Final Paper: Discovering Unaligned Expectations in Universities and Industry for New Graduates in Computer Science and Software Engineering and Finding Possible Solutions

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INTRODUCTION

There is a widespread agreement that new graduates from computer science and software engineering programs **do not always possess required skills, abilities or knowledge when joining the tech industry**: a lot of entry-level jobs actually require three years of experience [3]; gaps between Engineering Education, and Practice (what an engineer does in real life) do exist [12]; the software industry presents dissatisfaction in relation to the level of recently graduated professionals [10]; there is considerable room for improvement in what is taught to software students [in relation with job relevance] [8]; many employers find that graduates and sandwich students come to them poorly prepared for the every day problems encountered at the workplace [4].

The acknowledgment of this skill gap and the efforts to train new graduates for the industry go back as far as 1992 [5]. So, **if in a quarter of a century little to nothing changed, what is the real matter**?

We started thinking that the matter was not an inability of the academy to properly train students and that, instead, there is a *misalignment* in the expectations of the university, industry, and students; each one goes by its own way and ignores others' desire.

So, we set out to investigate such expectations by sending a survey to different categories of respondents, and we discovered some interesting things; especially, while it seems true that the university is totally uninterested in teaching students project management or soft skills, the underwhelming programming abilities of fresh graduates may actually be caused by a lack of teaching abilities in a school context.

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RELATED WORK

Some universities and programs took steps to try and fix this problem in some specific classes by doing all kind of things: from purposely hindering and disrupting the software development processes [4], to adapting and incorporating industry training strategies into a software engineering course [10], to creating and adapting a project-based software engineering course that led the students to face with current, real-world engineering problems [6], and to highlight to students how relevant is having and developing critical soft skills to succeed in projects[2].

We thought, as well, that different outcomes could come from different programs, so we explored the difference between Computer Science and Software Engineering programs, but those didn't prove really relevant; the official ACM/IEEE curricula for Computer Science [7] and Software Engineering [1], which many universities base their program on, are somewhat overlapping, and some studies trying to highlight differences in outcomes between CS and SE graduates were mostly inconclusive: a lot of core competencies are shared [9] [11]. And, those recently-updated curricula don't seem to incorporate lessons from the aforementioned efforts.

THE SOLUTION

We chose to investigate the topic by the means of a survey and with the help of a website - https://www.misalignedtech.com that helped us disseminate the research outside the OMSCS silo.

Research questions

We have two sets of questions. In the first set, our main question is: **does the perceived skill gap in fresh graduates exist because the academy is unable to provide a good training, or just because a) the academy is not even trying to do that kind of job, and b) the industry is taking that kind of job for granted, or c) the students think they should be getting something that the university has no intention to provide them with?** Here, we ask what could be the reasons that there exist a gap between students, professors, and industry professionals' expectations. We will look into these questions for both **undergraduate** and **graduate** level students that are recently graduated from school. We also ask the question that **how the students' degree can improve the chance of**

getting hired? Do the graduate-level studies help the students to gain adaptive skills in industry more quickly? In the second set of our questions, we are asking **what would be the best solutions that bring the university and industry's objectives closer to each other?**

The hypothesis

We think that:

- Most students, when picking their major, have little to no idea what they're going to actually study, and they probably expect to learn mostly about programming and creating applications;
- Most teachers, when designing their courses, think about teaching what they deem useful to achieve the so-called *computational thinking* in their students;
- Most professionals and employers, when hiring fresh graduates, expect they'll be able to immediately and fully carry out whatever real-world task is assigned to them.

So, we provided two sets of hypothesis to approach the research questions.

Hypothesis 1: One of the reasons for the perceived skill gap is that all those that should - in an employer's view - care for learning some skills to be used at work, don't actually have that aim during their education phase. In other words, the misaligned expectations between industry and university causes the skill gap. Those skills have impact on job proficiency and possibilities to get hired. We think that the expectations among four groups differ. These four groups are composed of **undergraduate-level students, post-graduate-level students, educators and school staff, and industry professionals**. The main problem is not only that one side hasn't enough resources or skills to achieve a certain goal, but, rather, that there's a different vision or gaol on what should be done, and different and unaligned *rewards* exist for different groups.

