AC 2012-4919: FRESHMAN AND SOPHOMORE INTRODUCTION TO MANUFACTURING-RELATED ENGINEERING HANDBOOKS USING KNOVEL DATABASES

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Freshman and Sophomore Introduction to Manufacturing-Related Engineering Handbooks Using Knovel Databases

Abstract

Graduates' abilities to find and apply relevant information from engineering handbooks and reference books to their engineering and technology problems can be considered foundational to their abilities to pursue lifelong-learning in their field. Searchable, electronic access to traditional engineering handbooks and reference books as provided by the database Knovel serves as a user-friendly platform to introduce students to both the breadth and depth of reference book information available.

Engineering technology students in a freshman manufacturing processes course and a sophomore materials and metallurgy course were given a hands-on introduction to the Knovel database to promote an early familiarization to relevant engineering references. Activities introduced course-relevant handbooks and search techniques offered through the Knovel database. Time was provided to explore content on a selection of course-related topics. Student responses to a required post-activity essay and an end-of-semester revealed unexpected challenges in convincing early students of the usefulness of engineering handbook and reference data.

Engineering Handbooks Accessibility for Today's Engineering Practitioners

Jean Poland of Purdue University, in 1991 summarized information use by practicing engineers:

> "We know that engineers turn to their colleagues as a first source of information. Even after personal contacts are exhausted, practicing engineers do not go to formal journal literature. Jones, LeBold, and Pernicka[2] reported that engineers in industrial settings use product catalogs and manufacturer's literature, technical reports and handbooks more often than the published technical literature. Hedvah Suchman[3] found that technical reports are used more often than other published literature." [1]

Information-seeking technologies and behaviors have changed a great deal since 1991. Product catalogs and manufacturing literature are available online, either by seeking the manufacturer information directly from the company website or via a search engine such as Google. Information available from colleagues has broadened to include engineering communities and other forums where technical information can be queried or retrieved through prior electronic questions and conversations. In 2009, Si, Chen, and Hou summarized the literature on the patterns of today's students who prefer "Googling," even after trying other methods of information retrieval.[4] Indeed, the Internet and common search engines have opened a wealth of quick engineering information but engineering and technical handbooks still exist and provide a level of detail, specificity, and professional reliability typically not available on the open Internet.

The Knovel database (pronounced like the word "novel") provides a text-searchable online library of scientific and technical eBooks, which has become a richer way for university libraries and corporations to provide a large collection of detailed technical handbooks and texts to their constituents. According to Knovel's current website, "62% of the world's top universities and 80% of the top engineering schools in the United States provide access to Knovel."[5] In 2009, *Industrial Engineer* highlighted the usefulness of Knovel to engineering practitioners.[6] (The 2010 starting cost of an annual corporate subscription to Knovel was quoted at $5,000.[7])

Figure 1 depicts an example of the technical subject categories which can be available through a Knovel library subscription.

