

## Where have all the mining engineering students gone? New study seeks insights to improve enrollment

by Jodi Banta, Isabel Barton and Lynnette Hutson



It's no secret that student enrollments in mining engineering programs have been declining globally. In the United States and Australia, numbers are down by nearly 50 percent (Roy et al., 2019; Roy, 2019) and as much as 80 percent (Minerals Council of Australia, 2019) from their respective peaks in 2013 and 2012, and it is much the same story for Canadian schools (Mining Industry Human Resources Council, 2018). We've all heard plenty of speculation as to why — young people think mining is dirty and archaic, it destroys the planet or maybe they just don't know it still exists? Then there's just straight-up competition from other fields.

In an effort to improve our programs, the University of Arizona's (UArizona) Lowell Institute for Mineral Resources and Mining and Geological Engineering department started asking students about their awareness and perception of mining and mineral resources and we learned some very interesting things.

According to a recent survey of UArizona students (UArizona mining perception study surveys, 2019):

- 72 percent agree that mineral resources are “important” or “very important” to their daily lives, with more than 40

- percent saying “very important.”
- 84 percent agree that “mining is necessary.”
- 49 percent rate the mining industry as “as responsible as” other industries, with more students rating it responsible as opposed to irresponsible.
- 34 percent rate the mining industry as “as modern as” other industries, with more students rating it modern as opposed to outdated.

Students were asked for their feedback on a variety of questions regarding mining and we did find that roughly half agree with the statement “Mining harms the environment.” Ninety-two percent agree with the statement “Mining provides jobs.” Based on responses to all the questions, our assessment of student perceptions of the industry is neutral. The perception of engineering students is significantly more positive than that of students enrolled in other fields.

In the same survey we found that while 74 percent

**A view of the University of Arizona campus in Tucson, AZ, home of the Lowell Institute for Mineral Resources and Mining and Geological Engineering department.**

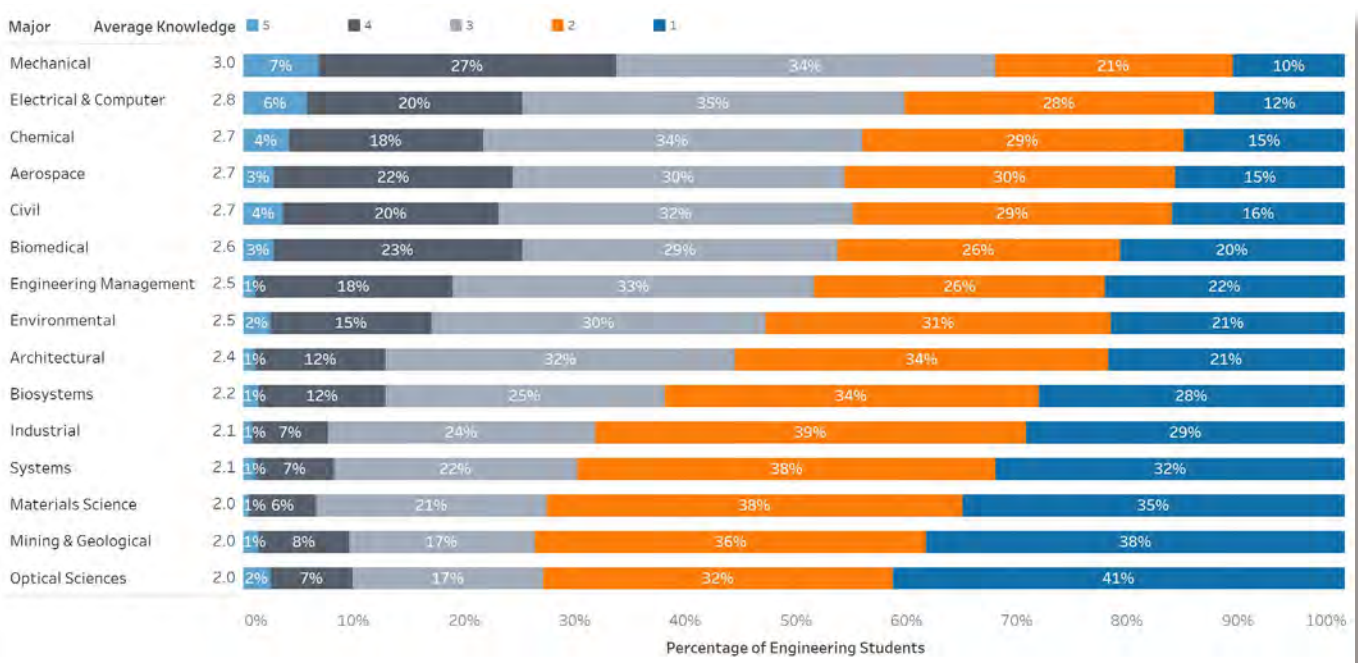
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# Mining Education

**Figure 1**

**Most incoming freshmen engineering students are not knowledgeable about mining.**

On a scale of 1 to 5, where 1 is “I know nothing” and 5 is “I know all about it”, please rate your interest in the following fields.  
N = 363



of UArizona students are aware that Arizona has active mines, and 66 percent are aware that UArizona offers a mining engineering degree, very few students have any knowledge of mining — with 67 percent reporting having

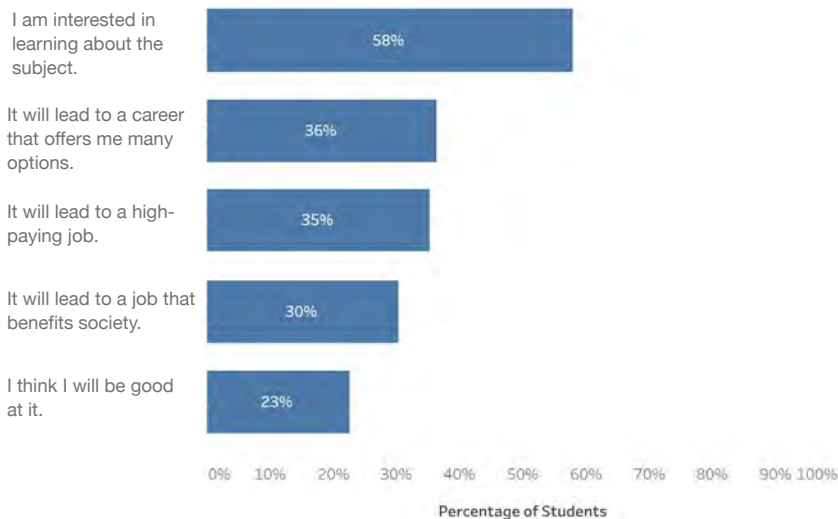
little to no knowledge of mining at all. In other words, awareness and perception, at least of the industry at large, and among UArizona students, are not the main problems here. UArizona students are highly aware of mining and in general do not have a negative perception of the industry — in fact, they’re convinced that it is important, but they really don’t know anything about it. We’ll come back to knowledge.

