First Experiences on the "Other Side" of the Desk: Practical Techniques for New Professors of Engineering

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Introduction

A new professor typically has many advantages, including a thoroughly up-to-date understanding of the subject matter, a genuine enthusiasm for sharing knowledge with students, and a fresh perspective on the admittedly difficult task of engineering education. Unfortunately, these advantages can be somewhat mitigated by the multiple challenges that face the new professor on a daily, practical level. When the well educated and highly motivated new professor first encounters the everyday challenges of teaching technical topics to students, the resulting mismatch between the anticipated situation and the actual one can be both surprising and distressing. In fact, the widespread feelings of discouragement and the high levels of stress associated with the first year of teaching are well documented.[1]

Perhaps the disappointments experienced by many first-year professors stem from the potentially large disconnect between their excellent preparation in some areas and their relative lack of preparation in others. Specifically, many new professors are extremely well prepared in terms of technical understanding and personal motivation, but they may be somewhat poorly prepared in the more mundane areas of planning, classroom presentation, and classroom management.

There is good news for the professor who needs help in these routine tasks: Techniques for improvement in the daily tasks associated with teaching can be easily learned. The goal of this paper is to present steps that can be taken by the new professor to initiate significant improvement in the everyday elements of teaching. To achieve this goal, the paper presents specific techniques and ideas for improving classroom performance in the areas of course planning, lecture preparation and delivery, student assessment, personal study, and long-range planning.

Course Planning

A liberal amount of time spent planning a course before it begins will pay big dividends throughout the semester. Areas that deserve particular attention include the course outline, the nature and timing of assignments, the grading policy, communication of the plan to students, and textbook selection.

The course outline should be as detailed as possible. Avoid the temptation to have a very broad outline – for example, an outline that states chapter 1 will be covered in week 1, chapter 2 will be

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covered in week 2, and so on. Instead, list the actual topics that you expect to cover during each class period. Although it is true that the precise schedule cannot be known, there are many benefits to making your best guess and thereby establishing a goal. One advantage is that the detailed outline gives you a plan for each lecture, reducing the amount of time and effort required to develop the lecture during the semester. Another benefit is that the outline tells students exactly what the course covers, minimizing questions about what topics will be on the exams and which concepts are particularly important. Finally, the detailed outline allows both you and your students to determine whether you are staying on track or not. If you are falling behind, you can refer the students to your outline and point out that you are going to have to move through the material a little faster. Our experience is that this type of collegial approach generally causes the students to be less resentful of an increased pace.

As you develop your course outline, look for opportunities to invite a guest speaker, stage a demonstration, or go on a field trip. It is tempting to see these types of activities as too costly in terms of time; indeed, too many of them would be. However, the judicious use of relevant special activities can greatly increase the students' levels of motivation and interest in the course, making these activities well worth the time they take.

Another critical area of course planning is the creation of a comprehensive list of course assignments with due dates. Decide when exams will be given, when homework assignments will be due, and when special projects or papers will be turned in. Consider your own schedule as you are setting up the semester calendar. For example, you might want to schedule exams for each of your classes in different weeks, so that the grading task will be spread out. Also, you might want to assign shorter homework sets with greater frequency to allow your preparation and grading time to be more evenly distributed throughout the semester. In addition to establishing the timeline, determine what types of assignments will provide the best aids to learning. We recommend including a writing/presentation component to every course. Technical communication is a critically important skill, and the ability to write a technical paper or give a presentation related to the course material provides a different way to assess the amount of learning that has taken place.

In terms of assessment, you need to clearly establish your grading policy before the semester begins. Again, it is important to be as thorough as possible in this area in order to avoid questions and complaints after the course begins. Do not create a policy that you cannot (or will not) back up. For example, do not say that you absolutely will not accept late homework, if you really mean that you will not accept it without a very good reason. A possible alternative would be to say that you will accept homework up to a week late for half-credit. Then, there is a stiff penalty for delinquency, but you have more freedom to work with the occasional student who might have a very good reason for being late. Student assessment is a large and difficult topic. We will discuss a few practical suggestions regarding assessment in a subsequent section, but we want to emphasize its importance in this section in terms of course planning and organization.

