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Meaning to Succeed: Learning Strategies of First-Year Engineering Transfer Students

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Meaning to Succeed: Learning Approaches and Strategies of First-Year Engineering Transfer Students

Abstract

The Evidence-Based Practice paper describes the learning approaches and strategies used by engineering transfer students in a design-based foundations course. Studying the learning strategies of engineering transfer students is important because the population of engineering transfer students is increasing, and is often more diverse and underserved than the general population of entering engineering students. This type of student presents a largely untapped source of engineers to address the current national shortage [1], even though attrition rates of transfer students from engineering programs is high

Although a large number of studies about learning approaches and strategies exist in the literature, relatively little is known about the specific learning approaches and strategies used by engineering transfer students, much less students who continue their pre-engineering degree program coursework at a different institution than where they began their postsecondary education.

Both first-year engineering students and engineering transfer students often develop the habit of working on homework assignments and studying for tests at the last minute, just-in-time to meet a deadline. The habit of attempting to learn both technical and non-technical material on short notice, which is indicative of poor time management and an underestimation of how long the work will take, often results in substandard academic performance These students may struggle later on, when they encounter a greater demand for conceptual knowledge, coupled with a heavier course workload in their upper level courses. As a result, they may choose to disengage from their course work rather than apply an approach to learning that would enable them to be more successful in their learning, as well as achieve higher grades. A better understanding of the existing learning approaches and strategies used by these students is a necessary starting point for the mitigation of their potential academic disengagement.

The participants in this study included 61 students who transferred from either a four-year or two-year higher education institution. Results revealed that there was a difference in learning approaches and strategies between what students expressed as goals for learning and what they do to achieve them. Learning strategies related to goals were linked to externally-driven influences, such as homework and test deadlines, yet many participants used specific learning strategies which exhibited an internal desire for deeper understanding of course material, with the intent to retain it for future use.

Although the urgency to meet deadlines is a way of life, educators can do more to encourage learning strategies for the retention of knowledge to better prepare for higher level coursework and counteract the threat of academic disengagement. The study results will inform educators about what types of guided practice may be useful to encourage these students to adopt and/or reinforce learning strategies that will help them to be more successful in their current and future courses.

Introduction

The learning experiences of engineering transfer students represent a largely underexplored area of research [2], yet their numbers and the barriers that they face have been increasing throughout the 21st century [3], [4]. One area of interest is the characterization of learning approaches and strategies among engineering transfer students, as well as first-year engineering students, because of its impact on academic success[5]–[7].

Both first-year engineering students and engineering transfer students often develop the habit of working on homework assignments and studying for tests at the last minute, just-in-time to meet a deadline. The habit of attempting to learn both technical and non-technical material on short notice, which is indicative of poor time management, often results in substandard academic performance [5]. Moreover, institutions often require that students manage their time effectively in view of competing academic and non-academic demands, without teaching them how to do so [5].

When learning is attempted superficially, the student may wonder what they actually learned when a course is concluded. They are then unable to transfer their knowledge to a course in which the instructor assumes that they already have a substantial level of understanding and ability to apply this knowledge.

By neglecting to set priorities, monitor progress, and search for the underlying meaning of their course material, these students will do well enough to “get by” or even achieve success in their foundation-type courses. However, they may falter later on, when they encounter a greater need for conceptual knowledge coupled with a heavier course workload in their upper-level courses. As a result, they may choose to disengage from their course work, or withdraw from an engineering program, rather than apply an approach to learning that would enable them to be more successful [8], [9].

The first-year of college is also an ideal time to identify and promote more effective and meaningful approaches and strategies because their benefits can be realized earlier and more often [7]. A strong first-year academic performance, driven by academic engagement and strategies for meaningful learning, can mitigate the prospect of attrition [10]. While attrition from an engineering program seems to be an extreme case, it has widespread consequences to the engineering profession as the demand for engineers continues to increase, but the supply has not increased commensurately [1].

The results of this study will provide a profile of which learning approaches and strategies are currently used among a sample of first-year engineering transfer students, in order to inform the design of guided practice which will help these students to enhance their learning strategies for greater academic success in their selected degree programs. Engineering educators may not be able to mitigate many of the institutional barriers faced by transfer students, but they can build upon the learning strategies that their transfer students currently use with additional guidance in meaningful learning strategies. Therefore, the following research question provides the focus for this study:

- How do engineering transfer students describe their current learning approaches and strategies?