These preliminary findings inspired us to undertake further research to better understand how students are choosing their engineering field of study. In particular, this research seeks to gain a better understanding of why particular engineering disciplines — including mining engineering — have chronically and consistently lower enrollment than other engineering disciplines. In the fall of 2020, we implemented a new survey of the freshman-level UArizona Introduction to Engineering Design course. One of the objectives of the course is to introduce students to the 15 different engineering fields of study available to them at UArizona. For this reason, we chose to run this survey at the beginning, and again at the end of the semester to measure the effect of the class on outcomes related to students’

**Figure 2**

**Incoming freshmen engineering students want to study fields they are interested in and will give them options.**

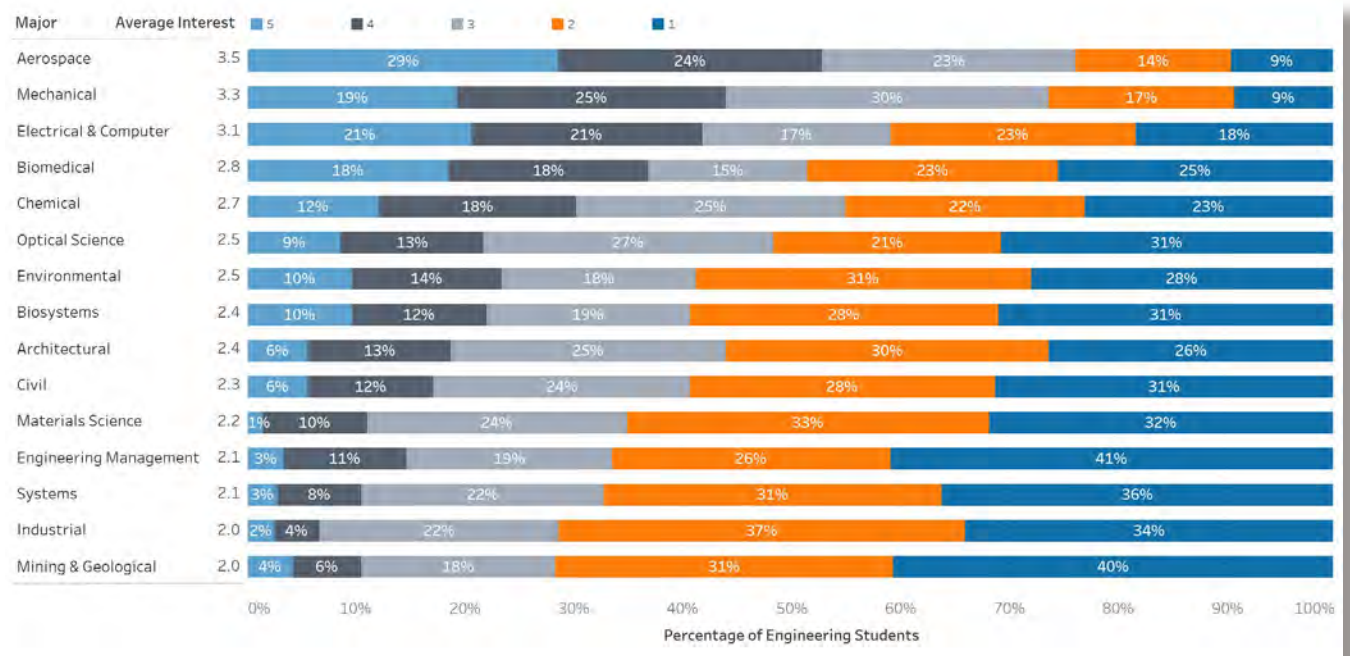
When choosing a major, the most important thing to me is (select up to three):  
N = 363



## Figure 3

**Incoming freshmen engineering students rate mining among the least interesting engineering majors.**

On a scale of 1 to 5, where 1 is “completely uninteresting” and 5 is “very interesting”, please rate your interest in the following fields.  
N = 363



choice of engineering major.

The survey at the beginning of the semester was administered online to the nearly 500 students enrolled in the course and resulted in a sample of 363 responses (UArizona freshmen engineering student surveys, 2020), representing more than 75 percent of the class. The students’ self-reported demographics largely matched those of the current UArizona College of Engineering and other engineering schools nationwide: notably 65 percent male, and 73 percent white.

Eighty-four percent of responders were 18 years old or younger. That’s the age at which students are choosing their engineering major. And by their own admission, when they enter Introduction to Engineering Design, they know very little about the 15 different engineering fields from which they’re meant to choose.

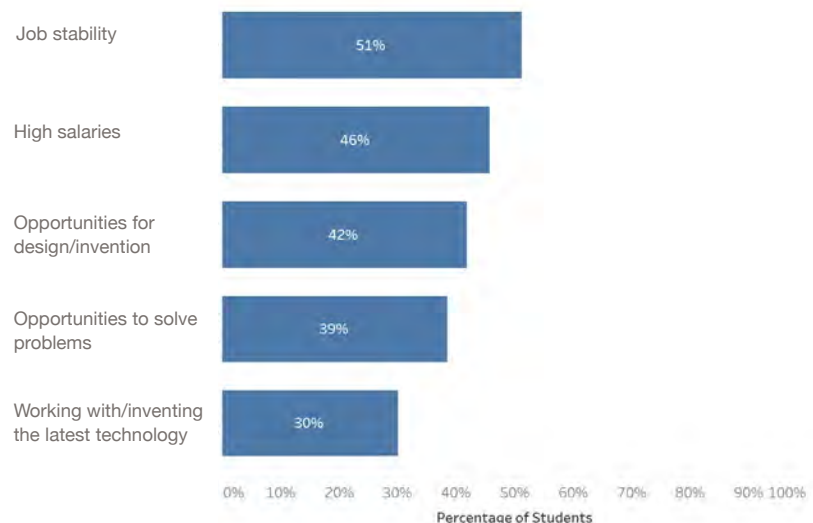
As shown in Fig. 1, we asked students to rate their knowledge of each engineering field on a scale from 1 to 5, with 5 being high. Mechanical engineering scored the highest with a mean score of 3.0, with one third of students

reporting some knowledge. Other fields that scored highest on knowledge were Electrical & Computer, Chemical and Aerospace. Mining Engineering came in tied for last place, with a mean score of 2.0 and nearly 75 percent of

## Figure 4

**Incoming freshmen engineering students are looking for job stability and high salaries.**

Which of the following attributes is important to you in your future job? Select up to three.  
N = 363



students saying they know nearly nothing about it.

We then asked the students to rate their interest in the same 15 fields (Fig. 3). Aerospace scored the highest at 3.5. Other fields that students found interesting included Mechanical, Electrical & Computer, Biomedical and Chemical engineering. Mining Engineering again tied for last place, with a mean score of 2.0, and a full 40 percent of students rating it as “completely uninteresting.”

Not surprisingly, there is a very strong correlation between students’ knowledge of a field and their level of interest in it. Students are unlikely to be interested in a subject they know little about.

