shown to enhance a student's learning experience and satisfaction with an institution [12]. One of the main limitations of faculty mentorship, however, is that it often has to be initiated by the student [13]. Brittian et al. (2009) discovered that major deterrents for seeking such mentorship opportunities included lack of awareness, lack of time, or lack of motivation or interest [14]. One way to make mentoring programs seem more appealing is by using mentors who are older students with similar college or life experiences rather than faculty members. So-called "peer mentors" are often more effective at creating initial bonds with mentees due to common perspectives and relatability [15]. Another way to circumvent the obstacles to mentorship mentioned earlier is to develop more integrated mentorship opportunities for a specifically targeted group that is the most likely to benefit from these initiatives, such as first year students. The first semester of a student's college career has been identified to be critical to future academic success as well as one of the primary indicators of whether a student will withdraw early from college [16]. Factors such as academic or adjustment difficulties or feelings of isolation have been shown to contribute to students dropping out of college [17]. Initiatives that focus on enhancing the freshman experience, such as first year peer mentor programs, have been found to be an effective way to increase the likelihood of success for first year college students. Research has determined that there are two primary effects to mentoring in first year classrooms: a "psychosocial" effect and a "career" effect [18-20]. The psychosocial effect is related to the relationship between the peer-mentor and the mentee and how the mentee feels about things that are not directly affiliated with the class. In Chester et al. (2013), it was discovered that peer mentorship for first year students was correlated with an increase in connection to an institution, as well as an increase in academic integrity, motivation, and critical thinking [18]. The career effect of mentorship relates to the objective outcomes such as aid in projects, assistance in coursework, and overall educational achievement [19]. In Chatham-Carpenter et al. (2014), this career effect of peer mentoring was studied in regards to retention and academic success. It was identified that peer mentoring led to a 6% increase in retention between the first two semesters for first year students (85.6% versus 79.6% for mentored and non-mentored students respectively) [20].

Upon examination of literature focused on peer mentorship in first year engineering classrooms, it can be seen that many of the aforementioned trends are maintained. In regards to retention, Gattis et al. (2007) showed that peer mentoring led to a 16% increase in retention between the first two semesters for first year engineering students (94% versus 78% for mentored and non-mentored students respectively) [21]. In a different study, peer mentoring in a fundamentals of engineering course was correlated to a 10% increase in students who received a grade of C or higher in the course [22]. Thus, the reviewed literature suggests that there are advantages to the

use of peer mentorship in first year engineering classrooms. A major limitation of the literature thus far, however, is that it often examines whether mentorship is inherently beneficial rather than determining which style of mentorship is most effective. Different styles of mentorship can range from a strictly professional relationship to more friendly and personal relationships [23]. Based on the literature reviewed, we seek to determine the most effective method of peer-mentorship in the project-based first-year Cornerstone of Engineering courses at Northeastern University.

Methodology

Students from classes where a peer-mentor program was used were surveyed using Google Forms. The survey resulted in 122 student responses from students who participated from the program's inception in fall 2017 to fall 2019. The survey included four sections: course information, peer-mentor description, final project reflection, and open-ended commenting on their peer-mentor experience. In the first section, participants indicated their professor and the year they participated. This identified under what technique they participated in. Students were first provided an opportunity to indicate their mentor through an open-ended response and then through a pre-populated drop-down menu of past mentors if they could not remember. This step was included to examine if any trends were indicated by remembering the name without assistance vs with assistance, erring on that potential being more valuable than simplifying the survey.

Then participants moved on to describe their peer-mentor in three adjectives and chose how they interacted with their peer-mentor from the following options:

- "Communicated with as many times as required by assignments"
- "Communicated beyond the requirements"
- "Only met in class during Milestone presentations"
- "Met with as many times as required by assignments"
- "Met beyond the requirements"
- "Never communicated", or "Never met"

In the following section, participants answered questions pertaining to their final project. These included their final grade for their project on a letter scale and two reflective questions pertaining to how proud they felt about the project and what effect their peer-mentor had. Each reflective question was in a scale response format from 1-10, 1 being a most negative response and 10 being a most positive response. Researchers did not confirm these student-mentor pairings or the final grades assigned, relying on the student responses.