The following sections contain the conceptual framework for this study, a description of the academic challenges faced by transfer students, identification of the study sample, data collection and analysis methods, results, and recommendations for further study.

Background and Conceptual Framework

The conceptual framework for this study is based on studies by Biggs and others involving college-level learning approaches and strategies [4], [11]–[14]. Biggs' framework was chosen for its consideration of both the goals for studying and study processes and behaviors, and because his descriptions of learning approaches and strategies were generalizable to an engineering context. This section also contains a description of several major differences in academic perspective between engineering transfer students and first-year engineering students which may influence their choices of learning approaches and strategies.

Biggs' Framework for Learning Approaches and Strategies

Approaches to learning are the overarching methods, including cognitive and metacognitive strategies, that students apply to their learning [11], [12]. Three major approaches to learning are:

- **Surface Learning**: extrinsically motivated to meet external requirements to the minimum extent permissible, to enable a student to "get by" and pass the course;
- **Deep Learning**: intrinsically motivated, whereby the student engages with the course material in a meaningful way, wants to understand it thoroughly, and seeks additional knowledge about it, and
- **Achieving Learning**: extrinsically or intrinsically motivated, where the primary motivation is achieving a high grade, through either a surface or a deep approach, depending on priorities and context.

Students who approach their studies with the intent to "get by" without engaging with course material in a meaningful way are said to have a "surface" approach to learning, as opposed to a "deep" approach. The "deep" approach involves a greater engagement with learning than the "surface" approach. A third approach has also been identified, called an "achieving approach", where the intent is to achieve high grades, whether through a "surface" or "deep" approach, or a combination of the two [11], [12]. Moreover, Biggs used the terms "surface-achieving" and "deep-achieving" to convey two different aspects of the "achieving" approach. "Surface-achieving" is motivated by the desire to reproduce information, while "deep-achieving" is motivated by a "strategic search for meaning" [11], [12].

Approaches to learning are often manifested in the practice of **learning strategies**, which are behaviors that students use for studying and learning course material, such as memorizing, re-writing course notes, planning and organizing materials, questioning self and others, and reflection [13]–[15].

When students describe their approaches to learning and related strategies, they are answering these two questions [11]:

- What do I want to get out of this? (i.e., the product of study)
- How do I get there? (i.e., the process of studying)

The former question is task-, motive-, and goal-oriented, while the process-focused question involves choices of learning approaches and strategies in view of available resources and constraints. While all three approaches to learning involve decisions related to the product(s) of study and one or more processes for studying, the "surface" approach is more strongly influenced by the products of study, and the "deep" approach by processes [11]. The combination of task, motive, resources and strategies has been labeled as "metalearning", which is a form of metacognition [11].

How Transfer Students Differ from First-Year Students

Both transfer and first-year engineering students face the major challenges of adjusting to a new and often much larger institution. However, transfer students have experience as college students because they had already attended a two-year or four-year higher educational institution. Now they must learn to be students within their new environment as they work to fully engage with their studies [4]. However, differences in both technical and non-technical course requirements may produce a "transfer shock", resulting in lower grades during the first semester [4]. If transfer shock persists, it can lead to academic disengagement through a questioning of competence for one's chosen major program or career path as a result of receiving poor grades [16].

Two-year transfer students had attended a two-year institution prior to transfer, while four-year transfer students had attended a four-year institution. While both two-year and four-year students may experience transfer shock at their new institution, two-year transfer students may enjoy an advantage over their four-year counterparts, if their exiting and entering institutions had an articulation agreement [17]. An articulation agreement represents a four-year institution's acceptance of certain credits earned at a two-year institution toward the four-year institution's degree programs [18] This type of agreement often enables transfer students from two-year institutions to complete their degree programs in less time than their four-year transfer counterparts, because more of their existing college credits are accepted by the four-year institution than those of students who transferred from another four-year institution [17]. Another difference is that, while both types of transfer students choose their transfer institution based on its degree programs related to their career goals, two-year transfer students tend to be more narrowly focused on a specific career path than either transfer students from four-year institutions or first-year students attending college for the first time [19].