So, what do engineering students say they consider when choosing a major? In our survey, they could choose up to three answers (Fig. 2).

The top choices were “I am interested in learning more about the subject” (58 percent) and “It will lead to a career with a lot of options” (36 percent), followed closely by “It will lead to a high-paying job” (35 percent).

Interest in disciplines that “benefits society” is also high with around 30 percent of students picking this option.

“I think I will be good at it” came in at a distant fifth place (23 percent). Other answer choices all received well under 10 percent.

When asked about what is important to them in a future career, shown in Fig. 4 (students could choose up to three answers), not surprising at this moment in time, the top choice was “job stability” (51 percent), followed by “high salaries” (46 percent).

“Opportunities to invent” and “Opportunities to solve big problems” followed, each selected by about 42 percent and 39 percent of responders, respectively. “Working with/inventing the latest technology” came in at fifth place with about 30 percent of responders. Other answer choices were selected by 20 percent of responders or fewer.

Translating that into intended majors, more than half the class reported intending to major in one of the four most interesting majors: Mechanical, Aerospace, Electrical & Computer and Biomedical Engineering.

When asked about their confidence in their choice of major, again on a scale from 1 to 5, the average was 3.5. When asked about their knowledge of careers associated with choice of major, the average rating was 3.0. So at 18 years old, with little knowledge of the subjects they may study, or of related careers, it is no surprise students lean toward general interest in a subject they think they know something about (as opposed to nothing) and something they hope will lead to a wide range of career options.

Early results from the end-of-semester survey

indicate that knowledge of all subjects went up an average of nearly 40 percent and mining engineering was the biggest mover with average knowledge increasing by 70 percent, which moved it up to fifth place in the knowledge rankings. From 74 percent of students saying they knew nothing or very little about mining engineering at the beginning of the semester, only 17 percent said so at the end. Interest also increased, from only 10 percent of students rating Mining Engineering as interesting or very interesting at the beginning of the semester, to nearly 30 percent by the end. We like to think our research and corresponding changes to how the major is presented are paying off. However, there’s still much more work to do, as while the number of students intending to major in Mining Engineering also increased, the increase was not as substantial.

Over the coming years, the UArizona will be taking a deeper dive into all of this. We will research what students find interesting about some fields (and not others), how to identify what students do find interesting about mining engineering and how to communicate that effectively to a wider audience, and how to bring to life the variety of career options available in mining engineering. We’ll also be seeking a better understanding of students we are currently successfully attracting to mining engineering, and those we wish we were but are not.

To learn more about these studies or results, please contact Jodi Banta [jhbanta@arizona.edu](mailto:jhbanta@arizona.edu). ■

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- UArizona mining perception study surveys were conducted face-to-face using tablet computers November-December 2019. Sample size = 344, confidence level of 95 percent, and margin of error of +/- 5.25 percent.
- UArizona freshmen engineering student surveys were conducted online (a) September 14-October 26, 2020. Sample size = 363, confidence level of 95 percent, and margin of error of +/-2.7 percent. (b) November 30-December 6, 2020. Sample size = 367, confidence level of 95 percent and margin of error of +/-2.7 percent.

# How to get more students to major in mining engineering? Answers from the University of Arizona

by Isabel Barton, Jodi Banta and Lynnette Hutson

What keeps students from majoring in mining engineering? As our previous article (*Mining Engineering*, Feb. 2021) pointed out, it's not that they think mining is dirty, or that it's low-tech, or that it's unnecessary (Banta et al., 2021), in fact, they know too little about mining to hold preconceived ideas about it at all. Instead, the problem is that students hardly know mining engineering exists as a possible career option. The facts are that the University of Arizona (UArizona) engineering students show up to college knowing less about mining engineering than they do about any of the 14 other engineering majors available, and correspondingly, lack interest in the subject.

What can be done to change this lack of exposure to the field? In this second report of our ongoing study, the UArizona's Lowell Institute for Mineral Resources and Mining and Geological Engineering department tackles that question. We look at how freshmen engineering students' levels of knowledge and interest in mining engineering change as they are exposed to new information. We'll also pinpoint some common student motivations and interests, and how mining engineering can fit within these.

### About the study

First, a note on methodology. We conducted two online surveys with students in UArizona's required course for engineering freshmen, engineering design. A baseline survey was done early in the semester, and a second one to measure change in knowledge and attitudes was done at the end of the semester. Most of the survey questions for each were the same and included questions related to demographics, levels of knowledge and interest in UArizona's 15 different engineering majors, career aspirations, motivations for choosing a major, and sources of information. The end-of-semester

survey contained additional questions asking students whether their intended majors had changed since the beginning of the semester and if so, why.

In between the two surveys students watched an approximately 20-minute video on each of the 15 majors in the UArizona's College of Engineering

and attended or watched the recording of a live question and answer session with a faculty member representing each major. We received 363 responses at the beginning of the survey and 367 at the end, representing more than a 75 percent response rate, a confidence level of 95 percent, and a margin of error of +/- 2.7 percent. The self-reported demographics of the responses largely mirrored the overall demographics of the UArizona College of Engineering with two-thirds male, 65 percent Arizona residents, three-quarters white, and approximately 20 percent Hispanic. The study was carried out under UA IRB protocol #2002354299.

### A little information about mining goes a long way

At the beginning of the semester, nearly 75 percent of students reported knowing almost nothing about mining engineering. By the end of the semester, that number had dropped to 17 percent. The average reported level of knowledge about mining engineering went from 2/5 at the beginning of semester to 3.4/5 at the end, representing the biggest increase of any engineering major, and almost double the average increase, which was +0.95. The reported average level of interest in mining engineering increased from 2/5 at the beginning of the semester to 2.7/5 at the end of the semester. That figure was less than the jump in knowledge, but still the second-biggest percentage increase of any engineering major. Mining engineering therefore went from being the least-known and least-interesting of the 15 majors at the beginning of the semester, to the fifth best-known and around the middle of the pack in average interest by the end of the semester.

### Increasing mining knowledge

Students are not interested in subjects they know nothing about, and increasing their knowledge doesn't always correspond with greater interest. For example, take civil engineering and engineering management. Early in the semester both were wallowing at only slightly higher levels of interest than mining engineering. But by the end of the semester, students knew a lot more about civil engineering and engineering management, but still had little interest in the subjects.