The most obvious vehicle for conveying the course outline, assignments, and grading policy to your students is the course syllabus. We recommend including as much information as possible in the syllabus and referring the students back to it frequently during the course. Treat the syllabus as a contract between you and the students, and help them understand the "real-world" concepts of deliverables and schedules. If you find that you need to make major adjustments to your plan during the semester, provide the students with a revised syllabus.

A slightly different area of class planning involves textbook selection. You may not be responsible for choosing the textbook for your courses, but if you are, the importance of making a wise choice cannot be overestimated. The textbook drives your course to a very large degree, so it is worth an investment of time to find the right one. Publishers will send free review copies of textbooks to professors, a wonderful practice that allows you to make an informed decision regarding the best book for your course. The most important item to consider is also the most obvious: the set of topics covered by the book. The text needs to cover the topics you intend to cover in an order, style, and depth appropriate to your purposes. Ideally, the topics should be applicable to other engineering courses taught in the department in order to allow the students to derive maximum benefit from the book. Another important aspect of the book is its organization and layout in terms of the presentation of material, the use of examples, the applicability of homework problems, the clarity of figures, and so forth. The basic approach to working problems is another critical aspect of textbook selection that is often overlooked. If you are accustomed to proceeding clockwise for a certain type of problem, for example, and the book tends to proceed counterclockwise, the difference could be potentially confusing and annoying for both you and your students.

It may be that you find multiple books that seem to be suitable in terms of topics, organization, layout, and problem-solving approach. If so, check to see what types of free supplemental aids the books have. Many textbooks have terrific web sites with a variety of features, including tutorials for students and sample exams for instructors. All other things being equal, you might as well choose the book with the most helpful instructor aids! Another way to decide between books that are very similar is to find out what other schools have adopted the books. If it is a really good book, you probably will not be the first person to discover it, so take advantage of your sales representatives to find out what other schools are using the books you are considering. The "facultyonline" website, created by Monument Information Resource and located at www.facultyonline.com, is another good source of information about textbook usage.

To summarize, specific suggestions for adequate course planning include:

- Establish a thoroughly detailed course outline.
- Create a comprehensive list of course assignments with due dates.
- Establish a clear, workable grading policy.
- Create an informative syllabus that conveys the previous three points to your students, along with other appropriate notes about class policy and procedures.
- Select the course textbook with great care.

Lecture Preparation and Delivery

In spite of the current emphasis on using more "student-friendly" methods of teaching,[5,6] the lecture remains a staple of engineering education. It is hard to find a more appropriate method to convey the highly technical content of most engineering classes; however, this necessary reliance on lecturing increases the challenge of holding the students' interest during class. The following paragraphs contain pointers for improving your lecture preparation and delivery in order to gain the attention of your audience, to increase retention rate, and to raise the level of enjoyment for both the students and the professor.

During initial preparation of lectures for a particular course, seek the assistance of your colleagues who have taught the course in the past. Perhaps they will be willing to provide you with lecture notes, handouts, and exams from past classes. If so, these materials will allow you to have a valuable starting place from which to develop your own direction for the course.

As you develop your course, you will naturally use your textbook as a guide; however, it is helpful to supplement the text with additional information to hold the students' interest. An excellent resource is another textbook on the same topic, which can be used to obtain sample problems, to find helpful methods of presenting material, and so forth. Do not go overboard on this idea, as you basically want to follow the textbook you have selected. The goal is to find an appropriate balance between following the textbook (for those students who like to hear and read the same material) and supplementing the textbook (for those students who want to hear something slightly different from what they read).

The internet is another valuable source of supplemental information, particularly when it is appropriate to mention current events during a lecture. For example, on September 11, 2002, the first anniversary of the 9/11 tragedy, one of the authors went to the IEEE web site and found a list of ways the engineering profession has responded to the tragedy. Using this list as a springboard, she led a ten-minute class discussion about responsibilities of engineers and opportunities for engineers. The students gave their full attention to the discussion and made favorable comments about it later on during the semester. Another example involves a biomedical engineering laboratory course taught by one of the authors, in which she devoted one full class period to a discussion of current events. Students selected a topic of choice from the BMEnet website news page and gave a report to the class on the particular engineering development they had researched. These successful experiments not only stimulated student interest, but they also gave the students practical experience in finding information for themselves – an idea closely related to the ABET directive of promoting life-long learning.