Research Methods

This research study involves 61 engineering transfer students in a one-semester foundations of engineering course, who wrote short essay responses to a series of questions about their learning approaches and strategies among all of their courses. The study sample consisted of approximately 80% men and 20% women. The questions asked students about goals for studying, planning what to study next, participation in study groups, credibility of course materials, and the relationship of course materials to real-life examples. Participants were encouraged to differentiate their responses among their courses, where appropriate, because their choices of learning approaches and strategies could vary with their goals and expectations for each course, as well as the influence of course requirements and delivery methods.

Study Context

The engineering transfer students at our institution had prior educational backgrounds in STEM-based courses, including certain disciplinary engineering skills. However, they may lack fulfillment of learning objectives required in our first-year engineering program's foundations courses. Therefore, these transfer students had three options for fulfilling these objectives:

- A two-semester sequence of engineering foundations courses;
- The second-semester course in this sequence, if they received credit for the first-semester course under an articulation agreement, or
- A one-semester engineering foundations course fulfilling all of the learning objectives of the two-semester sequence.

The majority of transfer students pursue the third option in order to enter their engineering degree programs at the earliest opportunity. As noted above, many have already identified a specific career goal earlier than their traditionally-aged counterparts, and are taking second-year courses concurrently, such as statics, introductory computer science, higher-level calculus, and/or one or more electives. Therefore, this study focuses not only the learning approaches and strategies that these students use in our one-semester introductory engineering course, but in all of their courses.

The learning objectives for the one-semester version of the introductory engineering sequence are as follows:

1. Use guided design methodologies to analyze engineering problems in order to achieve an optimal solution.
2. Identify and analyze holistic issues that impact engineering solutions, e.g., ethical implications, stakeholder needs and interests, and constraints.
3. Collect and analyze data and information to support/inform engineering decisions.
4. Use mathematical, graphical, and physical models in solving engineering problems.
5. Use various engineering tools, including algorithm development, procedural programming, and graphical communication to solve engineering problems.
6. Actively contribute to the solution of an engineering project in a team setting requiring management of people, materials, and other resources.
7. Produce and deliver documentation which develops and presents the evidence necessary to support an engineering decision.

The course contains both team-based and individual learning activities and situations, which prompt the course participants to adapt their learning approaches and strategies accord to their goals, motives, and available resources. Team-based activities are primarily focused on completing a design project and developing constructive teamwork within a non-self-selected team. Individual activities include technical skill development in computer-aided drawing and programming in support of the design project, as well as reflection assignments focused on a student's progression toward mastery of self-identified skills related to the course objectives.

Participants

The study sample consisted of 61 participants from a cohort of 109 engineering transfer students. The sample was selected by convenience, i.e., the students' consent to allow their data to be used for research purposes. Among the participants, 57.4% had transferred from a four-year institution, and 42.6% from a two-year institution. Current registration status as first-, sophomore or junior students was not included as part of this study, nor their prior academic history.

The sample can be compared to the population of first-year engineering students as follows:

Table 1: Gender and Citizenship Demographics for the Study Sample vs. Population of Entering Engineering Students

Description	Study Sample		Population of Entering Engineering Students [20]	
	Number	%	Number	%
Total Students	61	100	2021	100
Men	52	85.2	1548	76.6
Women	9	14.8	473	23.4
U.S. Country of Origin	53	86.9	1992	98.6
Other Country of Origin	8	13.1	29	1.4

The study results could be segregated, but may not contribute meaningful differences, because of the relatively small number of women and foreign-born students compared to the total study sample and population.

Data Collection

Data were collected as a course assignment for participation credit, consisting of a free response survey containing the ten questions shown in Table 2. The seven questions selected for analysis were taken from this ten-question survey:

Table 2: Study Questions in a Short-Answer, Free-Response Survey

Questions about the Product or Goal of Studying, indicating Approach
What is your purpose for studying?
How can you tell when you have "studied enough" for a major test or project?
Questions about the Process of Studying, Indicating Strategies
How do you decide what to study next?
How do you regard difficult material?
What are your most useful method of learning course material?
Do you ask yourself questions about what you are studying? If so, please give an example.
How would you describe your actual study pattern for a major test or project?
Additional Survey Questions Beyond the Scope of This Study
How often have you taken part in a study group with other students?
Do you ever question the certainty or truth of your course materials? Why or why not?
How would you relate any of your course materials to real-life examples?

The participants were asked to consider all of their courses when responding, not just the course in which the survey was administered.