Luckily, mining engineering is different: increased knowledge positively correlated

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## Figure 1

**Mining and geological engineering had the largest increase in knowledge over the course of the semester.**

On a scale of 1 to 5, where 1 is "I know nothing" and 5 is "I know all about it", please rate your knowledge of the following fields.  
N = 363 beginning, 367 end

	Beginning	End	% Variance
Mining & Geological	2.0	3.4	71%
Optical Sciences	2.0	3.3	64%
Materials Science	2.0	3.3	63%
Systems	2.1	3.2	54%
Industrial	2.1	3.0	42%
Biosystems	2.2	3.2	40%
Aerospace	2.7	3.7	36%
Architectural	2.4	3.2	34%
Environmental	2.5	3.3	33%
Engineering MGMT	2.5	3.3	31%
Chemical	2.7	3.5	31%
Electrical & Computer	2.8	3.6	30%
Civil	2.7	3.4	28%
Biomedical	2.6	3.3	28%
Mechanical	3.0	3.8	26%

## Figure 2

**Mining and geological engineering had the second largest increase in interest over the course of the semester.**

On a scale of 1 to 5, where 1 is "completely uninteresting" and 5 is "very interesting", please rate your interest in the following fields.  
N = 363 beginning, 367 end

	Beginning	End	% Variance
Materials Science	2.2	2.9	34%
Mining & Geological	2.0	2.7	33%
Systems	2.1	2.5	21%
Optical Sciences	2.5	2.9	18%
Architectural	2.4	2.8	15%
Engineering MGMT	2.1	2.4	15%
Industrial	2.0	2.3	14%
Civil	2.3	2.6	13%
Biosystems	2.4	2.7	13%
Chemical	2.7	3.0	10%
Environmental	2.5	2.7	10%
Electrical & Computer	3.0	3.3	8%
Biomedical	2.8	3.0	8%
Mechanical	3.3	3.5	6%
Aerospace	3.5	3.6	2%

with increased interest. For example, a 70 percent increase in knowledge (from 2 to 3.4/5) translated into a 35 percent increase in interest (from 2 to 2.7/5) and a 20 percent increase in the number of students who reported planning on majoring in mining engineering. For comparison, knowledge of civil engineering went from 2.7 to 3.4/5, but interest in this major rose only from 2.3 to 2.6/5. In engineering management, knowledge rose from 2.5 to 3.3/5, but interest only rose from 2.1 to 2.4/5. For about the same end-of-semester knowledge levels among all three of these majors, mining engineering garnered a much higher level of interest.

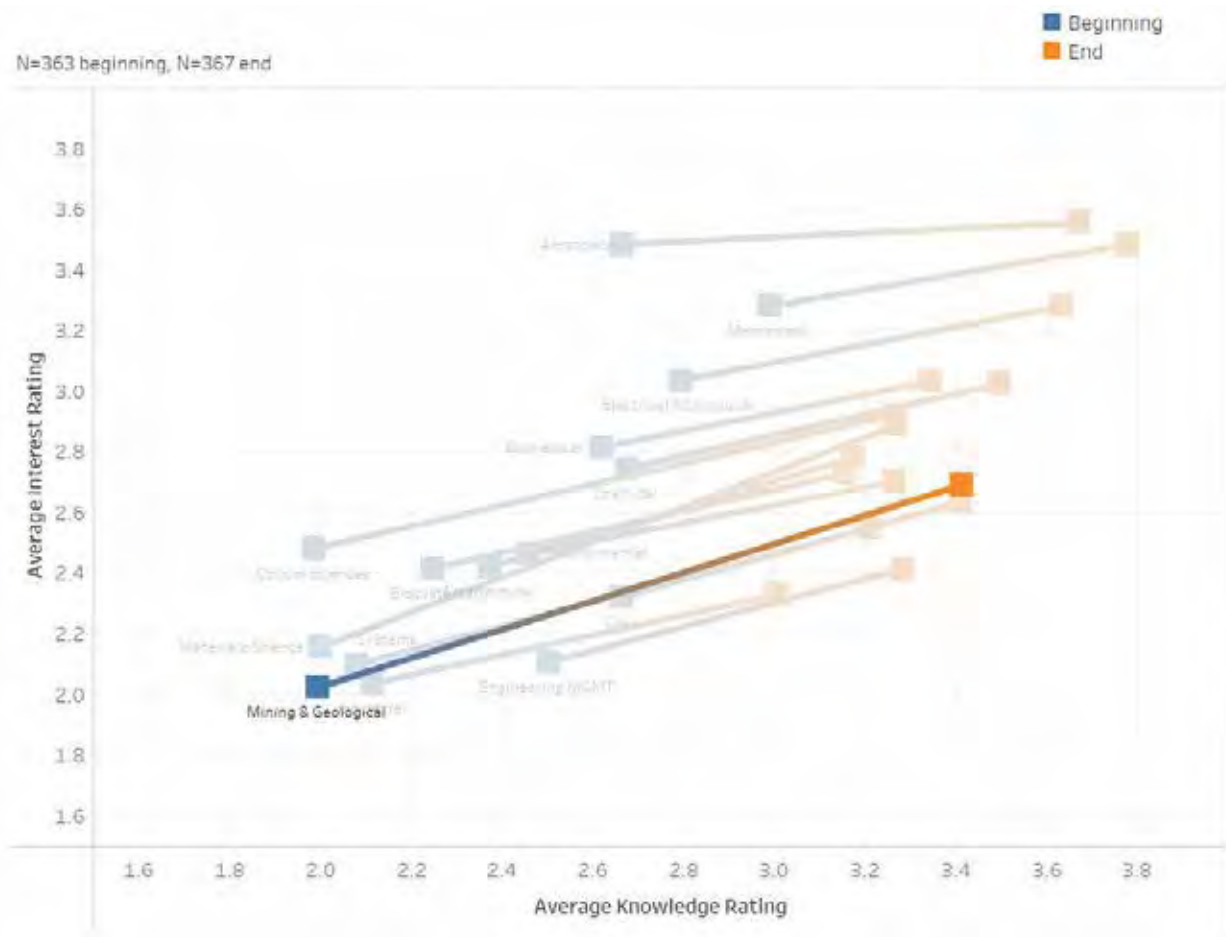
The rise in interest with increasing knowledge gives mining an advantage over most other majors in engineering. Materials science shows a

pattern similar to mining engineering, but levels of interest in the other engineering majors went up by an average of 0.33/5, which is less than 15 percent, for an average knowledge increase of 0.95/5 or 41 percent. Sometimes this was because a field, e.g., aerospace engineering, had started out with a high level of interest and didn't have much room to grow. But for most of the other engineering fields, an increase in knowledge over the course of the semester just didn't move the needle on interest. Mining's luck may be due to an unexpected wow factor. When an honors section of the engineering design course was asked which major they found most surprising, overwhelmingly they chose mining engineering. Aspects that surprised students included the importance—that mining supplies the materials

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Figure 3

Knowledge and interest in mining engineering increased more than many other disciplines over the course of the semester.



we rely on every day, and that they are needed for advancing society and technology. Students were also surprised at the opportunities for improving efficiencies and sustainability in the industry, and the potential to work all over the world. One student remarked that at first it “just sounded boring,” but that after learning about it, mining engineering turned out to be “absolutely fascinating.”