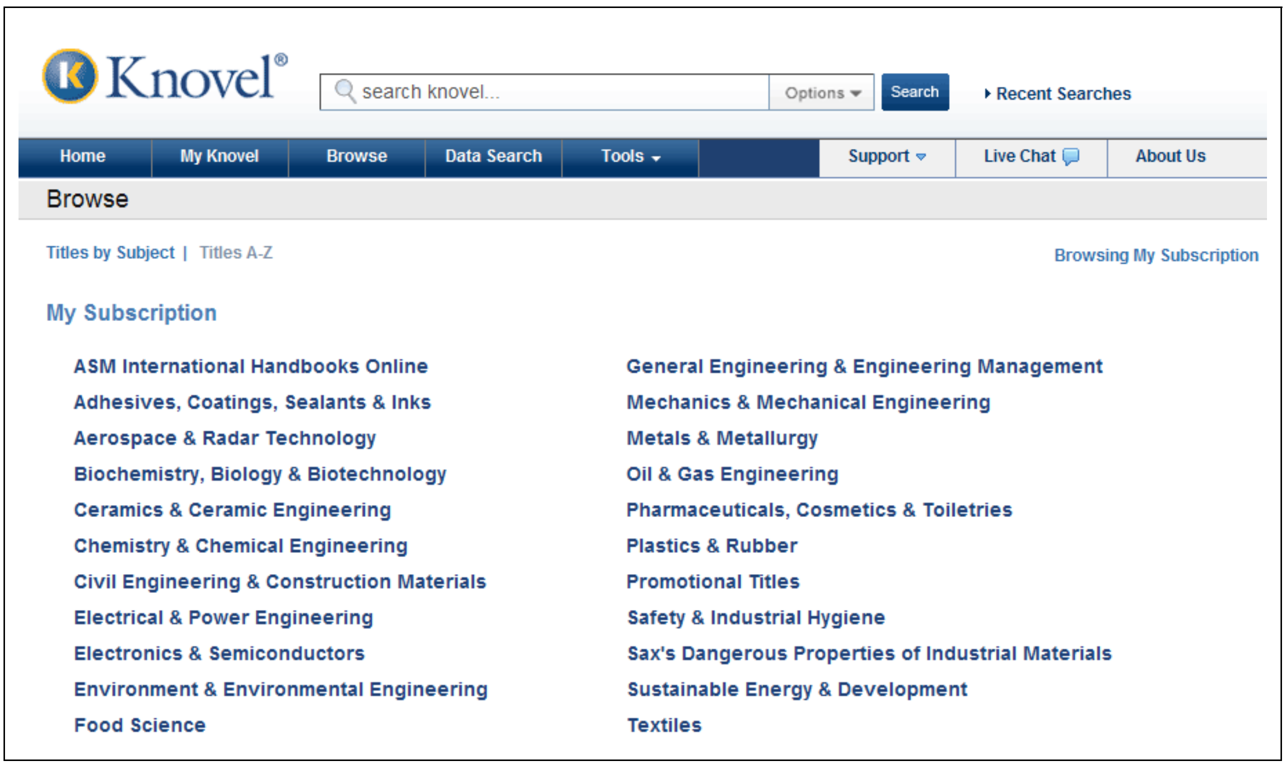

Figure 1. Sample selection of topic areas in the Knovel Database. (Selection may vary based on the subscription.)[8]

In the area of manufacturing, useful handbooks and texts available in the Knovel library include:

- *Machinery's Handbook*
- *Mechanical Engineer's Handbook*

- *Mechanical Engineer's Reference*
- *Manufacturing Engineer's Reference Book* (Elsevier)
- ASM International Handbooks (library)
- *Materials Selection in Mechanical Design*
- *Mechanical Behavior of Materials*
- *Engineers' Guide to Rotating Equipment - The Pocket Reference*
- *Engineering Vibration Analysis with Application to Control Systems*
- *Motors and Drives - A Practical Technology Guide*
- *Industrial Machinery Repair - Best Maintenance Practices Pocket Guide*
- *Automation, Systems, and Instrumentation Dictionary* (ISA)
- *Plastics Institute of America Plastics Engineering Manufacturing and Data Handbook*

For example, a Knovel search on a manufacturing topic such as "cutting tool coating" or "tool coating" generates references from resources such as:

- *ASM Handbook, Volume 22B - Metals Process Simulation*
- *ASM Handbook, Volume 18 - Friction, Lubrication, and Wear Technology*
- *Society of Vacuum Coaters Technical Conference Proceedings*
- *Handbook of Vacuum Arc Science and Technology - Fundamentals and Applications*
- *Ceramic Films and Coatings*
- *Handbook of Hard Coatings*
- *Metal Machining - Theory and Applications*
- *Surface Engineering for Corrosion and Wear Resistance*
- *Diamond Films and Coatings*
- *Handbook of Deposition Technologies for Films and Coatings - Science, Technology and Applications*
- *Tool Steels* (ASM International)
- *Cemented Tungsten Carbides - Production, Properties, and Testing*

