Hello,

My name is Yung-Hsiang Lu. I am an associate professor at Purdue University. This is the first lecture in a series about how to do research. Many students ask me about doing research. Many students have done research projects with me. I will use this series of lectures sharing my experience about doing research. Even though many people have heard about the term “doing research”, some of them have wrong ideas about what is research. As a result, they may join research projects and do not enjoy the experience. Some students think research is not for them and miss great opportunities. I want to share my opinions and experience so that you get some ideas about research. Please understand that different people may interpret research differently. What I describe here is only my opinion and is not necessarily shared by anyone else.

The target audience is undergraduate or graduate students.

What is research?

In my definition, research means solving problems and nobody in the world has solutions for these problems.

Based on this definition, we can clearly understand what is not research. Research is not learning, even though you probably need to learn many things while doing research. If you can find a problem’s solution in a book, a news report, a paper, from a professor or anyone in the world, it is not research. Anything that can be learned, by the definition, is not research.

Some students say “I am doing research by searching relevant information on line.” This is searching but not research.

Why do people do research? Many reasons.

They want to understand the world better, solve new problems, improve existing solutions, etc.

One way to think about research is to look around us. How many things were created in the past 100 years, or even past 10 years? Examples are everywhere, such as spacecraft, electronic toll collector on highways, autonomous vehicles, and so on. To make any of these possible, people have to solve many difficult problems. In other words, people have to do research.

Why do students do research? Graduate students need to do research as part of the requirements for their degrees. Why do people enter graduate schools? Why do undergraduate students do research if research is not required for obtaining their degrees? Research is not required in many curricula. The most important reason of doing research is to learn how to solve problems and nobody knows the solutions. Research means creating new knowledge. Students’ main focus is learning but research is not learning. Research is to invent new knowledge. Most students do not have the experience creating new knowledge. To be competitive in one’s career, it is essential to have the skills and methodologies solving new problems. Thus, students want to do research and develop such skills.

What are the benefits of doing research? Doing research can learn the methodologies for solving real-world problems. It is common that research problems are so complex and need many people working together. Hence, people working on research projects must learn how to work in teams. When working in teams, researchers must improve their communication in both writing and speaking so that other team members can understand. A research project also provides great opportunities developing leadership skills. To solve difficult problems, researchers often need to integrate knowledge from many different subjects and courses. The ability of integration is very helpful to one’s career. This ability can greatly improve the prospect in employment or the pursuit of advanced degrees. Even if you do not want to pursue an advanced degree, such ability will make you stand out in your peers.

When students join research projects, they are often confused by the vast differences between classroom learning and research projects. In fact, research is so different from classroom learning and sometimes these two things are almost the opposite. Let me explain and compare the differences between classroom learning and research.

The most important difference is the purpose. In classroom learning, the goal is to acquire knowledge. Students operate in the “input” mode. They want to learn what is already known from textbooks and by professors. In contrast, researchers operate in the “output” mode. They want to create solutions to problems and nobody knows the solutions yet. In classroom learning, there are clear boundaries between semesters. At the end of each semester, grades are reported and the courses are over. When a new semester starts, everything resets. Students take new courses, meet new professors, read new textbooks. Research does not have such boundaries. It is extremely difficult to predict that a good solution can be found before a semester ends. Thus, the distinction of semesters is pretty much meaningless to researchers. Researchers continue their efforts until solutions are found.

In classroom learning, usually professors and teaching assistants know the answers. The purpose of homework assignments is for students to demonstrate that they have acquired the knowledge. Homework assignments are usually designed by professors or teaching assistants. When you do research, do not expect anyone else to know the solutions. If someone else knows the solution, you are not doing research. Because nobody else knows the solution, nobody else knows how to evaluate your solutions. You need to design methods for evaluating your solutions. Do your solutions work? Are they better? When students start doing research, they are often surprised that there is no homework assignment.

Let me emphasize this again. Students’ focus is learning as input. Research focuses on finding solutions as outputs.

Based on my experience, the most important difference when students start doing research is the change of mindset from student thinking to researcher thinking. Students believe that everything is available in textbook or handouts, thus taking notes would be unnecessary. Even when they take notes, the purpose is for themselves. Researchers know that what they do is not available in any book and they know the importance of documentation. Moreover, researchers know that documentation is for other researchers as well as themselves. As a result, documentation must be clear and complete.

A common mistake for students is that they want to join research projects to learn. What they should do is to contribute. Remember that learning means input. Contribution means output.

When you join a research project, you should ask many questions. Students rarely ask these questions when they do homework assignments. Important questions include

What is the real problem?

Why is this problem important? Who cares about the problems and the solutions?

What has been done? If you are going to find new solutions, you need to know what has been done so that your solutions can be better.

You need to clearly explain your solution. Since your solution is new, you need to explain the differences from existing solutions.

Is your solution better? In what ways? By how much?

These are the important questions researchers should ask.

You can think of research as weight training. It takes a lot of efforts. Research is not sightseeing. Tourists just see things without doing anything. Some people say, “You need to get your hands dirty.” You cannot do research if you want to be a tourist.

Doing research needs a lot of effort. Thus, you should consider doing research only if you can spend enough time. My suggestion is that you need to spend at least 10 hours a week for at least 15 weeks, if you want to accomplish anything at all.