Hypothesis 2: We think that the following hypothesis is that the graduate-level studies, on the contrary, can play an important role on reducing the skill gap between industry and university, and therefore, can be considered as one good resolution for that issue. More specifically, we think that **high-quality online graduate-level programs** such as Georgia Tech OMSCS (Online Master of Science in Computer Science) are quite aligned with industry expectations. These such programs also target many people from all over the world, who can become proficient in their job quickly as well as being active in an academic environment.

METHODOLOGY

Still, we leveraged modern technology to achieve something useful; we **created a survey** where we asked questions to assess the thoughts of various categories related to our research - CS/SE students (graduate and undergraduate level), CS/SE university teachers, and industry professionals in the tech sector - to discover what it is, in their opinion, the current goal of university degrees (both Bachelor's degrees and Master's degree in Computer Science, Software Engineering or whatever a similar degree is called in one's country), and how that

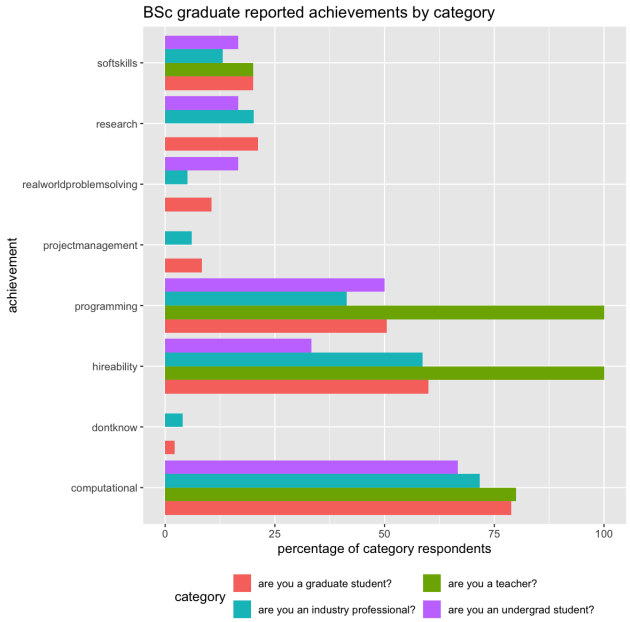


Figure 1. Currently, what do you think an UNDERGRADUATE student in CS or SE achieves, when he/she graduates?

affects job proficiency and chances of being hired. Following this, we provided open-ended questions in the last section of the survey that participants would share their thoughts on possible solutions on how to reduce the skill gap caused by misaligned expectations. The survey questions were designed to highlight contrasts between what students achieve and what people would like them to achieve. In this last section, we also pointed out graduate-level online programs as a possible solution and asked them what would be the benefits of such programs on resolving the described issue.

Beyond the category, we had some other independent variables, like age, country of employment, country where people got their degree, highest completed education degree, company size.

We tried to reach out as many people as possible but, while we had an internal target of at least 300 respondents, we just got about half that number of responses.

Once we collected their answers, which were constituted essentially by categorical data (for both dependent and independent variables) and some qualitative data (open questions), we looked at differential patterns: are there situations where some variable, especially the category, has a serious impact on some perceived or desirable skill?

RESULTS

Surprisingly, we've found that the expectations don't seem to be that misaligned on many topics. All of our categories, for example, have got very similar opinions on most BS graduate skills and would-like skills with one interesting twist.

We can see - figure 1 and 2 - that most of our respondents, regardless of their category, think that a BS graduate achieves the

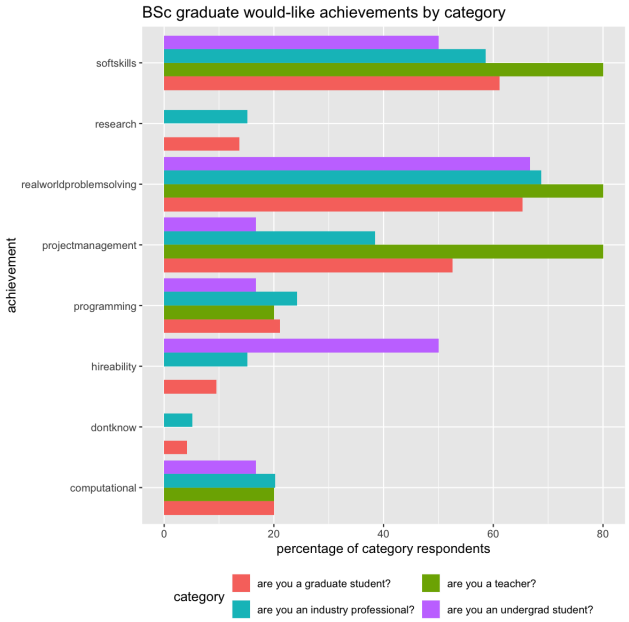


Figure 2. Are there any skills, that you think an UNDERGRADUATE student would need to learn at university, where it is not taught by universities, and are essential in working industry?