The final section asked open response questions about their experience with their peer-mentor. The questions were: "How did your experience with your mentor affect your project?", "How did your experience with your mentor affect your first-year experience at Northeastern?", and "Is there anything else you would like to share about your experience with your mentor?".

Survey data from the final section was examined for emergent themes in the student responses and a coding scheme was developed based on those themes. An initial review of a subset of student responses showed clear distinctions in the long-term quality of association they held with their first-year engineering experience in the context of their peer-mentor interactions and in the type of relationship they fostered with their peer-mentor. The first theme, their reflection of the experience, was assigned the codes of *positive*, *neutral*, and *negative*. The distinction being whether their tone and the content of the responses suggested they had a *positive* association with the experience, a *negative* one, or if there was either nothing to suggest a positive or negative association or the student had clearly responded with "no effect, N/A, etc." (*neutral*).

The second theme, type of relationship, was assigned the codes of *mentor* or *consultant*. The distinction being whether the relationship was purely transactional and focused only on their First Year Engineering project (coded as *consultant*) or if there was an indication that their relationship with their assigned peer-mentor went beyond that of pure counsel on their project, i.e. mention of discussion of life at Northeastern, help with choosing a major, aid in picking classes, etc. (coded as *mentor*). Note that these upper-class students are hired with the title 'peer-mentor', inferring the role is as a 'mentor', but instruction and assignments focus interactions around the course projects, guiding their utilization towards 'consultant'. This coding scheme uses the industry terms due to their heavy use and well-established definitions in industry [4-5] but we refer to them by their full title in this document to minimize confusion due to the overlapping terms.

The dataset was broken into subsets and assigned to the researchers such that each entry was coded by at least 3 members. Codes were applied for each survey response for each theme. A student response was assigned a code if the majority of reviewers assigned it that code. The coding results were collected and officially assigned based on the average of responses. In scenarios where there was no consensus among the initial 3, additional reviewers were added for those data points until a consensus code was achieved.

Results and Discussion

531 first year engineering students utilized the peer-mentor program from 2017-2019. We received 122 responses, which was 23.0% of the student population from all classes with the majority of responses - about 87% - belonging to the students enrolled in technique 2 peer-mentorship program. While 2019 had the highest participation rate for both techniques, technique 1 had the least participation rate in 2017 and 2018 making the interpretation of the data harder. Table 2 shows the distribution of the responses received as well as the number of students enrolled in each class separated by year.

Table 2: Participation rate and total enrollment

Technique	Year									Total		
	2017			2018			2019			R	E	RR (%)
	Responses	Enrollment	Response Rate (%)	R	E	RR (%)	R	E	RR (%)			
1	4	61	6.5	5	63	8	10	50	20	19	174	10.3
2	21	94	22.3	25	114	21.9	58	149	39	104	357	30
Total	**25**	**155**	**16**	**30**	**177**	**17**	**68**	**199**	**34.2**	**122**	**531**	**23**

Results from the first section of the survey

The result of the 'Do you remember your mentor?' question is summarized in Figure 1. In this question, the students who answered 'yes' were prompted to write down their peer-mentor's name. Due to the diverse nature of our student population and peer-mentors, all of the results from this section with or without proper spelling of the peer-mentors' names were considered valid. Those who did not remember their peer-mentor were given a list of names to pick from in a follow up question. Figure 1 only illustrates the results for the 'Do you remember your mentor?' question without prompting to choose a name from a list.