Before you can contribute to a research project, you need to spend time understanding the problem, learn the relevant knowledge, tools, and skills. You need to know what has been done. In most cases, you work with a team and you need to know what they do. You have spent a considerable amount of time but you have not actually done anything yet. After you spend the time doing the preparation work, you can start thinking about the specific problem you want to solve. Then, you need to survey existing solutions as references, compare them to understand the strength and limitation in each solution. You definitely need to document this process. Again, you have not contribute anything yet. After all this work, you can now start doing research.

As you can see, doing research takes a lot of effort before you can do anything. Thus, you should consider research only if you can spend at least several hundred hours. If you want to be a tourist, don’t waste your time. In fact, if you want to be a tourist, you waste other people’s time. They have to explain their projects to you. They help you understand the topic. If you do not contribute to the project, you really waste their time.

If you really want to do research, you must take ownership of the problem you are solving. Some students think they are helping. Don’t. Research projects need problem solvers, not helper. If you want to help, you don’t think it is your problem and you think it is acceptable to withdraw at any time. You must understand that in a team, everyone is responsible for different parts of the project. Other people rely on your progress. You should participate only if you are determined to contribute. Of course, you should discuss your topic with other people. However, do not expect anyone to magically know the answer.

I know I have been cautious. In fact, it seems that I want to discourage you from doing research. The truth is that some students do not understand the meaning of research. They join research groups but realize that research is not for them. I hope you understand what research is so that you can make a informed decision.

Here are some advice for new researchers. First, you need to understand the differences between student thinking and researcher thinking. As I explained earlier, they are almost opposite to each other in many case. You need to focus on solving problems and you need to develop the skills explaining your solutions in speaking and writing. You need to know how to evaluate your solutions. There is no homework assignment or midterm exams. You should stay in the same project until you solve a problem. If you jump around, you accomplish nothing. You should not expect anyone to know the answer. If it is a research problem, nobody knows the answer and you have to solve the problem by yourself.

Here are some frequently asked questions and my answers. I hope they can help you further understand what research is about.

Question: I do not have high G P A. Should I consider doing research?

Answer: Do you want to learn how to solve difficult and important problems? Many great researchers do not have high G P A. I do not find very strong correlations between G P A and the ability to do research. In fact, some students have high G P A but they cannot do research. They want to learn things from textbooks and they do not want to explore and find new solutions.

Question: Would research experience help me in applying for jobs or going to graduate schools?

Answer: There are many cases where students receive exceptionally strong recommendation letters from their research advisers.

Question: If I do not want to go to graduate school, would research experience be helpful?

Answer: There are many cases where students obtain positions because of their contributions in research projects.

Question: I understand professors do not know the answers. Can I still ask the professors questions?

Answer: Yes, of course. Expect the communication to be discussions. Do not expect the professors to have answers right away. Even though professors do not have answers right away, they have experience and they know the area well enough to suggest directions for finding solutions.

Question: What are the most common reasons of failure?

Answer: First, you cannot "fail" in research. You may fail to find a good solution but you will still develop the skills in solving problems. . The most common problem is that some students expect research to be the same as classroom learning. weekly homework, office hours, teaching assistants, textbooks, midterm exams ... Students tend to think "everything resets and disappears after the semester is over." This is wrong. If it is a research project, it does not end after a semester is over.

Question: How to become good researchers?

Answer: You must think for long terms. Do the right things if you would stay in the project for many years. Do not take shortcuts. Document your thinking, design, and steps.

Question: What should I do if I decide this is not for me?

Answer: Tell the team as soon as possible. Do not wait. Your team members depend on you. Don’t surprise them later. Honesty is very important.

Question: Should I focus on keeping my high G P A? Will doing research reduce my G P A?

Answer: You need to have a reasonable G P A. However, does it really matter if your G P A is x or x + 0.05? Outstanding contributions and a exceptionally strong letter will be more helpful.

Question: Why isn't research required if it is good for students?

Answer: Research is good for some people, not everyone. That is the reason I am making this video helping you understand whether research is good for you.

Question: Why doesn't the professor know all answers?

Answer: Congratulations! You are doing research now. If the answer is discovered, the professor moves on to the next question. Thus, your professor is always looking for answers to questions. Remember that research is to solve problems that have no known solutions.

Question: Why don't my teammates know the answers?

Answer: Your mind is too much deep into the "classroom thinking". In a classroom, everyone does the same assignments. In the real world, each person does something different to build a team. Imagine a restaurant has only cooks and there is no waiter or waitress. This restaurant would not work.

Now, let me say a few words beyond research. One day, you will graduate and your ability to do research will become one of the best assets in your career. If you want to have a rewarding career, find one that requires research, one that needs solutions to new problems. If your job does not need new solutions, you will soon find the job boring and you have limited growth potential. Similarly, when you hire someone, find a person that can do research, not a person that can apply knowledge from textbook. No manager will hire a person to learn. Managers want people to solve problems and contribute. In your career, try to build a team, a team you can work with, a team to solve difficult and important problems.

If you are interested in research, let’s talk. I am confident that you will find this experience challenging and rewarding.

Thank you for watching.