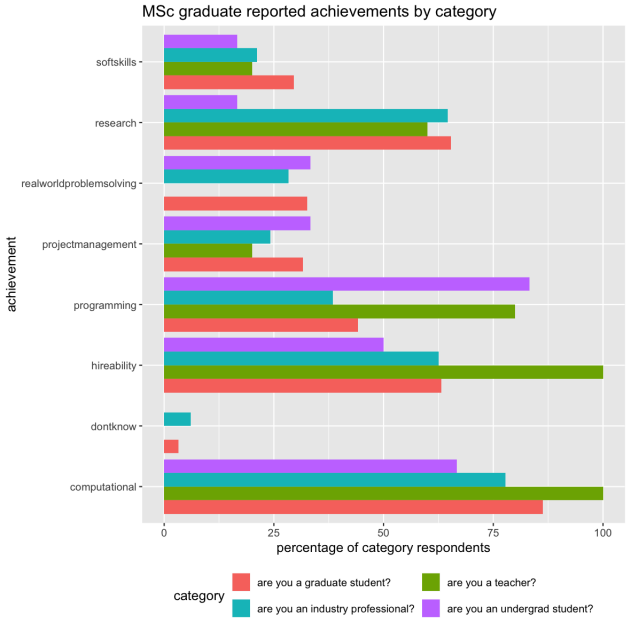


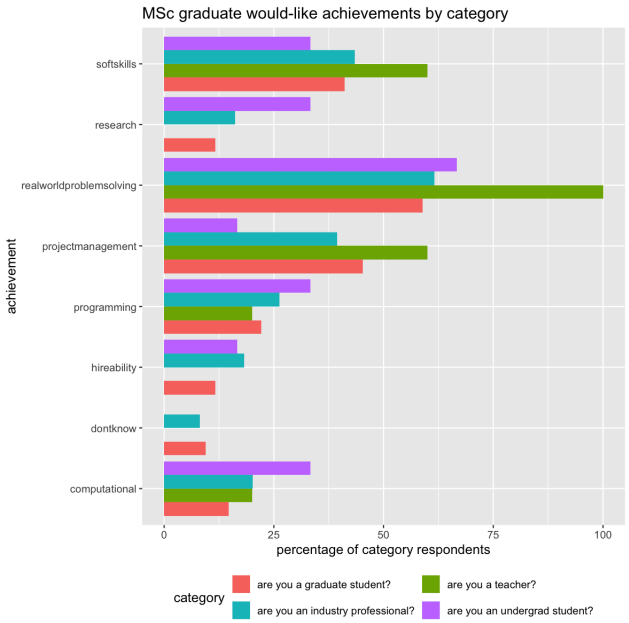
Figure 3. caption

so-called *computational thinking*, and, secondarily, a certain chance of getting hired and some programming skills. Here, we can actually see a bit of contrast between two categories: the teachers, and the industry professionals. The former group think that programming is something a BS graduate definitely acquires; the latter, being the ones that actually employ such skills, are far more reluctant to say that you get this skill in university.

Regarding the would-like skills, there are not great surprises; it seems that the most interesting selected items, that aren't achieved at university, are real-world problem solving, soft skills, and project management. Undergrads especially did not vote for this latest skills, however, improvement on chances of getting hired is one of this category's would-like achievements from academic educations.

One surprise comes from programming skills for undergrads. It's not marked as a clear achievement by most respondent, and **neither it is marked as a desiderata**. How should somebody hone his programming skills? On the other hand, it seems that programming skill is mostly achieved by post-graduate level students and is not selected as a high demand for would-like achievements.

The other surprise comes from research skills. Teachers don't think it's something that is taught, and neither that should be taught. Possibly, that's left to graduate education?