Another form of supplementing the text during your lecture is to provide the students with relevant handouts. For example, if you are presenting a long list of terminology in a particular lecture, it would save time to provide the students with a handout containing the required terms

and definitions. While we generally believe students learn and retain more by taking notes rather than reading from handouts, we recognize that the judicious use of handouts can complement both the textbook and the lecture very nicely.

A final note about the relationship between the textbook and your lecture is to make specific reading assignments – not just on the syllabus, but verbally during class as well. Let the students know that you *expect* them to do the reading, as it will make your lecture much clearer to them. Ask them to look at a particular figure or table in the book during your lecture to emphasize the importance you place on reading the assignment as a prerequisite for attending class. Emphasis on reading as well as hearing should aid in the learning process, as evidence has repeatedly indicated that learning is enhanced when the information presented to students is both visual and verbal.[7]

When planning an individual lecture, be realistic about how much material you can cover in a day. After you have delivered lectures for a week or two, you should have a very good sense of how many pages of notes comprise a good lecture. If your plan for a class period deviates from that expected amount by too much, you will probably want to reconsider your plans for that day. Remember the old adage that the material you deliver is not necessarily the same as the material the students absorb – and what matters is the material the students absorb. Covering a topic in a hurried manner is not the same as teaching it.

Another valuable aid in planning the lecture is to consider the goal for each lecture. Why are you covering this topic? What do you want the students to learn? How does the material for this particular lecture fit in with the overall course? Then, plan to open the lecture with a one-sentence explanation of the "big picture" for the day. This practice will keep you on track by ensuring that whatever you plan to discuss has some purpose, and it will help the students to maintain an awareness of the goals and purposes of the course.

During the lecture, use visual aids whenever you can. For example, in an electronics class, show students an integrated chip and the manufacturer's sheet that accompanies it. In an image processing class, show students a plastic phantom and images of it taken in various modalities and from varying perspectives. Bring the real world into the students' hands, and allow them to glimpse the excitement of an actual product that results from the equations and theories being discussed. Not only will the students be more interested in your presentation, but studies show that we retain visual information at more than twice the rate of verbal information.[7]

Visual aids will not be practical or even possible for every topic, but the principle of visual information can be used in a variety of ways. For example, if you verbally deliver two or three paragraphs worth of detailed material without writing anything on the board, you have almost certainly lost the majority of your students. As a visual aid, try putting highlights of your discussion (not just the equations) on the board in bullet form as you are talking. Consider introducing the capacitor in a circuits class. You would almost certainly write the two equations

shown below on the board at some point during your discussion.

$$q = Cv$$
$$i = Cdv/dt$$

Among other things, the first equation would prompt you to verbally note that the capacitor is a storage element where the amount of charge stored is proportional to the voltage across the capacitor, and the second equation would prompt you to note that the capacitor acts as an open circuit to dc voltage. Rather than just making these comments, write simple phrases on the board to emphasize them. You might even put the phrases "storage element" and "open circuit to dc voltage" in a corner of the board and refer back to them throughout the class period. At the beginning of the next class period, ask the students to tell you two main points (or however many you ended up with) about the capacitor. Write them in the corner once again and just leave them there as you work problems or present additional information related to the capacitor. Not only will this approach help you emphasize the key points about a particular topic, but it will also help your students have better notes when it is time to do homework or study for an exam. If you follow a similar procedure for main points throughout the course, the students should end the semester with a grasp of ideas as well as equations.

For complex topics that require a great deal of development, try presenting the answer first and then deriving it. For example, the solutions to first-order RC and RL circuits are very formulaic, but there is a certain amount of mathematical development involved in arriving at the formulae. Tell the students you are giving them the answer first, and then do the development. This approach has the advantage of letting the students know the most critical piece of information first so that they can avoid the very easy trap of "losing sight of the forest for the trees." Also, it gives the students the satisfaction of knowing where the discussion is heading and the pleasure of arriving at the desired answer as the lecture progresses.

Another approach to complex topics is to incorporate small-group activities or problem-solving into the lecture. Rather than working every problem from your notes, have the students work in groups on a selected problem. Then, in reviewing the problem, have a student with the correct solution teach it to the class. Students will appreciate the variety of having another presenter, as well as enjoying the fact that "one of their own" is instructing them. When appropriate, have the students generate design ideas in class for a particular process or instrument, such as filtering, insulating, safety considerations, and so on. Not only do these types of activities help to keep the students' attention throughout the class period, but they also provide some exposure to such industry practices as team development work and brainstorming.