The Knovel database is particularly rich in materials and chemical information. The combined experience of Drexel University and Colorado School of Mines reported in 2005 seemed to indicate that chemical engineering and chemistry programs have been forerunners in applying Knovel resources to university work. However, Knovel recently expanded content in additional areas applicable to mechanical and manufacturing engineering and technologies. For example, in 2007 Knovel established a partnership to include publications from the Instrumentation, Systems, and Automation Society (ISA), and in 2010 announced additions to form a nanotechnology library area.[9,7]

In addition to standard e-texts, Knovel also introduced interactive capabilities into equations and tables offered in many standard references, allowing the user to input his or her own data directly into the "book" equation or graph.[10]

Introducing Online Engineering Handbooks to Students

Information literacy educators have long noted the hurdle in getting students to leave their global Internet search engine (e.g. Google) long enough to try library database searching, such as periodical searches or other specialized databases such as Knovel. Si, Chen, and Hou (2009)[4] and Bhat et. al.[10] discuss some webpage resources and technologies applied by libraries to bring the database resources more readily to user attention, particularly attempts to integrate library resources into Google search tools, library catalogs, and links on subject area reference pages developed by the library. The Colorado School of Mines has particularly found success in the capability of integrating the Knovel library listings as available resources within the university library's own card catalog.[10]

However, to get the power of full-text searches, practitioners need to enter and search the Knovel database. They need to know of the availability of the Knovel database and recognize when to apply it.

TAC-ABET criteria (h) reminds us of the two components of lifelong learning:

(1) Recognition of the need for lifelong learning
(2) Ability to engage in lifelong learning. [11]

Litzinger et. al.[12] note that these components were described to ASEE as early as 1978 by G. H. Flammer[13] under the terminology "motivation" (or "will do") and ability (or "can do"), and the broader education research supported this claim, such as in Candy's 1991 book *Self-Direction for Lifelong Learning: A Comprehensive Guide to Theory and Practice.*[14]

If we consider engineering handbooks and their use as an important tool in an engineering practitioner's lifelong learning, as educators, we expect graduates to exhibit not only the ability to identify and use these resources (the ability to engage), but also recognition of the need to use and apply them.

Bhatt et. al. discussed various strategies involving collaboration between libraries and faculty at Purdue University, Drexel University, and Colorado School of Mines to specifically to introduce Knovel to engineering students, either as part of course requirements, or as promoted workshop sessions or as-needed library assistance.[10]

Since 2007, Knovel has sponsored a contest called "University Challenge" to assist in the promotion of the use of Knovel among university students,[15, 16] who compete by using Knovel to find the answers to "a set of three randomized problems from engineering disciplines."[16] Associate Professor and Librarian Patricia Kirkwood's leadership is credited for the University of Arkansas, Fayetteville's win of the 2010 Knovel University Challenge[16] (by being the school with the most entries correctly answering three problems).[17] She persuaded faculty to require student participation in the challenge within a freshmen engineering program course experience. Kirkwood states, "The only way to get it [Knovel] used is to require the students to use it in a meaningful way so they get familiar with it. Then they're likely to use it when they need it later on for lab work or research."[16]

Our approach provided Mechanical Engineering Technology freshman and sophomore students with an early hands-on, activity-based introduction to the types of references and resources available in Knovel, specifically as applied to course content in the Manufacturing Methods (freshman) and Physical Materials and Metallurgy (sophomore) courses. We introduced the use of the database as a necessary tool for the course, and gave students time to explore the database according to their own interest (within the broad context of the course subject).

Similar to the Kirkwood's model, our approach sought to introduce Knovel as a resource early in the curriculum, in our case, to freshman and sophomore students. Our approach differed from the "Knovel University Challenge" introduction in two ways:

1. The topics tied directly to information needed toward engineering *problems relevant to a current course of study*, not random questions of engineering interest.