It’s also a good sign that the number of students planning to major in mining engineering increased over the course of the semester as they learned more about it. For four of the 15 fields, the number of intended majors either stayed flat over the semester (i.e., architectural engineering and engineering management) or decreased (i.e., optical sciences and environmental engineering). It seems mining engineering has a definite advantage: once students know about it, they start to think it’s cool.

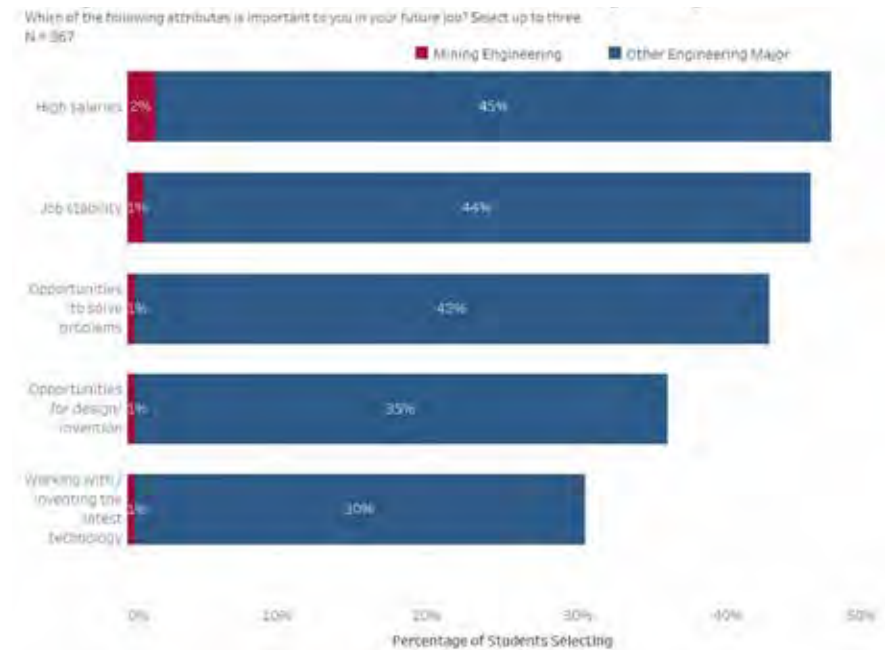
### How information affects major choice

This study also found that once students have picked a major, it doesn’t take long for attitudes and plans to harden. By the end of the

semester, only 6.5 percent of students were undecided, and students with a selected major reported much more confidence in their choice than they had at the beginning of the semester. The change was especially notable among students who planned to major in mining engineering. Early in the semester, this group reported being moderately confident in their choice (average 3.5/5). By the end of the semester, that confidence level had increased to 4.3/5. During the course of the semester, students planning on a mining engineering major had gone from tenth most confident out of the 15 majors, to most confident of all. Mining engineering students also rated themselves as the second most knowledgeable group about careers available in their chosen major (3.6/5) after industrial engineering majors (3.7/5). Knowledge of available careers showed a statistically significant positive correlation with confidence in major choice. This is consistent with related findings suggesting that students’ ability to connect education to careers improves their confidence in the value of their education (StradaEducation.org/PublicViewpoint October 27, 2020).

## Figure 4

Mining students value similar career attributes as other engineering students.



### What students want in a major and a career

What is it that students are hoping to get out of mining engineering, or for that matter, out of any engineering major? That answer doesn't vary much across most engineering disciplines, nor from the beginning to the end of the semester. Stable jobs, high pay, and opportunities to invent and to solve problems are the most often cited motivations among survey respondents.

The findings of the survey show that all students want much of the same things out of their careers, and they have similar expectations about what they will get out of their majors. When mining engineering students were asked to select their top three reasons for choosing their major, by far the biggest responses (75 percent) were related to interest in the subject. "It will lead to a career that offers me lots of options," was a choice selected by 50 percent of the planned mining engineering majors (up from 30 percent in an earlier survey), and "It will lead to a job that benefits society," was selected by 33 percent (up from 20 percent in an earlier survey). Mining engineering students were less likely to pick "I think I will be good at it," or "It will lead to a high-paying job," compared to other engineering students. However, none of these differences was statistically significant to  $< 0.05$ , so the responses from mining engineering students were close to those for other engineering freshmen.

### Unique qualities of mining engineering students

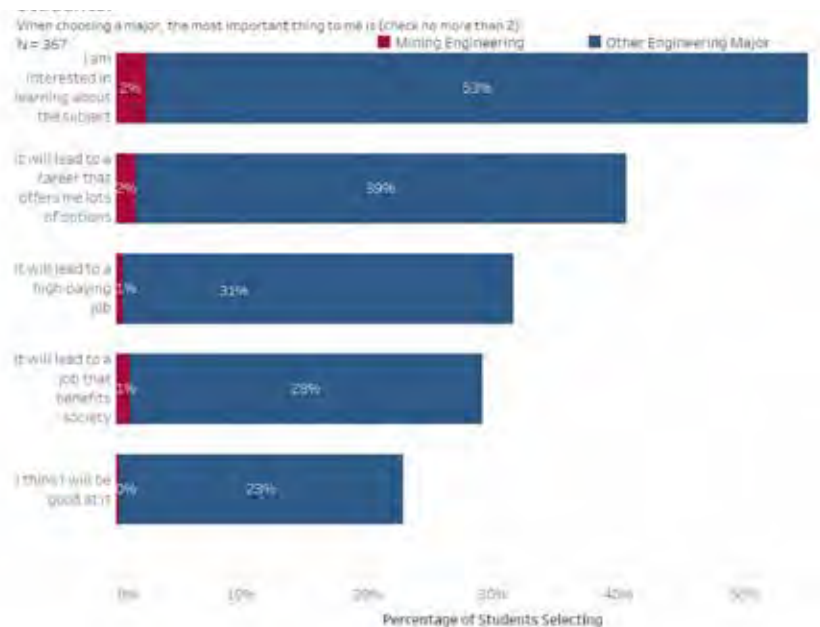
We asked students in the early semester survey to rate their level of interest in various fields of high school science, and we found these results to be an indicator of interest in mining engineering as a major in college. For example, compared to the rest of the freshmen engineers, students majoring in mining engineering reported far more interest in earth science and slightly more interest in environmental science, chemistry and astronomy than their engineering peers. Further, they were significantly less interested than other students in optics, computer science, and health science. Interest in math and biology was average with other students.

If there's one feature that clearly

sets apart students who want to study mining engineering from other freshmen, it's what we might call cubicle claustrophobia. Overwhelmingly, mining engineering students want to be able to work outside. A whopping 42 percent selected opportunities to work outside as one of their top three most important career

## Figure 5

Factors influencing mining students' choice of major are similar to other engineering students.