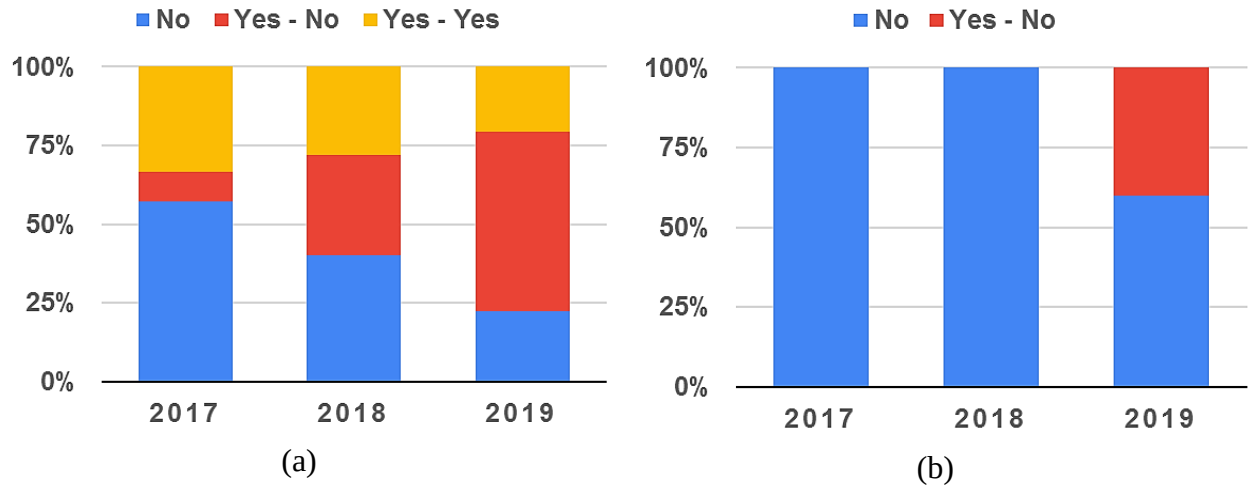


Figure 1: Percentage of the students remembered their peer-mentor's name - TA or not without prompting for a) technique 2, b) technique 1.

As discussed in the introduction section, one out of every four peer-mentors in technique 2 served as a Teaching Assistant (TA) during any particular semester. The TA attended the lectures four times weekly, and thus the students had more opportunity to interact and engage in

conversation. Students who remembered their peer-mentor's name when their peer-mentor was also a TA are labeled as 'Yes-Yes' in Figure 1, those remembered their peer-mentor but the peer-mentor was not a TA with 'Yes-No' and those that did not remember are labeled as 'No'.

As expected, time had a positive correlation with the student's memory in both techniques. A larger number of students were able to recall their peer-mentors in the recent year (2019) compared to the previous years. However, time was not the only factor affecting their memory in both techniques.

In technique 2 - Figure 1a - peer-mentors who were also a TA for the class made up the majority that the students were able to identify in 2017. Due to the anonymity of the survey, it is impossible to see whether the students correctly identified their peer-mentor or the TA as their peer-mentor due to the greater amount of interaction both in and out of class. The number of students recalling their peer-mentors increased from 10% to 60% in the years after which might be due to the assigned interaction out of the class.

On the other hand, in technique 1, peer-mentors only participated during in-class presentation and were neither instructed to meet/interact with students outside of class nor assigned to any particular teams. Therefore, there were occasions where the peer-mentors were passive and did not provide any constructive feedback to the presenters during the class presentations. Although the participation rate for technique 1 class is very low, only 6.5-8% for 2017-2018, students seem to have a harder time remembering their peer-mentor. A similar pattern was seen in 2019 compared to technique 2. The students described their peer-mentors in 2017-2018 as "Minimal, Not memorable".

In the follow-up section of the survey that the students prompted to identify their peer-mentor from a list, a pattern similar to those discussed previously were seen. All of the TAs in the list were identified by the students either as their own peer-mentor or a name that they recalled. While the students could have benefited from their mentors without remembering their names, name recognition with or without prompting shows a stronger connection between the mentor-mentees.

Results from the second section of the survey

The results of the responses to the extent of interaction question between the students and peer-mentors is summarized in Figure 2. The options have been categorized 'Required Interaction', 'Beyond Requirements' and 'Never Interacted' for better presentation of the results. In technique 2, Figure 2a, at least a third of the students went beyond the assigned out of class interaction requirements to meet/communicate with their peer-mentors. A similar pattern is seen in 2019 for technique 1 with a slightly smaller percentage. These seem to be the overachievers that make up almost a quarter to a third of the student population for each year regardless of the technique used. However, the assigned relationship in technique 2 seems to have given a larger population of students from 2017-2019 the courage and confidence to go above and beyond the requirements with their peer-mentor.