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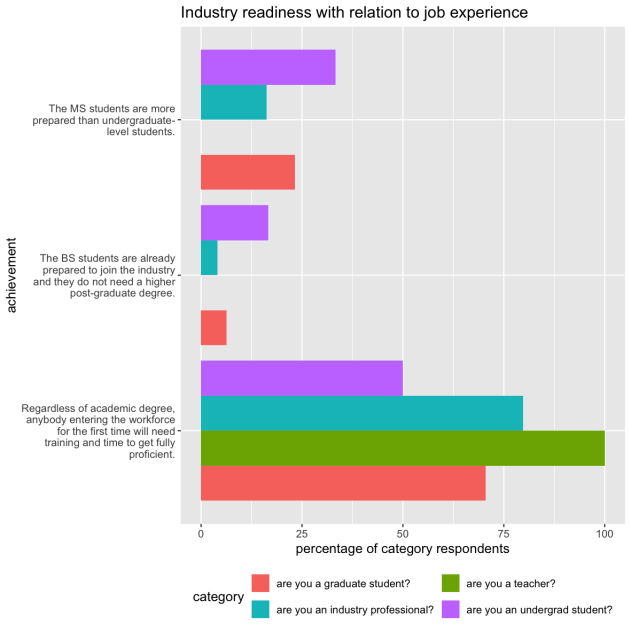
Here we see the opinions about graduate education. It appears to be a partial solution for some parts of undergrad education, but not completely. Most people *but industry professionals and graduate-level students* would agree that MS education



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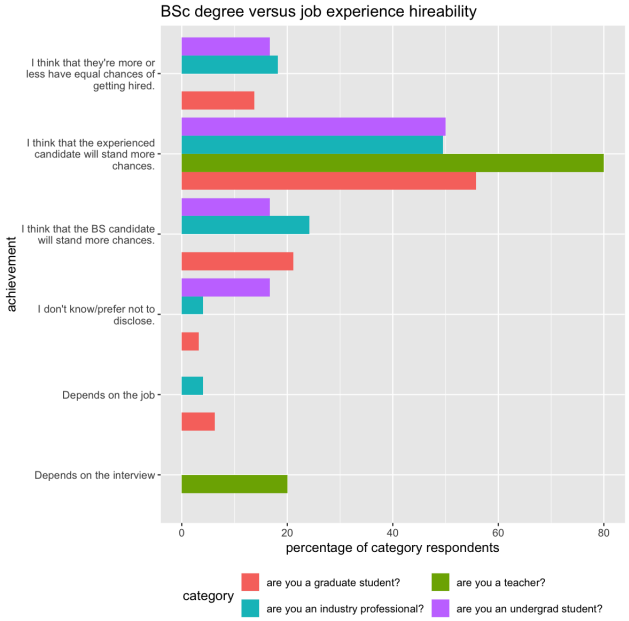


Figure 6. caption

improves your programming skills; since industry professionals are actually the most qualified at such opinion, it's not really encouraging, since they estimate MS graduate abilities on par with BS graduate abilities. On the other hand, teachers and undergraduate students categories (> 75%) selected this skill as an achievement after MS graduation.

We see better results for research: a reasonable amount of respondents think that graduate education is the stage at which research skills are taught.

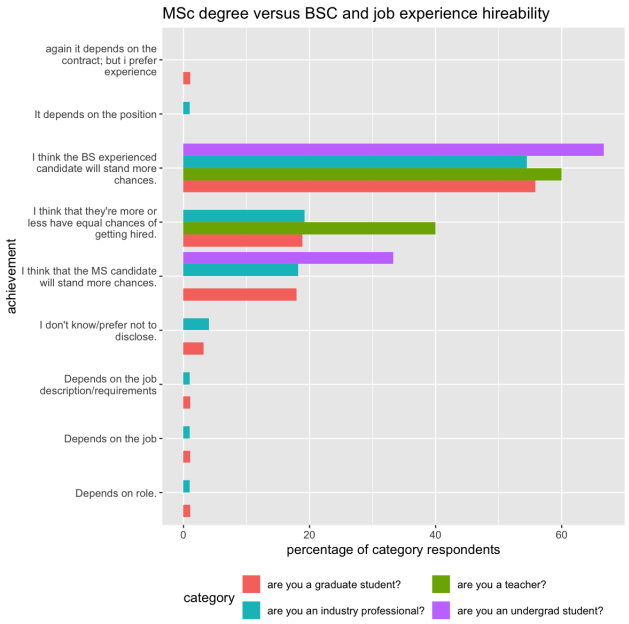
But real-word problem solving is still an open problem, even after a MS degree; and soft skills, along project management, could fare much better; there seem to be a large amount of teachers that agree on the fact that MS graduates would need more skills that can be applied directly in the real world.