2. The approach did not ask for specific information *results*, but encouraged students to explore the *types* of information located in the engineering handbooks and reference texts housed in Knovel.

Previous experience of both the course and library faculty suggested students prefer the opportunity to apply unfamiliar search tools to explore topics of their own interest, and since our goal was for students to see the database as a valuable resource for future engineering information, we hoped curiosity and self-directed discovery would provide a greater appreciation for future use of this resource. We provided a broad list of suggested topics related to the course and asked students to see what types of information they could find on that topic, and then share their discoveries with the class.

Classroom Introduction of the Knovel Database

For both courses, students were first given a peer-led demonstration of the library homepage, the library subject guides, and then basic entry and use of the Knovel database. The "peer-led" demonstration involved a student being asked to demonstrate on the computer projected to the rest of the class, following step-by-step directions from the librarian. Other class members followed along on their own screens. (The peer-led method is applied because of studies showing students are more engaged if a peer leads the demonstration, even if he or she has never done the activity.[18,19,20,21])

Next, the class participated in an activity relevant to their particular class subject. The freshman Manufacturing Methods class accessed the Machinery's Handbook, which they previously used in print format in the laboratory to access information for sine bar inspection of angles. They also each selected a topic from a list of manufacturing process topics supplied by the instructor to determine what resources and information could be found in the Knovel database:

- Electro-discharge machining
- Powder metallurgy
- Laser machining
- Electrochemical machining

- Small-hole drilling
- Broaching
- Brazing
- Deburring
- Machining plastic
- Ultrasonic welding
- Metal spinning
- Coated cutting tools
- CNC tapping

The sophomore course in Physical Materials and Metallurgy had a similar peer-led introduction, and, likewise, a charge for students to see what sort of information could be found on topics we had been encountering in the materials course.

Assessment and Results

For both courses, assessment data comes from an online quiz directly following the Knovel database activity, and then a survey question at the end of the course, over ten weeks later. The class sizes were small, so results are not statistically significant. Still, some consistency in student responses are telling, suggesting future modifications which might improve the activity's success.

The Assessment

Freshman Manufacturing Methods students were asked the following on the quiz following the Knovel database learning activity:

> <u>Question 1</u>: What is the name of the specific reference book which we used in the manufacturing lab and in today's class meeting to locate sine bar tables, threaded fastener data, and other information? (Make sure you spell it correctly for fullest credit.)
>
> <u>Question 2</u>: What is the name of the database we used to access this book (and others)?
>
> <u>Question 3</u>: Imagine one of your friends was absent during today's discussion and wants to know what was covered because it may be on a quiz. In a paragraph or two, explain:
>
> a. How to access the database that was discussed and
> b. What sorts of manufacturing-related information can be found in this database.

The sophomore students were asked to answer Questions 2 and 3, with the last question modified to ask:

> b. "What sorts of materials-related information can be found in this database that might be useful to a design engineer."