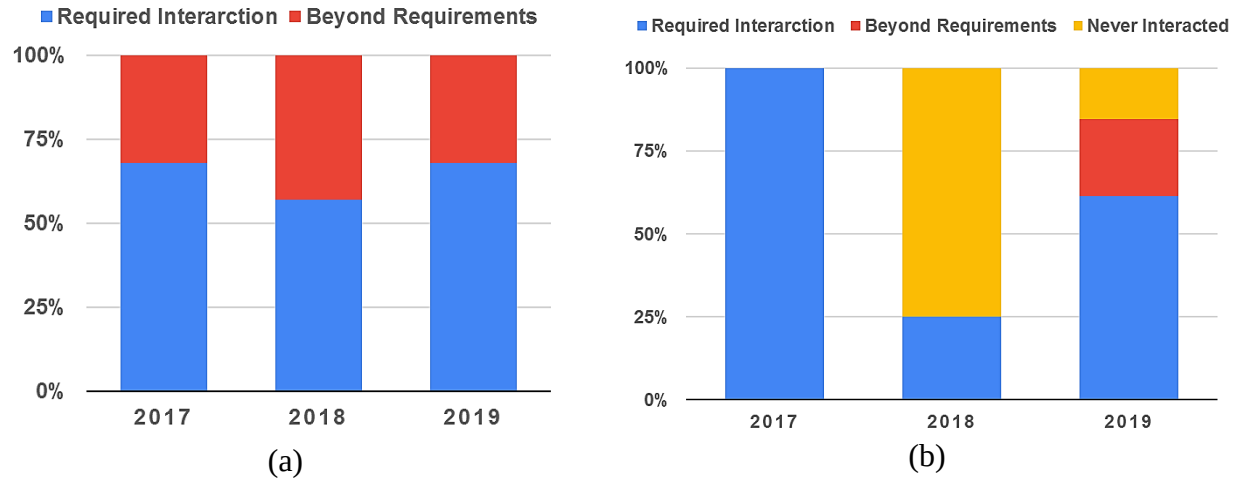


Figure 2. Extent of interactions with the peer-mentors that students self-identified in a) technique 2 b) technique 1.

In addition to the two categories discussed in the previous paragraph, a small percentage of the students in 2019 for technique 1 reported 'never interacting' (meeting or communicating) with their peer-mentor. Further evaluation of the results show that these are the students that either have no memory of the class/mentors at all or received no feedback regarding their presentation or project from their peer-mentor in class and thus categorizing their interaction as 'never interacted'.

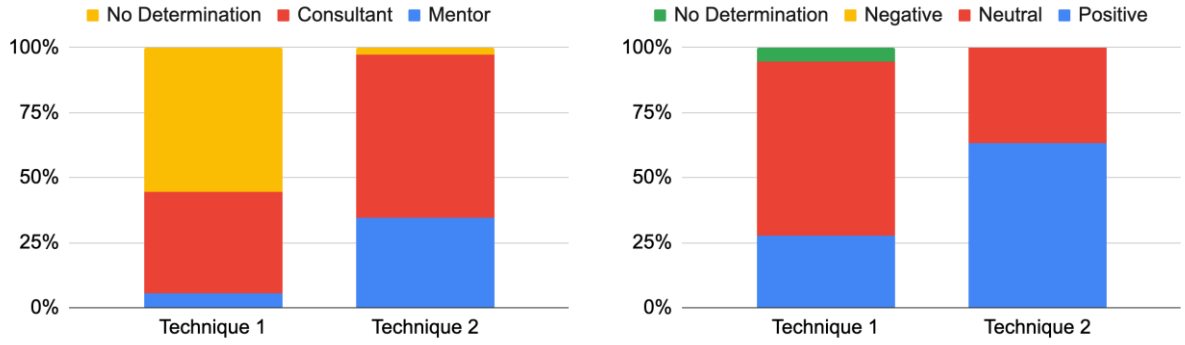
Unlike technique 2, due to the small number of participants in 2017-2018 for technique 1 no conclusions were drawn for those years and the data is presented only for completeness.

Results from the last section of the survey

The discussion of these roles needs to be prefaced with an acknowledgement of the difference in responses for the 2 techniques. There were 5.78 times more responses for technique 2 than for technique 1 in total, meaning an additional technique 2 student response would have a less than 1% influence on the results but an additional technique 1 student response would cause a more than 5% change. The differences between the results though are much greater than that discrepancy in influence.