On a stylistic level, have some enthusiasm! For example, if you are covering a topic one day that you particularly enjoy, tell the students. If you have a brief story or experience that relates to the topic, share it. It is likely that their attention will be at least slightly increased just because you have said something extra or different about the topic. Similarly, if you are covering a topic in the

course that allows them to use several techniques covered earlier in the course, tell them! Explain that this section is an exciting one, because the topics we have been covering all come together. Most students respond very positively to genuine enthusiasm.

Finally, have some sympathy! Remember that seeing complex material for the first time can be rather daunting. It can be helpful to acknowledge in class that a particular topic might seem difficult at first; however, with practice, it will become second nature. A little encouragement goes a long way toward fostering a pleasant and productive learning environment.

To summarize, specific suggestions for lecture preparation and delivery include:

- Take advantage of material used to teach the course in previous semesters.
- Supplement your lectures with other textbooks, information from the internet, and the judicious use of handouts.
- Supplement your lecture with specific reading assignments from the required textbook.
- Be realistic about how much material you can cover in a day, and resist the temptation to rush through a topic just so you can say it has been covered.
- Be sure you have an overall plan for the course, and be aware of how each lecture fits into your plan.
- Use visual aids whenever possible.
- Write concepts and key ideas on the board, in addition to equations.
- Be creative: Try different approaches to presenting complex topics.
- Be enthusiastic: Students might just believe you when you tell them something is interesting!
- Be sympathetic: Students generally respond well when they are convinced that you truly want them to learn the material.

Student Assessment

One of the most challenging tasks for the new professor is student assessment. Not only is the task objectively difficult, with entire books and courses and even degree programs devoted to it, but it can also be an emotionally charged task.[4] The best assessment methods and policies for the individual professor come with practice, but the suggestions in the following paragraphs might provide a starting place for the development of your own ideas.

As mentioned in the Course Planning section of this paper, it is critically important to outline your grading plan very clearly on your syllabus. Then, stick with it! If you decide at some point during the semester that a different grading plan would be better, make a note of your idea for the next time you teach the class; however, do not change the rules for the current class. Students do not like surprises of this sort.

In addition to establishing an overall grading plan for the course, it is important to have a plan for each major assignment. Consider whether you will give partial credit on exams; consider what

components will comprise a project grade and assign percentages to them; consider whether you will offer to drop the lowest homework grade; and so on. Clearly convey your grading plan for a particular assignment to the students when the assignment is made.

So far, we have addressed the need for a consistent assessment plan that is communicated to the students and implemented as designed. This planning stage is only the very first step, and it is by far the easiest step. The real challenge begins with developing each assessment tool and actually performing the assessment. The following paragraphs provide suggestions for developing and assessing the most typically used tools of exams, projects, and homework.

To develop a good exam, it is helpful to maintain a running list of potential exam questions as you prepare and present your lectures. As questions come up in class, or as you find good examples that you do not have time to work in class or to assign as homework, make a note of them. The advantages to this approach are that you are not starting from scratch when you make out your exam, and your exam questions are likely to be appropriately related to the material you have presented.

Consider what you want to find out about the students' knowledge level when you are developing exams. In some courses, it can be useful and informative to devote a small section of the exam to something other than problems. For example, you could have five short answer questions worth two points each; thus, ten percent of the students' grade for that exam is dependent upon their ability to articulate concepts in words rather than simply work problems.

When grading exams, grade through the entire set of exams one problem at a time to ensure consistency. Develop a detailed grading scheme for each question to clarify the partial credit breakdown. You can allow this scheme to unfold as you are grading by simply keeping a list of each new mistake that you find with its associated point value. The added advantage of such a list is that it shows students that you are making every attempt to grade fairly. If a student comes by your office to question the amount taken off for a particular type of error, we have found that a quick reference to the detailed list in front of the student to confirm your decision tends to silence any criticism.

For class projects, it is very helpful to have checkpoints along the way. We do not see any need to grade these checkpoints; they are simply a progress assessment. For example, if you expect the students to build a simple circuit for the final project in a circuits class, you might have two intermediate checkpoints: one to show you the schematic of the circuit they plan to build, and another to show you that they have procured the parts and built a prototype. These checkpoints ensure that the students will not wait until the last minute to work on the project, and they have the added merit of providing students with experience in the corporate idea of deadlines and checkpoints. Point out the "real-world" connection to your students!