Table 1. Mapping of Knovel Activity Outcomes Assessment

TAC-ABET Criteria	Course Outcome	Assessment Method	Achievement Target	Results	Outcome Achieved?
h (1) recognition of the need for lifelong learning	Students recognize the desirability to go to engineering handbooks and other Knovel database resources to future course and career applications.	Quiz Question 3b: Students identify a way in which Knovel database information might be useful in their future engineering/technical courses or career.	80% or more students give at least one example or type of manufacturing- or materials- related information that could be found in the Knovel database	Freshmen: 17% give an example of a type of engineering relevant information Sophomores: 60% give an example of a type of engineering relevant information	Freshmen: Outcome **not met** Sophomores: Outcome **not met**
		End-of-Semester Survey Question: Students are positive about using the Knovel database toward future engineering-type projects (in their future studies or employment)	80% or more students report they "already have," "definitely will," or "probably will" use the Knovel database in the future.	Freshmen: 40% reported "probably will," others below Sophomores: 60% reported positive; (40% "already have," 20% "probably will"); remaining 40% "maybe"	Freshmen: Outcome **not met** Sophomores: Outcome **not met**
h (2) ability to engage in lifelong learning	Students exhibit the ability to locate applicable engineering resources in the Knovel database	Quiz Question 1 (Freshmen only): Students correctly identify the name of the handbook	80% or more students accurately or closely identify the handbook name.	Freshmen: 100% reported a name close enough to search	Freshmen: Outcome met
		Quiz Question 2: Students correctly identify the name of the Knovel database.	80% or more students accurately identify the "Knovel" name (close enough to find it in a database list, starts with "K")	Freshmen: 92% accurately identified Sophomores 100% correctly identified	Freshmen: Outcome met Sophomores: Outcome met
		Quiz Question 3a: Students adequately describe steps to accessing and searching the database	80% or more students specify to locate Knovel among the library's online "databases"	Freshmen: 75% accurately identified Sophomores 40% correctly identified	Freshmen: Outcome **not met** Sophomores: Outcome **not met**

The survey question, embedded with the end-of-the-semester course evaluation, ask for a response to the question, “Do you think you will use the Knovel database in any of your future mechanical studies or employment?” with the following options for answers:

a. I already have
b. Definitely will
c. Probably will
d. Maybe
e. Probably not
f. Definitely not

These assessment questions can be mapped to the TAC-ABET criteria (h) as shown in Table 1.

Some may argue that our achievement target for student “ability to engage” is a low bar. At this stage, our goal is more to get students actively seeking and searching the engineering handbooks and references through Knovel. We are not evaluating their ability to effectively strategize their search terms.

Results

Table 1 includes a summary of the assessment results for both freshmen and sophomores, for both aspects of the lifelong learning objective: (1) their recognition of the applicability (or “need” of the Knovel database resources, and (2) their ability to “engage” (or use) the Knovel database. Although the freshmen and sophomores typically performed at different levels (see Figure 2), there is a alignment between the two groups in terms of meeting outcomes.

<u>Quiz Questions 1 and 2</u>: All but one student were able to provide the title of the handbook and database on the quiz, so familiarity was achieved in terms of name recognition. Recalling the name of the Knovel database is important so in the future they can correctly select it from the myriad of databases provided by the university library (or to find and/or recognize it later in his or her career).

<u>Quiz Question 3a</u>: 75% of the freshmen specified the step of locating Knovel among the libraries “databases.” We feel this is pretty good, since students may not have interpreted this as an important step to note on their explanation. We were one student short of our goal of 80% accurately describing this step, so it is an outcome that is not considered “met.”

There were two of the five sophomores who did not adequately describe the step of going to the library’s “databases” in order to locate Knovel, so that also left the sophomore group not meeting the achievement target.

<u>Quiz Question 3b</u>: The last question on the same-day quiz provided open-ended answers which provided authentic assessment of the students’ understanding for the need for such engineering reference information—the second component of our TAC-ABET criteria (h).