Data Analysis

Responses to each survey question were open-coded to identify specific learning goals and strategies, noting differences in context among all of the responses to a particular question. Pattern coding was then applied to the open codes to organize them into themes for the goals for studying and strategies for the process of studying. One example of pattern coding for the purpose or goal of studying was whether or not the preparation for a career was specific to a particular engineering discipline or position. Another example of pattern coding for specific strategies was the labeling of all coded responses that mentioned planning a study schedule according to what was due next as "response to deadlines."

Drawing on Biggs' framework [11], [12], a specific learning approach was then assigned to each theme, using common attributes of the "surface", "deep", and "achieving" approaches as *a priori* codes. The "achieving" learning strategies were combined with either the "surface" or "deep" learning approach, resulting in two additional approaches: "surface-achieving" and "deep-achieving."

In addition, the most common learning strategies indicative of each learning approach were compiled to provide a more detailed description of the attitudes and behaviors associated with each learning approach, which was similarly informed by common characteristics identified in the underlying conceptual framework [3], [4]. These codes are listed Table 3 below:

Table 3: *A Priori* Codes for "Surface" , "Deep", and "Achieving" Learning Strategies

"Surface" Learning Strategies
Memorizing [11]
Note taking [14], [15]
Passing the course just to graduate or get a good job [21]
Little interest in usefulness of the course [11], [21]
Seeking "canned" solutions to homework problems [22]
"Deep" Learning Strategies
Arranging an enabling study environment [13], [15]
Self-monitoring to evaluate learning [15]
Self-questioning [14], [15]
Re-copying class notes; writing a study guide [14], [15]
Planning what to study next [12]
Focusing on understanding rather than memorizing [22]
Seeking help with understanding from instructors and TAs [23]
Comparing the value of one course to another course for learning [24]
Summarizing or draw conclusions through reflection [25]
Relating course material to real-life examples [25]
"Achieving" Learning Strategies
Matching strategies to complexity of material [15]
Monitoring and evaluating the use of methods strategically [15]
Setting explicit goals for studying [15]
Assigning a value to what is learned [26], [27]
Self-negotiating [15]
Checking results [15]
Allocating resources as part of planning [13]

Peer learning, such as with a study group [13], [14]
Practicing through repetition, such as working practice problems [14], [28]
Comparing one course to another course for testing or career goals [11], [24]

Finally, in order to compare responses from two-year and four-year transfer participants, the distribution of learning approaches was constructed for the responses to each question as percentages of the entire study sample, of the participants from four-year institutions, and of the participants from two-year institutions.

Limitations

This study is limited by the size of the sample and its time frame, as well as by the institutional space and participants' frame of mind when completing the survey as a homework assignment. These limitations could be mitigated by the collection and analysis of additional data from a similar cohort of transfer students, or with data from a cohort of entering engineering students.

Responses could also be limited in depth by a lack of effort due to demands from the rest of a participant's workload, or by an overall tendency to write little more than one sentence per response. The use of a survey often encourages short responses due to its format, even though it was provided in a template that was not constrained by word count. In this case, this study could be expanded by interviewing a subsample of the participants about their learning approaches and strategies, after administering the survey.

Participant and researcher bias also influence the quality of responses and may limit their usefulness. The first type of bias was mitigated by giving participation credit for completing the survey rather than grading it according to a specific rubric. Because the same faculty member had designed the study, applied the participation credit, and collected the data, it was important to separate these roles to the extent possible. Therefore, the data were not analyzed until after the completion of the course in which the survey was administered.

Results and Discussion

Learning strategies obtained by *a priori* and open coding are listed by their corresponding approach in Table 4, attached. The major difference in strategies between a "surface" or a "deep" approach was the difference between the statement or implication of an externally-imposed goal, such as course requirements, instead of an internally-imposed goal, e.g., comparing new knowledge to prior knowledge to attain a higher level of understanding. The "achieving" approaches were determined by strategies directed toward achieving high grades on tests or projects. Differences between the "surface-achieving" and "deep-achieving" approaches were based on the extent of engagement with course material related to the test or project.