Figure 3a presents the coding results by technique vs perceived role. There exist clear distinctions between the 2 techniques. Regarding perceived role, technique 2 students were 6.2 times more likely to be coded as 'mentor'. Under technique 1, the majority of students noted only a utilization of these resources in direct regards with their project ('Consultant') or outright indicated that they made no use of the peer-mentors or they had little to no effect ('No Determination'). Technique 2's requirement that students make use of their assigned peer-mentor clearly, and unsurprisingly, forces them to establish some clear 'consultant' or 'mentor' relationship. More importantly, the provided instructions for those interactions do admittedly focus on the project itself and steer those interactions towards a more transactional interaction,

which explains the majority ‘consultant’ roles identified. Clearly without having interacted, they do not even have a chance to promulgate a relationship at all, particularly one that goes beyond the project and towards developing as a student and budding engineer.



(a) (b)

Figure 3: a) Perceived Role b) Student Experience vs. Mentoring Technique

The results by experience vs technique are provided in figure 3b but the influence is better illustrated by examining the experience vs role, see figure 4. When a student’s response was coded as ‘mentor’ for perceived role, their experience was also coded as ‘positive’ in 100% of cases. A ‘consultant’ role also had a vast majority coded as ‘positive’ experience, 80%. In the cases where no perceived role could be determined, the experience was commonly considered ‘neutral’, showing no signs of any long lasting positive association outright stating the lack of peer-mentor influence on their experience.

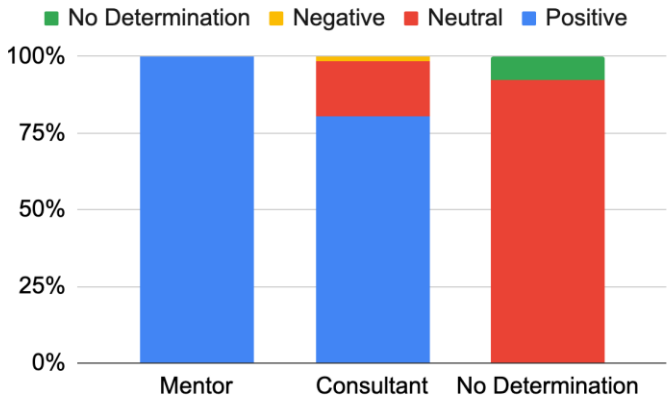


Figure 4: Student Experience vs. Perceived Role

Conclusion

Two peer-mentoring techniques were assessed in this work, one based on assigning a peer-mentor to work with a group outside of class, and one based on mentoring in-class. A survey was administered to students from several years of classes utilizing the different methods to answer the following research questions:

1) How did the students describe their relationship with their peers-mentors?

2) Did peer-mentor interaction experience benefit their Cornerstone project?

3) How do the different peer-mentor techniques benefit Cornerstone students?

4) How did peer-mentoring affect Cornerstone students' first year experience?

Results of the survey showed that the majority of students described a positive relationship with their peer-mentors, but the assigned peer-mentor technique (technique 2) led to better relationship formation. A majority of students also reported in both techniques that peer-mentors were helpful, with assigned interactions showing longer-term social instances. Overall, assigned peer-mentor relationships resulted in more positive effects but both techniques benefited the first-year students' Cornerstone experiences.

Another area examined from the survey included whether the peer-mentors were being utilized as 'mentor' or 'consultant' using a coding scheme based on established industry defined terminology. In both techniques, peer-mentors were largely used as consultants due to the instructions guiding the students to utilize mentors as advisors on their course project. However, in technique 2 (assigned peer-mentors), results pointed to a 29% greater coding of 'mentor' style relationships forming. When students described their peer-mentors as an industry-defined mentor role, the memories of their project experience were 100% positive, compared to the industry-defined consultant role (80% positive).

The initial aspiration for the peer-mentors was twofold: develop and pass on some institutional knowledge pertaining to the first-year engineering projects and to provide a connection to the university as whole through upper-class peer interactions. The former has occurred in a majority of cases, where a consultant relationship forms around the transactional interactions of students meeting requirements by seeking guidance from these assigned peer-mentors. The consultant role has provided much for our students and, in general, their experiences are positive or at least neutral. The latter aspiration did not occur in a majority of cases but there is still a fair number of cases, in technique 2, where that relationship progressed into the realm of a more traditional ongoing mentor relationship. This work has provided clear reason to push harder towards that aspiration even simply to ensure more positive associations with our first-year engineering courses. The findings here may provide the insights necessary to encourage more mentor relationships to truly form among our first-year engineering students and their peer-mentors.

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