Generally, we can see more traces of this belief in another answer:

Only a few undergrads (12.5%) hope that, at the end of their four-year studies, they'll have a high chance to enter the workforce and just have a great career. Other categories mostly believe that an apprenticeship phase will be mandatory for everybody - in this phase, most probably our graduates will learn about **soft skills, project management, real-world problem solving, and actual programming**.

This idea is reinforced by other answers in our survey; when discussing the chances of being hired, we asked our respondents to compare experienced and unexperienced candidates with and without degrees.

As we can see, a large majority (between 75% to 80%) thinks that experience matters a lot. Interestingly, teachers seem that experience is even more important, probably acknowl-



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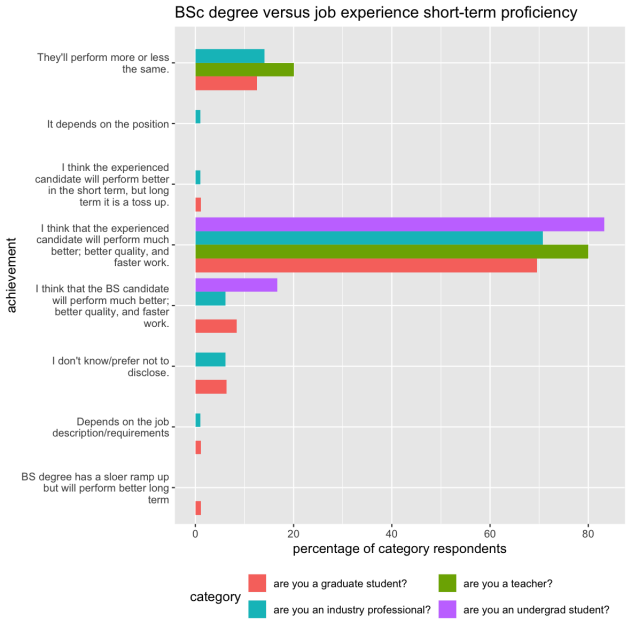

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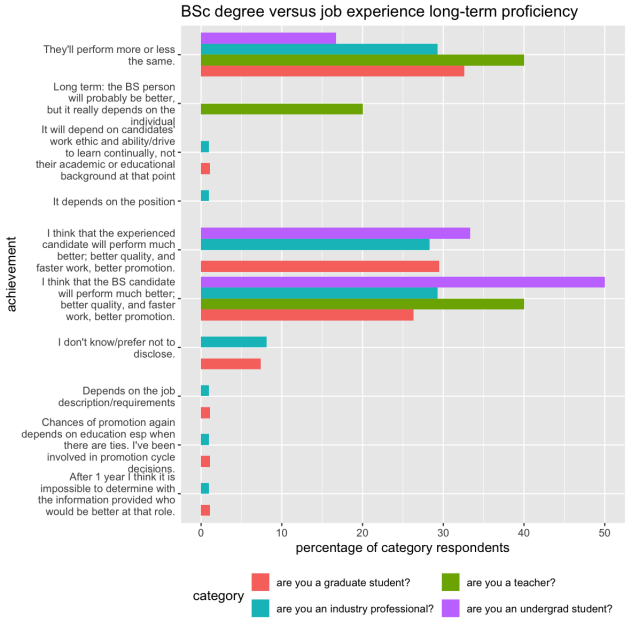


Figure 9. caption

edging the industry-school expectation gap and our supposed misalignment.

One last interesting result explains the job proficiency in short-term and long-term for both BS and MS graduates:

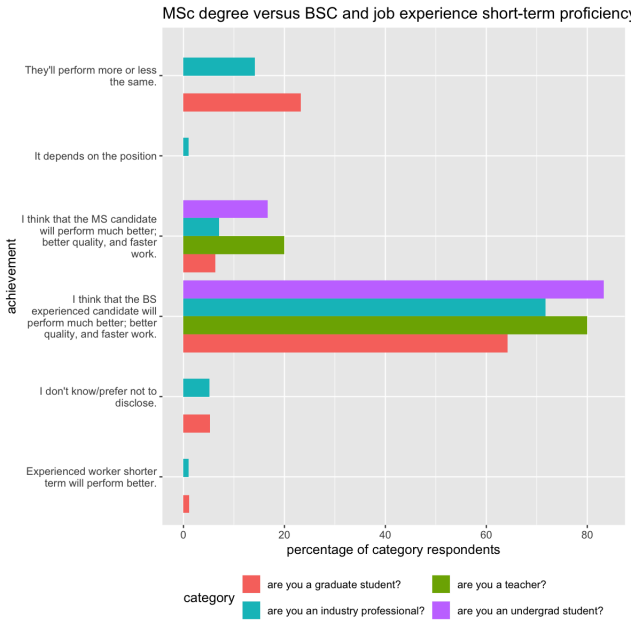
Here, we can explain two things:

- In the short term, experience is more effective than a degree.
- In the long term, a degree doesn't necessarily mean a better worker.

While the first statement may be a bit expected, we think that the second is clearly a novelty; even teachers don't acknowledge a clear advantage for graduates at doing their job. This is quite a clear image of the misalignment: there seems to be at least a slight indication that people in the academy don't really think that a lot of the topics they teach are *that* aligned with modern industry requirements, neither in short-term nor long-term proficiency.

We have seen quite scattered responses about the impact of GPAs and top schools, and we don't think we can draw big conclusions about those topics (The graphs are collected at `http://www.misalignedtech.com/`)

In the next step, we collected data about possible solutions and suggestions on how the students in both levels can gain useful work experience during their studies. We found that most frequent answers are as internships, real-world work, part-time jobs, extra courses or learning new languages, open-source projects, research, and studying. As it shows in the table below, the majority of the participants pointed out "internships" as the most effective practice for that. The next two major suggestions are part-time job and open-source projects. It is interesting that the part-time job is selected doubled the time



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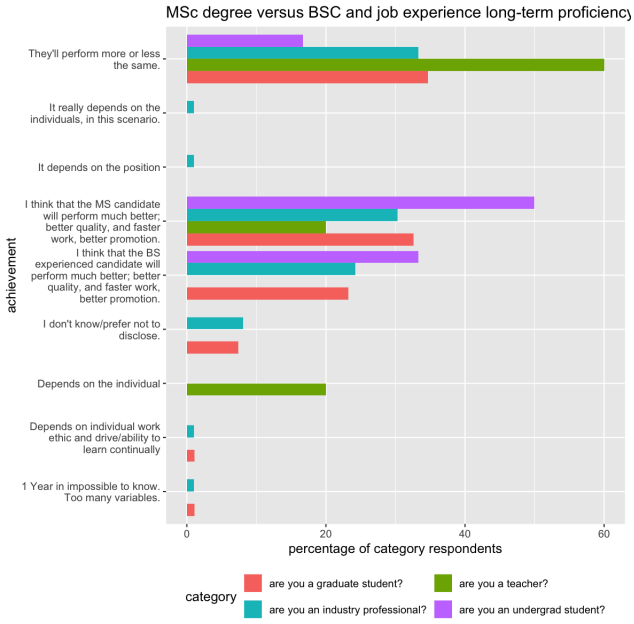

Figure 11. caption

for MS studies compared to BS studies. Another item to point out is the Research selection. As it shows in the table, 13% of the respondents think that Research can help in MS studies to gain useful work experience. However, only 6% recommend Research as an option to better be prepared for job industry.

Here, we looked at valid alternatives to MS education for a professional in need of retraining. As we expected, the MOOC and, certainly, on-site job training received the highest percentage among all the categories. The "in-person learning" received less than 40% of responses from all categories except teachers and professors. about 60% of professors think that in-person studies can be a convincing option for MS studies. Another interesting item is to compare undergraduate-level students responses. It shows that there is a percentage increase (about 20%) of choosing MOOC compared to on-site job training. This shows the high demand from undergraduate students to attend high-level online graduate programs and substitute this option with in-person or on-campus studies.

LIMITATIONS

We think our research has several limitations.

First: we didn't get as many respondents as we would have liked. We got about half the respondents we' were expecting; we miss statistical power.

Second: our categories are quite polarized. We have got a lot of industry professionals and graduate students, but we lack teachers and undergraduate students. Surely ,those few undegrads and teachers' opinion has a disproportionate effect in our analysis.

Third: most of our respondents come from the US. We don't think this research can have a worldwide validity, it's probably just one view of the problem.