Table 4: Common Goals and Strategies Indicating a "Surface" vs. "Deep" Approach to Learning

Surface Approach
Study to pass the course or get "good" grades
Study what is interesting to me
Study according to externally-imposed deadlines
Regard difficult material as a nuisance unless I can find a use for it
Avoid difficult material and accept the consequences
Watch others complete the practice problems
Cram for tests sporadically and at the last minute
Surface-Achieving Approach
Attain high grades and/or high salary
Study to prepare for a non-specific career
Allow an adequate amount of time to meet deadlines
Gain confidence about anticipated tests by doing practice problems
Cease studying when too tired to continue or reached limit for learning
Rely on grades to measure mastery of course material
Identify everything that will be covered on the test
Ask myself, "Am I covered for this test?"
Deep Approach
Apply course concepts to new situations
Retain knowledge for understanding how the world works
Persist to build confidence and enjoyment through understanding
Accept that learning is a gradual process – practice with material repeatedly
Allocate time and effort according to the difficulty of the material
Identify patterns and relationships among course topics and concepts
Eliminate distractions when studying difficult material
Learn from alternative sources of information and instruction
Compare new knowledge to prior knowledge
Pay attention in class all of the time
Focus on a thorough understanding of concepts and how to apply them
Self-question and self-evaluate my knowledge and understanding as I study
Ask myself, "Does this solution make sense?"
Deep-Achieving Approach
Direct time and effort to my most important courses and concepts
Study to prepare for a specific career
Study according to the course plan for my major program
Write my own study guide
Attain confidence that I can teach the material to others
Apply all relevant concepts correctly, including details and exceptions
Develop multiple ways to solve a problem
Answer self-generated test questions correctly and without notes
Seek help from others when I encounter difficulty
Review poor performance on homework or tests
Divide complex material into components and work them sequentially
Ask why something works, then work a similar problem

Table 5, below, contains the percentages of learning approaches for each of the survey questions for the entire study sample, the sub-group of 4-year transfer students, and the sub-group of 2-year transfer students.

Table 5: Distribution of Learning Strategies by Among All Study Participants

Questions about the product of studying:				
What is your purpose for studying?	**"Surface" Approach**	**"Surface-Achieving" Approach**	**"Deep" Approach**	**"Deep-Achieving" Approach**
% of all participants	26.2	***27.9***	19.7	24.5
% of all 4-yr transfers	28.6	***37.1***	20	14.3
% of all 2-yr transfers	23.1	***26.9***	19.2	30.8
How can you tell when you have "studied enough" for a major test or project?				
% of all participants	0.0	***72.1***	0.0	27.9
% of all 4-yr transfers	0.0	***62.9***	0.0	37.1
% of all 2-yr transfers	0.0	***84.6***	0.0	15.4
Questions about the process of studying:				
How do you decide what to study next?	**"Surface" Learning Strategies**	**"Surface-Achieving" Learning Strategies**	**"Deep" Learning Strategies**	**"Deep-Achieving" Learning Strategies**
% of all participants	***42.6***	6.6	27.9	21.3
% of all 4-yr transfers	***48.6***	11.4	25.7	14.3
% of all 2-yr transfers	***34.6***	3.8	30.8	30.8
How do you regard difficult material?				
% of all participants	31.2	1.6	***67.2***	N/A
% of all 4-yr transfers	22.9	0.0	***77.1***	N/A
% of all 2-yr transfers	34.6	3.9	***61.5***	N/A
What are your most useful methods for learning course material?				
% of all participants	32.8	24.6	***42.6***	0.0
% of all 4-yr transfers	31.4	28.6	***40.0***	0.0
% of all 2-yr transfers	34.6	19.2	***46.2***	0.0
Do you ask yourself questions about what you are studying? If so, please give an example.				
% of all participants	***34.4***	24.6	***34.4***	6.6
% of all 4-yr transfers	22.9	31.4	***34.3***	11.4
% of all 2-yr transfers	***50.0***	15.4	34.6	0.0
How would you describe your actual study pattern for a major test or project?				
% of all responding participants (1 response blank)	8.3	***55.0***	0.0	36.7
% of all 4-yr transfers	8.6	***60.0***	0.0	31.4
% of all 2-yr transfers (1 response blank)	8.0	***48.0***	0.0	44.0

For the questions about the product or goal of studying, the largest percentages of participants exhibited a "surface achieving" approach, except for 2-year transfer students, who more often used a "deep achieving" approach. This difference could be explained by the tendency of two-year transfer students to have a more definite commitment to a specific career goal, as well as a more realistic understanding of what it will take to achieve it than many of their four-year counterparts [19].