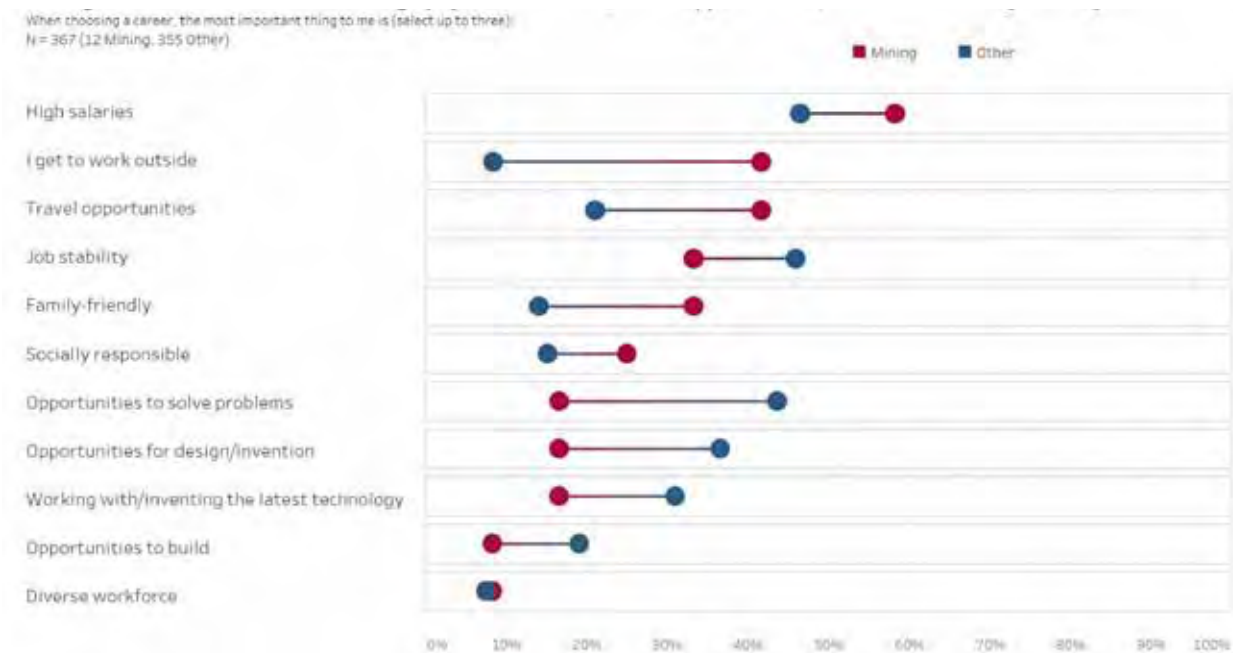




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## Figure 6

Mining students want careers with high pay, outdoor work, travel opportunities and that are family friendly.



attributes, compared to only 8 percent for all other students. That made outside work the second most popular career attribute for mining engineering students. The most popular reason for choosing mining, and almost every other type of engineering, was the opportunity for high salaries. Perhaps related to working outside, 42 percent of responses from mining engineering students selected travel opportunities among their top three career attributes.

### Key take-aways

How can we use these survey results to attract more students to mining engineering? First, focus on increasing knowledge, both of mining and mining engineering careers. Second, start by sharing foundational knowledge and start early. For example, answer these questions with youth. Why do we mine? Why is it important? What does a career in mining engineering look like? Emphasize options and variety in subject matter knowledge, careers, and locations where mining engineers work, including outdoors and around the world. Sharing information about environmental and social responsibility, the latest technology, and high salaries won't differentiate mining from other types of engineering, but it will help keep it competitive with other technical and scientific industries. The Lowell Institute's K-12 program has information and ideas on how to outreach to youth and can be found at <https://minerals.arizona.edu/engagement> or contact Christopher Earnest at [earnest@email.arizona.edu](mailto:earnest@email.arizona.edu).

### Conclusion and what's next

By the time students wrap up their first semester in college, they have pretty much made up their minds about their majors, and are unlikely to change them. For this study, the number of undecided students went from 75 to 24 during the course of the semester, while students who had already chosen a major became much more confident in their selections. Once majors are declared, close to 70 percent of students will not change their major based on national statistics (National Science Board, 2019). Even if students want to change majors, by the end of their first year, most are locked in by curriculum requirements, finances, family and peer pressure, and the need to graduate and get a job.

As we continue our research we'll be talking to students who choose mining engineering to get a better idea of why they're interested in it, and when and how this interest began. We'll probe where students get their information about various majors, and what are their most influential resources. ■

### Further information

To learn more about these studies or results contact Isabel Barton at [fay1@email.arizona.edu](mailto:fay1@email.arizona.edu) or Jodi Banta at [jhbanata@email.arizona.edu](mailto:jhbanata@email.arizona.edu).

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# Getting students interested in mining engineering: How can we reach them?

By Isabel Barton, Jodi Banta and Lynnette Hutson



**H**ow do we attract more students to mining engineering majors? In two previous articles (*Mining Engineering*, Feb. and Oct. 2021), we identified the main problem: Students arrive in college knowing less about mining engineering than they do about any other engineering major, and they are not interested in subjects they do not know much about. Remedy that disparity in background knowledge, even by a little bit, and there's a large upward swing in interest.

But to be effective, information has to arrive early. Even starting freshmen have strong pre-formed interests, opinions and plans, and they harden fast (Barton et al., 2021). Three weeks into their freshmen semester, about 80 percent of the students we surveyed had already decided on a major. Three months later, a mere five to seven percent still listed

their major as “undecided.” Less than a third of the students — including those who began as undecided — reported changing their planned majors over the course of the semester. That does not leave much time or space to change minds.

So what are the most effective channels of information? Where should university mining engineering departments focus their limited resources? What kinds of communications matter, and which do not change minds? This article uses additional data from our fall 2020 and fall 2021 surveys of the University of Arizona (UArizona) freshmen engineering class to identify where students look for information about potential majors, what does not influence them so much, and what motivates them to change their major. We conclude with some lessons learned and recommendations about where to focus recruitment efforts for the greatest impact.