If your project involves writing a paper, consider giving two (or more) grades: one for content

and one for grammar/style/format (or separate these items into individual categories). Engineering students are notoriously poor writers, and we professors need to do all we can to encourage improvement in this area. Separate grades allow a technically good paper to be rewarded for its strengths without ignoring any deficiencies in writing. Of course, you must decide what portion of the overall grade comes from content and what portion comes from grammar/style, and you will need to inform students of the breakdown when you make the assignment.

For homework assignments, it can be good to occasionally break the monotony with unique methods of assessment. For example, you might try grading one or two selected problems for a particular assignment rather than the entire problem set. As always, tell the students your intent when you make the assignment. (Of course, we are not suggesting that you tell them which problems you plan to grade, but just that you will be grading a subset of the assignment!) We have found that students who typically fail to complete assignments are more likely to do so when they know that only selected problems will be graded.

Another possible source for the occasional homework grade is to have each student come by your office for a few minutes during a given week to discuss their favorite and least favorite homework problems with you. Make it very clear what type of discussion constitutes an A, B, C, D, or F. In our opinion, the only way to make an F on this type of assignment would be to not show up! Basically, we would hope that each student would make an A or a B. A "gift" for one homework assignment is not going to sway the overall grade too much, and you and the student might both learn quite a bit from this type of verbal discussion assignment. This idea sounds time-consuming, but it must be compared to the amount of time you would spend grading the regular homework assignment. If you have a grader, this type of interview just once during the semester could provide you with valuable insight into each student's attitude and aptitude.

A variation on the verbal discussion assignment is to have each student come by your office toward the end of the semester to discuss the overall course with you. You could ask a standard set of questions to find out what the student thinks of the book, the pace of the course, the project assignment, the amount of work involved in the course, or whatever else you are curious about. These interviews can provide a wonderful list of ideas for improving the course, and they can give the student's homework grade a small boost. As we said in the previous paragraph, a single homework assignment will not have much effect on the overall grade, but gaining another A or B gives the student a feeling of satisfaction.

One final word regarding assessment is that there must be some room for flexibility. This statement sounds like a contradiction to our earlier admonitions to be consistent and unchanging, but we believe it is a necessary inconsistency. There will always be the possibility of a student who has a serious illness or family tragedy during the semester, and there are also less serious situations that simply demand a small concession of some sort. Within the framework of consistency, the fair thing to do is sometimes to make a small exception. As long as these

situations are rare, they should not cause a problem.

To summarize, specific suggestions for student assessment include:

- Outline your overall grading plan clearly on the course syllabus.
- Outline the grading plan for each major assignment and convey it to the students when the assignment is given.
- Keep a list of potential exam questions as you develop your lectures.
- Consider including brief sections of short-answer questions to supplement the standard problems on some exams.
- Grade one problem at a time to ensure consistency in granting partial credit.
- Consider having intermediate checkpoints for projects.
- Consider having separate grades for technical content and grammar/style for papers.
- Try to break the monotony of homework assignments with occasional changes from the routine.
- Use brief office interviews as a win-win situation, providing information for you and a small gift of a good homework grade for each student.

Personal Resources

The new professor faces multiple questions during the first several months on the job. Although this statement is true of almost any new employee, it can involve added stress for the new professor, since teaching is often a solitary job in which the professor is expected (by students) to have all the answers. The difficulty lies in the fact that the students do not just want technical answers about course material, but they also want answers about how to register for classes, how to get computer access from a dorm room, how to write a lab report, and so on. Where can the new professor go to find answers?

One of the best resources available is the internet. During the first semester of teaching, one author used the internet to find a project idea for an engineering economics class, a project idea for an introductory circuits class, a good format for lab reports, an answer to a calculus question that was pertinent to a particular lecture, along with countless other less critical needs. The internet can also keep you informed of the latest engineering developments, current job prospects (for your students), and just about any item of interest or concern.