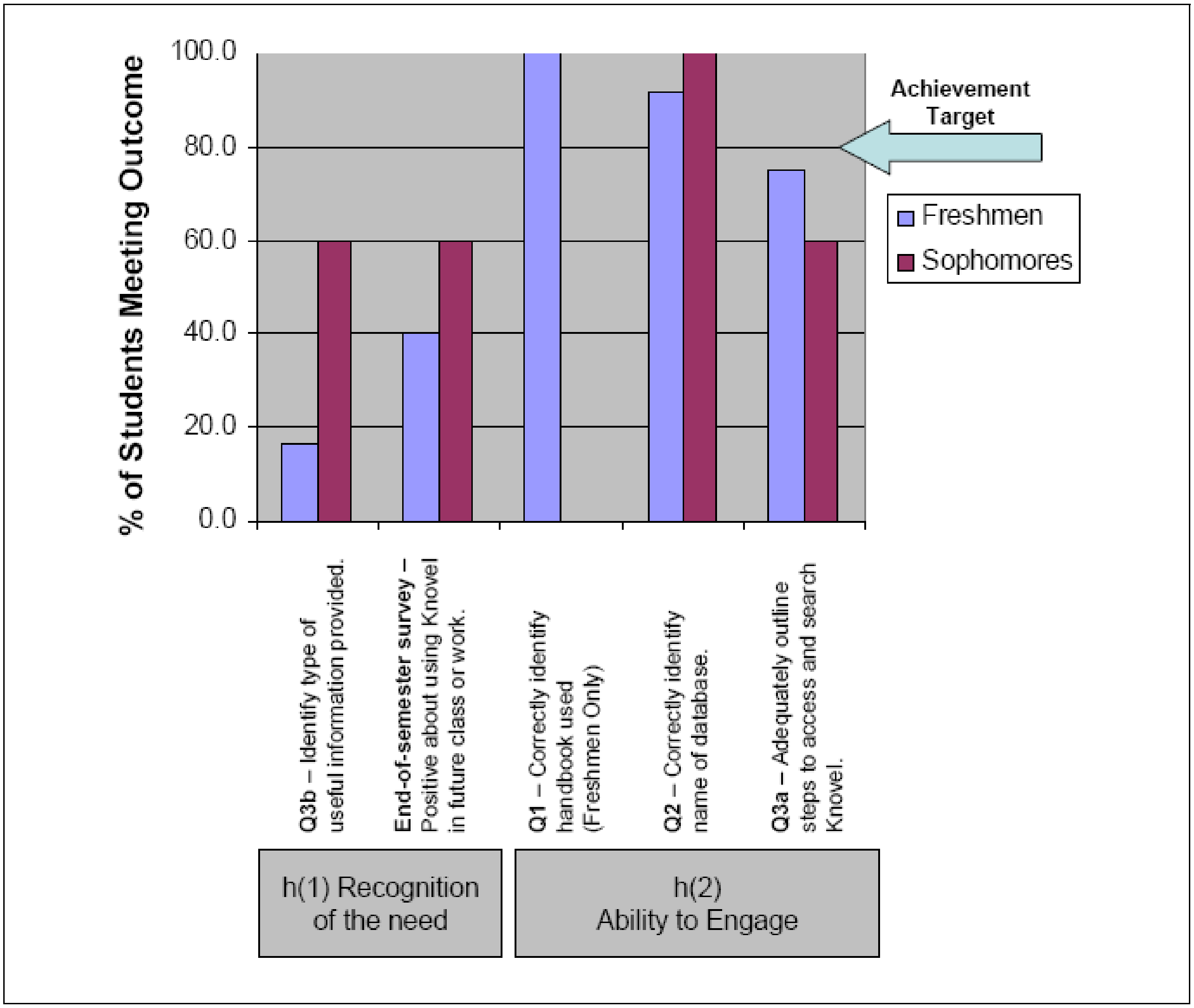

Figure 2. Comparison of percentages of freshmen and sophomore students meeting learning outcomes.

Freshmen students seemed generally unprepared to understand and specify types of manufacturing information which might be needed, instead declaring amazingly broad, sweeping generalizations of "What sorts of manufacturing-related information can be found in this database":

- "Just about everything, from entry to professional level."
- "You can find anything on manufacturing in the database"
- ". . . offer every handbook and every detail to engineering or any other course available."
- ". . . anything and everything you would possibly need."
- "It looks like any topic related to engineering can be located in this database."
- "You can find anything that you need for your engineering class such as information, charts, graphs, measurements, and drawings."

Only one freshman student (out of 12) specified the topics he had seen addressed within an explored topic:

- "Welding, Surface Finish, Sine bar, and almost anything you may need to look up for a manufacturing class or project."