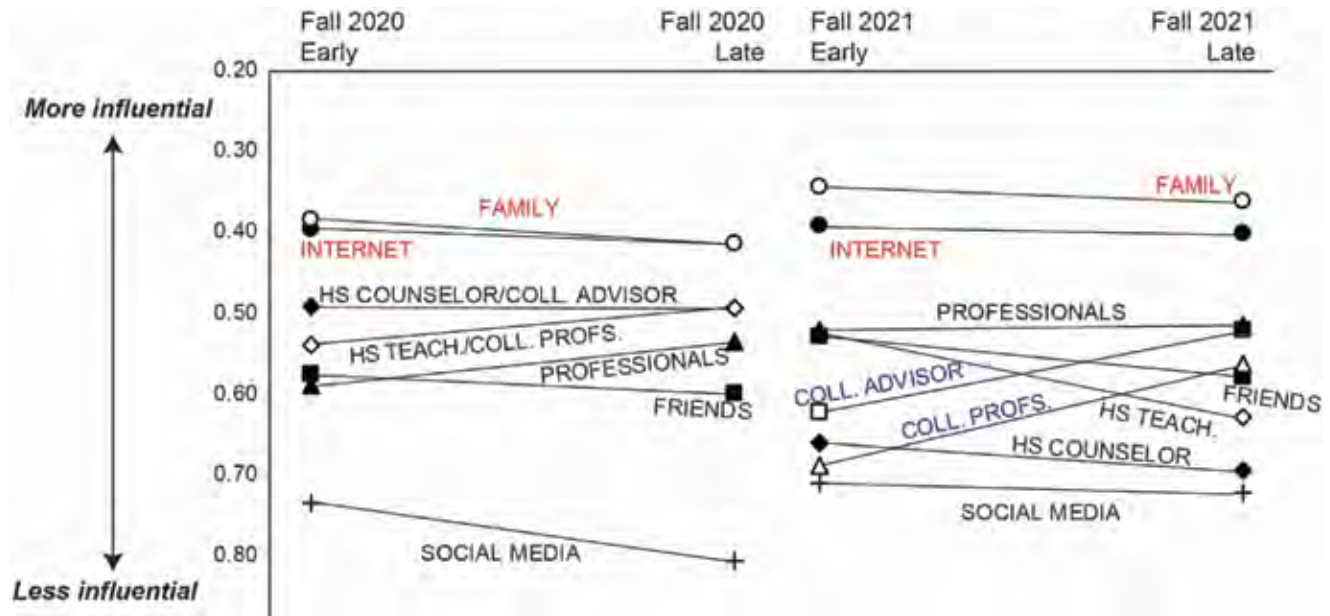
### Background information

A few words first about the freshmen engineering class at UArizona and our study.

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**Figure 1**

X-axis: time of survey. Y-axis: relative strength of influence, calculated as an average ranking by students (1 = most important, higher numbers = less important) divided by number of options available to rank (seven in fall 2020; nine in fall 2021).



All incoming (nontransfer) freshmen students planning any engineering major are required to take the same engineering design course in their first semester. The course has two components: focused design work in smaller class sections and a large, combined weekly lecture that exposes students to material about majors and careers in engineering.

Throughout the middle eight weeks of the course, the material in this combined lecture class is given by designated representatives of each of UArizona's 15 different engineering majors. Each representative/group provides an approximately 20-minute video introduction to the major. All students are required to watch the video before class, take a quiz on its essential points and then attend a 20-minute class-time question and answer session with the representatives.

In the final two weeks of the semester, representatives from each major arrange for an open house that consists of a longer (one-hour) information session on the major and the careers it opens up. These commonly include hands-on activities when done in person, and a question and answer session with a broader range of faculty for both in-person and virtual open houses. The organization of the open house is up to each department housing the major. Students in the freshmen class must attend at least two open houses of their choice for engineering majors.

We administered two online surveys each semester in the fall of 2020 and 2021, one at the beginning and one at the end of the course. The

surveys included demographic information, levels of knowledge and interest in different engineering majors, planned major, sources of information, career goals and desired career attributes (Banta et al., 2021; Barton et al., 2021). After excluding incomplete responses and responses from students under the age of 18, all surveys had a confidence level of 95 percent with a  $\pm 3$  percent margin of error.

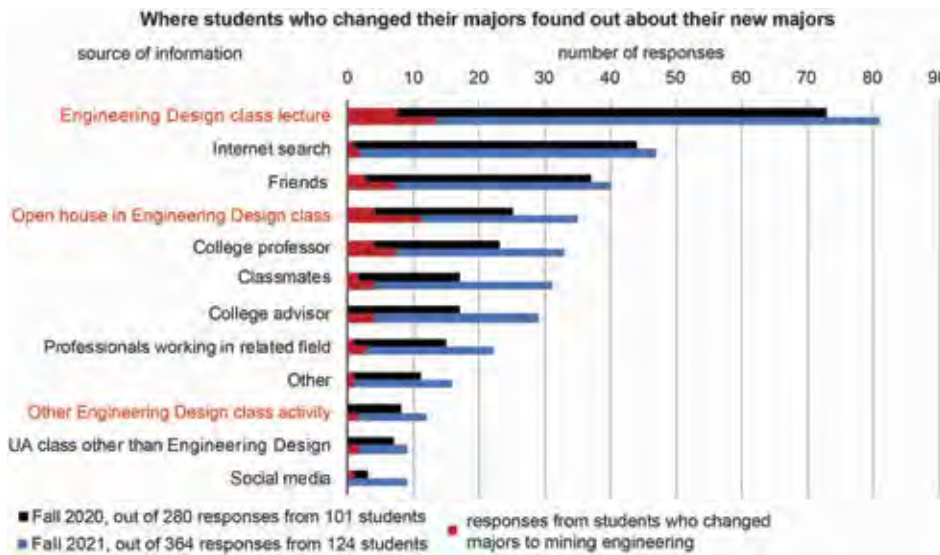
Among other questions, we asked students to rank, in order from most to least influential, the following sources of information about potential majors: family, friends, internet search, social media, high school teachers, college professors, high school and college counselors and professionals working in a related field. The same question was also on the end-of-semester survey and we compared the results.

### Where students look for (important) information about their majors

Two sources of information clearly stand out as most influential: family and internet searching. Particularly at the beginning of the semester, no other sources of information come close. Family ranks as slightly more influential than internet searching, but the two are close, and the gap decreases over the semester. Social media is the least influential in all surveys.

Clearly, information that reaches students in high school is important, especially early in the semester when their exposure to college material is limited. In the fall of 2020, the trends are obscure, since high school counselors and college advisors were grouped into the same

**Figure 2**  
Responses as to why students change majors.



response category as were high school teachers and college professors.

In the fall of 2021 these were broken out into four distinct groups, increasing the total number of options from seven to nine. Although this means that the results of the fall 2020 and fall 2021 surveys are not directly comparable, it did distinguish the influence of high school teachers and counselors (which starts out high and declines over the semester) from the influence of college advisors and professors (which starts out low but rises steeply over the semester). The influence of professionals in a related field is moderate and static. Friends begin as a significant source of influence, but this declines over the semester.

### Why and when students change majors

At the end of the semester, we asked students if they had changed their planned major since the start of the fall semester. To students who said yes, a follow-up question asked them to select the principal reasons why. Overwhelmingly, the top answer was the information presented in the lecture series of the freshmen engineering design class. Internet and friends were a distant second and third, and the open house visits in the engineering design class and their engineering professors were close behind. Social media came in last.

The importance of information acquired in the freshmen engineering design class was particularly clear among students who changed to mining engineering majors. In both semesters, the lecture, video and question and answer sessions were by far the most common selections among new mining engineering majors, and the open house associated with the engineering design class came in second.

Friends, classmates and college professors were also influential. In contrast to most other students who changed their majors, new mining engineering majors were less likely to report being influenced by information from college advisors or the internet.

The results also underscore the importance to mining engineering recruitment of simply having a single first-year introductory class that exposes students to all engineering majors. Freshmen enter college already well-informed about mechanical, aerospace, electrical/computer and biomedical engineering.