However, the results for approaches related to the process-related survey questions were less consistent. Many of the participants used a "surface" approach to plan their studying, such as responding to externally-imposed deadlines, yet implemented more of a "deep" approach in specifying their most useful learning strategies, as well as how they dealt with difficult course material. Common examples of their "deep" strategies included self-monitoring and evaluation of understanding, seeking patterns in knowledge, recognizing the value of knowledge retention for future courses, and seeking alternative ways to solve homework and practice problems. Another way to show this lack of correspondence between the product- and process-related survey questions is shown as follows:

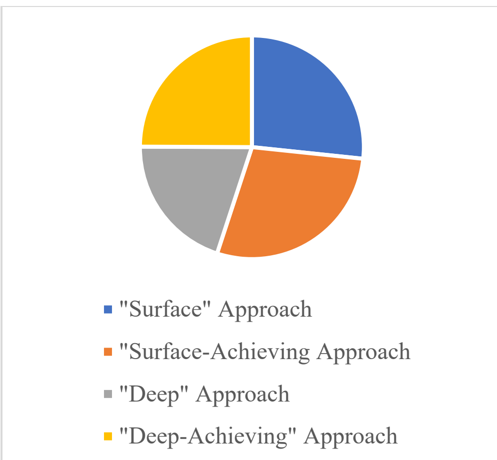

Figure 1: Responses from all Participants to, "What is your purpose for studying?" (product of studying)

Figure 2: Responses from all participants to, "What are your most useful methods for learning course material?" (process of studying)

The lack of correspondence between the learning approaches revealed the responses to the "product"- and "process"-oriented survey questions illustrates the differences in participants' focus between their fundamental goals and how they are working to achieve them. One possible reason for this difference is the short-term urgency of responding to deadlines versus the long-term importance of a thorough grounding in the course material for knowledge retention and transfer, as if these two types of goals were mutually exclusive.

One potentially useful instructional method was revealed by students using a "deep-achieving" learning approach, in which they sought multiple ways to solve a problem. The identification of multiple methods requires an approach based on conceptual rather than "cookbook" knowledge. Conceptual knowledge includes limits to the ways in which a concept is applied.

Finally, the question about asking oneself questions when studying yielded the largest difference between the responses of two-year vs. four-year transfer students. While most of the four-year students exhibited a "surface", "surface-achieving" or "deep" approach more or less evenly, two-year transfer students most often acted according to a "surface" approach, either by not asking themselves questions as they study, or asking questions to gain the "right" answer for a test. By contrast, the four-year students were more likely to ask themselves where else the course material might apply, how it compared to their prior knowledge, or what other methods might be used to solve a problem.

Conclusions and Recommendations

The learning approaches and strategies used by a sample of engineering transfer students were explored in order to identify what these students do to set and attain their goals for learning. Its results will also be compared to those from a similar study about the learning approaches and strategies of first-year engineering students. The results from both studies can inform the development of guided practice in "deep" learning strategies to reveal the meaning behind what is learned, which is the key to the retention of knowledge for future academic success. Although prior studies have provided substantive results about the learning approaches and strategies used by undergraduate students, neither class year nor academic discipline was specified, except for one study involving engineering students from multiple class years [3]–[6], [13], [14], [16]–[18].

This study's most important outcome is the difference in learning approaches and strategies between what students expressed as goals for learning and what they do to achieve them. Goals for learning were often expressed as externally-driven homework and test deadlines, exhibiting a "surface" or "surface-achieving" approach, yet many participants actually used internally-driven learning strategies that were more indicative of the "deep" or "deep-achieving" approach, with more of an intent to retain it for future use. Additional studies could be conducted to further explore how students set goals and then decide how they will achieve them.

Another area to explore is the identification of where and how students acquired metacognitive learning strategies. These strategies involve the ways in which students direct their thinking, such as choosing which learning strategies to use, when to use them, and why they are useful [32].

Educators can do more to encourage all of their students to realize that meaningful learning approaches and strategies are not limited to what is urgent, but what is important for long-term knowledge retention and transfer. Examples of learning strategies that can be taught and practiced in the classroom, as identified in this study, include the use of multiple ways to solve problems, consciously checking results for credibility, addressing student-generated self-testing questions, dividing complex material into a series of components, and teaching material to others.

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