Another excellent resource is your new set of colleagues. Our experience is that the people who have been around campus really enjoy helping new people. Even if they do not take the time to seek you out (which they may not due to their own time constraints), they will almost certainly respond with pleasure if you go to them out with a question. If not, simply try someone else next time. Obviously, your new colleagues are particularly helpful for questions about how things are done on your local campus, but they also tend to be a wealth of information about teaching in general.

It can also be beneficial to stay in touch with friends from graduate school who are in new teaching positions. These connections can provide an opportunity to compare notes and glean real encouragement from someone who truly understands your situation. Similarly, contact with your former professors can provide you with a wealth of information and resources.

You may also want to establish relationships with faculty in engineering departments at other local schools, if your region offers some density of engineering programs. One of the authors has worked with a neighboring school to get some ideas about service learning for her students. The other school has a well-established program in this area and has provided many valuable insights.

To summarize, specific suggestions for developing personal resources include:

- Use the internet.
- Get to know your new colleagues.
- Stay in touch with friends who are on a parallel path.
- Establish relationships with engineering faculty at other schools in the region.

Long-range Planning

With hopes of having a long, enjoyable career as a college professor, it is never too early to start planning for the future. This section briefly covers a few ideas that might make academic life easier down the road.

Keep good records on your class notes! If an idea works well, make a note of it and plan to do something similar that next time you teach that class. If an idea doesn't work well, make a note of it and plan to improve it next time around. Discipline yourself to spend less than five minutes making these notes right after each class period. It is surprising how much can be forgotten from one semester (or one year) to the next! Pulling your course notes out without any notations a semester or a year from now may prompt some distant memory of what worked well and what did not, but it is very helpful to note successes and failures while they are fresh on your mind.

Keep a running list of things you want to do. The list could include items such as downloading a new trial software program and testing it for incorporation into a class, checking on an internship opportunity for a promising student, reading an article you noticed in a technical journal, writing a paper for publication, and so forth. Notice that some items on the list are very time-consuming, while others are not. The idea is to have a comprehensive list of all sorts of things you want to accomplish, and when your schedule lightens up (as it eventually will), you can go to your list and be productive with your extra block of time, no matter how small it is. If you do not have such a list, it may be difficult to remember your ideas when the block of free time appears.

Keep a folder of successes in teaching, scholarship, service, and whatever other parameters your university uses to determine promotions and raises. Then, when it is time to report to the tenure board or other decision-making groups, it will be easy to come up with examples of your

accomplishments.

Keep documentation of all meetings with your student advisees. If you have counseled them to add or drop a course for a particular reason, you may need to refer to this change in the future. Similarly, keep documentation of any major decisions that are made regarding curriculum, course content, and so forth. A written history is an important part of departmental (and individual) success.

Finally, look for ways to collaborate with other departments on campus. Employers are increasingly requesting that students be trained in the "soft" skills of communication and teamwork, and universities are increasingly interested in cross-departmental interaction. In fact, some scholars see such interaction as a necessity for meeting the goals of higher education.[3] Find a business professor who will work with you to allow students to work together on projects, with the engineering students doing design work and the business students writing a marketing plan or an advertising campaign. Find a communications or English professor who will work with you to assign and assess papers and presentations, or have English education students contribute to the grading of papers written by engineering students. The education students gain practice in grading, and the engineering students gain feedback from someone other than you.[2] (You would want the grading to be done anonymously, of course, since students are involved on both ends. Also, you would want to have final input on the grades to ensure consistency across the set of papers.) There are numerous possibilities for interaction between the departments, and these types of collaborations are beneficial to everyone involved.

To summarize, specific suggestions for developing personal resources include:

- Make a note of successes and failures on your class notes as soon as possible after a given class period.
- Maintain a list of things you want to accomplish, and refer to your list during slow times.
- Keep track of successes in all areas pertinent to promotion at your institution.
- Document all major decisions involving students, curriculum, courses, et cetera.
- Seek ways to collaborate with other departments on campus.

Conclusion

First-year engineering professors find themselves in a unique situation, often coming from positions at the height of their technical careers while perhaps lacking certain skills in the area of teaching. The aim of this paper has been to offer a host of practical suggestions from the viewpoint of two new professors. One final piece of advice – recognize that you will make some mistakes! Most of your colleagues – and even your students – will understand your position and will be forgiving of errors. With strong efforts to improve your teaching style and a positive attitude in the classroom, the success you experienced as a graduate student will find its way to the "other side" of the desk.

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