Fourth: we had initially missed (an error while converting a document to Google Forms) a fundamental question in our survey (the category). Since we knew some of the respondents, we have inferred the categories for our analysis' sake for a small set of initial respondents (the survey was later amended).

Many people (in online forums where we had spread our survey as well) told us one interesting point about the "chances to get hired" section: the experience, or the degree, only matter up to a point in order to be *hired*. It may matter in order *to get an interview*: if we ever replicate this survey, it would be better to substitute "hireability" with "chances to land an interview".

CONCLUSIONS

About our two main hypotheses, we could say that:

For the first hypothesis, we could say that collected data *partially supports* it. Undergrad programs aren't meant to teach project management, problem solving, or soft skills, while a lot of people would just love to see Bachelors graduate with such abilities; so, there's a misalignment between the intentions of the industry and of the researchers. Interestingly, most undergrad students seem fully aware of the situation.

Programming, on the contrary, seems a matter of teaching abilities. It seems that schools are unable to create good programmers. But then, most people just seem to think that apprenticeship and on-the-job training are not replaceable by pure education; maybe we should just accept that we're yet unable to abstract away that kind of learning from real-world experience, and we should scale down students (and employers!) expectations about new graduates: they won't be good programmers without an appropriate on-the-job training.

The graduate education part appears to be a bit more foggy. We supposed that graduate-level programs would better fill the school-industry gap, but we cannot say that this is the case. Most of the industry is not concerned with research, and most industry professionals don't see great programming skills in MS graduates. For sure, it's a beginning, it's something more than basic BS education; but, probably, spending the same amount of time on a real job would yield the same results about soft skills, real-world problem solving and project management.

POSSIBLE FUTURE WORKS

We think it would be very interesting to replicate the experiment on a different scale, with slightly different premises. **Recruitment** seems to be the hardest part of our research; it would be interesting to partner with some large organizations (be it companies, conferences, universities) in order to push a (similar) survey to them.

It would be interesting to investigate the concept of good programmers, as well. Do bootcamps/MOOCs/other kind of programs produce better coders than university? Are they

Solutions to get useful job experience during BS and MS studies

	Internship	Real-World workd	Part-time job	Extra course/Newlanguage	Open-source projects	Research	Study and Learning
BS studies	56%	4%	13%	7%	18%	6%	2%
MS studies	42%	4%	25%	5%	14%	13%	1%

Figure 12. The table shows the suggested solutions by participants on how to gain useful work experience during BS and MS studies.

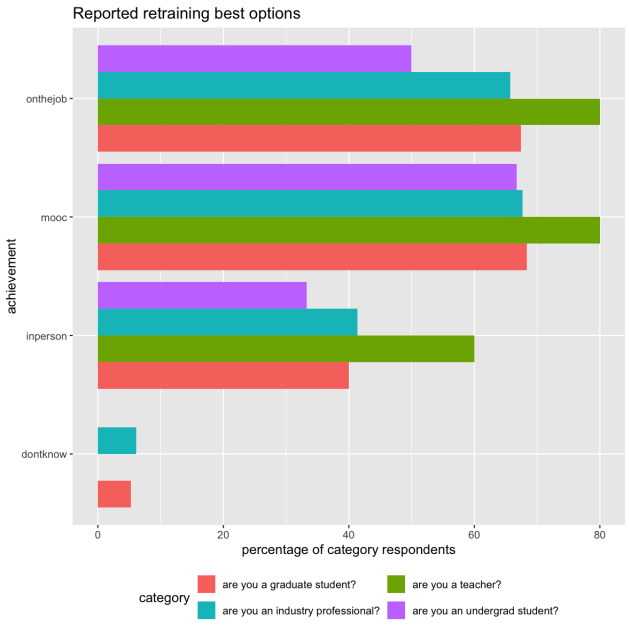

Figure 13. This graph displays the comparison between category responses on alternatives to MS education for a professional in need of retraining.

on par, but within a shorter timeframe? Could the university improve something?

It may be interesting to check if multiple categories (e.g. industry professionals that are MS students as well) have significantly different answers from "bare" categories; this was a bit outside the scope of our analysis because of time constraints and because of the polarization of our respondents, but could be quite useful.

It would be very useful to get more data from the academy. We haven't seen a clear indication for the purpose of the higher education programs; we may say that they appear a bit confused on whether it would like to focus on research, or it would like to help more the industry, or would just pursue knowledge for knowledge's sake - which could be a totally valid purpose!

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