Another student rightly mentioned that one could find ASME data or other standards, an answer that we find marginally acceptable:

- "Any sort of hand book (sic) or ASME info such as standards or almost anything relevant to MET can be found in this database."

We presume multiple reasons at play for their lack of specificity, most likely:

1. Students didn't think specificity was important to quiz credit (or didn't care).
2. Freshman students lack experience in the type of information needed for engineering-problem-solving, so were not prepared to value particular kinds of manufacturing-related reference information.

The sophomore group also referred to the broad breadth of information, but did note information as it related to recent labs involving tensile or impact testing, or included resources particular to specific materials, such as composites or rubber.

In spite of the lack of student experience with general engineering information, the instructor hoped the students would have noted topics relevant to their current manufacturing course and topic. After all, this was the reason that the search was directed to course-relevant topics. It is tempting to conclude that perhaps students just did not care to be detailed with quiz answers. However, further insight on student's recognition of the applicability of Knovel database resources can be gleaned from the end-of-course survey question.

End-of-the-Semester Survey: Results of the end-of-semester survey from the freshmen (returned by 5 of the 12 students) indicated about 40% (2 of the five students reporting) provided a positive response that they "probably would" use the Knovel database resources in their future coursework or employment. Another 40% were in the middle "maybe" category, and one freshman student reported "probably not."

Sophomores achieved more positive results than the freshmen, with 60% of students providing examples of materials-related information that could be obtained, and with a more positive overall rating of whether or not they expected to use Knovel for future classwork or employment. Two of the five sophomores returned the highest positive rating of having already used the database in other work. The lowest rating was "maybe." This is still less than our goal of 80% or more ratings in the "probably will" or more positive categories, so the outcome is not met. A more enthusiastic response to this rich resource of engineering information was expected.

In summary, for both the freshmen and sophomores, the activity adequately met our expectations for student achievement of how to access and conduct a Knovel search of online engineering handbooks and references. However, our assessment indicates that the activity failed to convince students of need and desirability of consulting the Knovel database resources for problems or projects, either in their future courses or employment.

One promising result is that the sophomore group, while not warming to the need as much as we had hoped, did have an improved number of students seeing the applicability of Knovel resources. This improvement is graphed in Figure 2.

The assessment questions could be strengthened (or given extra grading weight) to better encourage attention to precise applications examples, information details, or reference examples in their response. However, the end-of-the semester surveys show the majority of freshmen and sophomore students question whether they will need these sorts of engineering references in the future. The lifelong learning outcome component "recognition of need" is not being met.

Conclusions

The combined comments of both groups suggest beginning students are less aware or impressed with the need to find or mention specific information, unless and until requested. Even the typically higher-performing freshman students who generally are interested in course content may be unsure of the types of materials they will need and value as an engineering practitioner, or even in their coursework. Moreover, the research on learning preferences of millennial students reminds us that this generation is not generally worried about later finding themselves in need of a specific piece of data; they come from a world in which they believe they can look up anything whenever needed. Perhaps the burden is on us as faculty to prove that the information they need is *not* always at their fingertips, as they have come to anticipate, on the open Internet.

The more positive response by sophomore students gives us reassurance that those students have had a little more experience with engineering courses are more prepared to appreciate the need for searchable engineering handbook and reference books.

For future presentations of the Knovel database, we conclude supplementary application activities are needed to help beginning students fully understand and apply the power of engineering information available from handbooks and textual resources. In this sense, the "Knovel University Challenge" model appears to be more effective.

However, we are still interested in engaging students to apply handbook and reference book information *to the engineering problems which they are currently encountering* in their freshman and sophomore-level work—or perhaps even to extend their exposure by introducing more relevant, career-realistic case problems within the context of their introductory courses. Additional application activities would be helpful to model need and to promote deeper critical thinking, identification, and reinforcement.

Additionally, reinforcement of the applicability of engineering handbooks and reference texts in subsequent junior and senior-level problems courses seems necessary to build on and affirm the introductory application experiences.

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