Most of them will select one of those majors by default, particularly in the absence of exposure to other options.

By contrast, the lower-profile majors such as mining engineering and materials science see a disproportionate rise in levels of knowledge, interest and intended majors over the course of the engineering design class (Barton et al., 2021). As Fig. 2 demonstrates, most of that rise is due to exposure in the freshmen engineering design class and favorable experiences during associated open house activities.

By contrast, universities that admit students directly into individual majors without a common first-year class place smaller enrollment engineering majors, including mining, and are at a disadvantage relative to higher-profile alternatives.

### Does coming from a mining family matter?

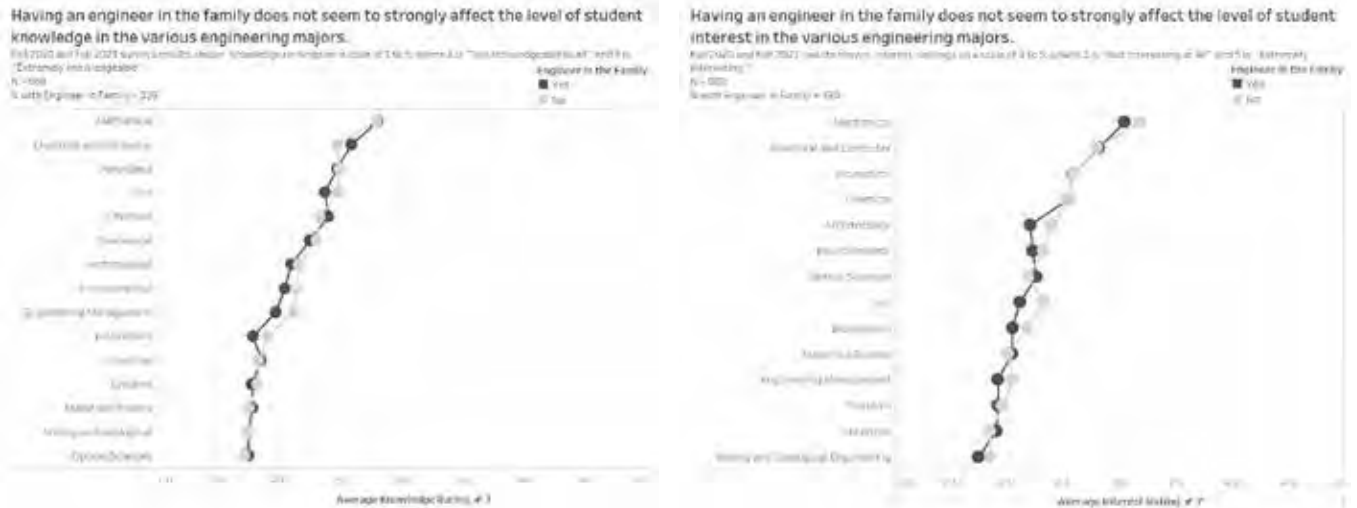
It is a common belief that most students who major in mining engineering are from families with mining engineers, miners or other mining industry professionals. Let's see whether that belief holds up against the data.

Starting with family influences: As both Figs 1 and 2 indicate, families outrank even the internet as important sources of influence. But judging from our in-depth results, family influence seems to consist more of a general encouragement toward an engineering career than as a push into any specific field.

The reported degree of family influence, or having engineers in the family, does not correspond to a higher-than-average level of knowledge or interest for any engineering major. When we compared the reported levels of knowledge and interest at the beginning of the semester between student groups with and

Figure 3

Results and possible influence of having an engineer in the family.



without engineers in the family, we found that there were no statistically significant differences. Figure 3 shows differences at the level of individual majors; the darker color represents students with engineers in the family.

But by drilling deeper into the survey data and looking at individual types of engineering, the picture changes. A total of 15 students in early fall 2020 and 2021 reported having a mining engineer in the family. Their average levels of knowledge about and interest in mining engineering were somewhat higher than the average for the survey populations as a whole: mining was the field they were most knowledgeable about and the third most interesting to them on average (behind mechanical and electrical/computer engineering). Three listed mining engineering as their planned major. Although the population is small, this is a significantly higher proportion (20 percent) than the less than 10 percent of students in the overall class who planned a mining engineering major in the early-semester survey.

The data show that students with mining engineers in the family are twice as likely to consider or plan a mining engineering major, but their numbers are so small that most mining engineering majors actually come from nonmining families. Thus, we conclude that while having a mining engineer in the family makes a student more likely than most to select mining engineering as a major, a larger number of students are attracted to the major by other sources, particularly exposure to mining engineering in the freshmen class.

### Lessons learned: Channels for effective recruitment

Let's close with some takeaways from this phase of the survey. Where should university

mining engineering departments focus their recruitment efforts to maximize effectiveness? On the other hand, what is a waste of effort?

To recruit students already in college, one answer is clear: Put the most effort into ensuring that exposure in the freshmen engineering design course is high-quality and gives students a positive impression. Often in university departments, freshmen outreach and other recruitment-related tasks are allocated to faculty based on who has the most time and willingness to undertake them, not on who would do the best job.

As the results above demonstrate, exposure in the freshmen engineering course is the overwhelming reason why students change majors, particularly those who switch to mining engineering. Ensuring that mining engineering is well represented to incoming freshmen with high-quality and engaging materials and teaching is probably the most important part of a recruitment program for university mining engineering departments. It is also important that there be an accessible, friendly faculty or staff member available for students to follow up with. Many students want to consult with someone in the department before finalizing their decision, but they may not know whom to talk to or where to go.

It is harder for college professors to get into high schools for recruiting, but still important. By the time students get to college, most of them have already made up their minds about their majors, and most will not change them. High school teachers and counselors are an important source of information for students early on, at the time when most of them are selecting majors.

Feedback from our education and recruitment outreach coordinators suggests that very few high school teachers and counselors

know much about mining engineering careers. If the counselors are not aware of mining as a career option, students will not be either.

Lastly, online efforts are better spent optimizing internet search results than social media presence. Social media may be omnipresent in students' lives, but that does not seem to exercise much actual influence when they make important decisions like choosing a major. It is important to maintain a baseline social media presence, which is largely expected these days and can be helpful for giving students a taste of the social environment (what is it like to be a mining engineering student?), but we should not confuse presence with influence.

In contrast, students do seek out and use information from online searches. Making sure that they have abundant, reliable and accurate information about mining engineering at their digital fingertips is crucial to inducing them to think about it as a career.

## Going forward

The UArizona's Lowell Institute for Mineral Resources and Mining and Geological Engineering department is continuing our research. In our next installment, we will examine how different demographic groups view mining engineering, drawing some lessons about how to reach a larger and more diverse range of students. We will look at the effectiveness of different approaches to recruitment and creating a larger and more diverse pool of future mining engineers. Stay tuned. ■

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