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*Speaker 1:* So could you please briefly introduce yourself for the purpose of the interview?

00:00:09

*Speaker 2:* So my name is Ariel Lindner, I am and I'm a researcher in France and director of unit of interdisciplinary researchers called the Collaboratory of the Research and the Center for Research in Interdisciplinarity, and this unit is part of a university structure which was in the University of Paris on one side and the National and Biomedical Research Institute of France. And with foremost, I'm a researcher and an educator, and I have been trained as a chemist. I moved to the field of biochemistry and biology and genetics, then to bioengineering and then through different. Encounters and different sorts and making more and more efforts on the education part of my of my career and my ambitions. And I started to be interested also in learning disabilities and overall sort of, I would say, zoom out on education systems in general. So I have two lines of research. One is really on biology bioengineering and the other is more related to education.

00:01:23

*Speaker 1:* Yeah. Fantastic. Thank you very much. So my PhD is all about the research is all about higher order thinking skills in interdisciplinary context, especially my educational setups. So in one lane, how can we develop tools for teachers that can help students develop a certain specific skills that are more relevant for interdisciplinary approaches or multi transdisciplinary approaches context? So the purpose of this interview is that in literature, there are not much information available yet to date up to date. And in order for me to proceed, I need a foundational understanding of what does higher order thinking skills mean and how it is practiced in in classrooms. And for that, I am collecting data from teachers, researchers, educators in higher education who are much more closer to interdisciplinary approaches, basically engineering and interdisciplinary education. So that is the whole purpose. So I have a line of questions that could probably help me gain perceptions of yours regarding topics such as higher order thinking skills, interdisciplinary research. So my first question is. How would you describe higher order thinking skills in your educational setting? What kind of higher order thinking skills are, what does it that exactly you mean when you think of higher thinking skills?

00:02:52

*Speaker 2:* Good question. There's so. I would I would I would start with with with them. I mean, there are different ways to try to divide this, but maybe the easiest way to try to tackle your question is looking no from an individual perspective to start with. And but I'm a strong believer that education is not a single person in a vacuum and we'll get to it. And so I think that the first skill is a communication skill. And the communication skill is his, but it comes in two different flavors. I would say at this point one, you can call a disciplinary disciplinary in the sense that you know, if, if, if, if, if a learner already knows something that means that he can expose and exploit it, he can. So the easiest way to look at it can teach it to someone is what does it mean to teach it so you can explain it to someone? It's OK. And but that's sort of the primary level. The secondary level is not to explain to someone that has the same background as the same as the learner. I think that's where things become much harder. Because we know this also for professionals right between professionals, we can discuss with terms and words and give examples and metaphors, and that are, we share the

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same vocabulary that, are clear. Mm-Hmm. When you start describing what you know to someone else that does not come from the same background, culture and background, disciplinary background, age, age difference, et cetera, et cetera, that becomes a very complicated because we don't use the same language. And when we use the same language, the words that we use don't always mean the same thing. You know, we can go into many, many examples, but I think that the primary skill beyond this is really a transferable skill of transferring knowledge to others. Mm hmm. Independent of independent of their age, their discipline, their background, their their, I would say, their their proficiency in what you mean, what you say. The next part of it is it's one thing to describe what you understand to others describing what you do not understand. And is yet harder and essential. I hope so. And in a world where we think that knowledge is there to help us thrive, survive and so therefore problems around us. We need the capacity to define what the problem is. Define what the question is. And defining a question right is probably, well, right. You know, we say sort of you're already 80 percent of the way to find a solution. But in order to be able to to define a question right on a real on on a real problem, right? And engineering is that's what they're dealing with, right? And the problem is never a disciplinary. So you need to have again the skill of communication, right? That goes beyond what you know in order to describe a problem that you can only capture. No part of it. Right, I mean, we can go to the to the blind and the elephant, et cetera, et cetera, as different metaphors. But in essence, there is a real. There is a real skill there that most of the people are missing. And and I think one one builds upon the other because for the first one, you were as an individual sort of in an interdisciplinary context and you need to know your home base extremely well. And so I think that something extremely important sort of before we think about meta skills in order to develop menta skills, you need to know your stuff really, really well. And this enables you to be able to communicate it to others. Right? And other ways will listen to you because they see that you're robust in something that they do not understand. But when it comes to addressing. Real challenges or real problems, right? You also have to be able to zoom out and know the limitations of your of your knowledge, of your of your discipline. Right? Putting words on things that you do not understand. Is very, very hard because what you are don't understand, does not come from your own feelings. And so how to do this? This is a real skill and it's an acquired skill, right? It's a skill because you need to find a way to define a problem right with your own vocabulary. Knowing that you're missing, you're missing something, but it should be enough that others can anchor and work with you. OK, so how do you how do you build this capacity of communication with others? So you define the problem, right? That's that's the second level and the third level. In this respect is no. To understand what is a solution. I can give you many, many examples if you want to be concrete, but. And in many instances and now you can, you can treat a certain problem, you can treat it a certain challenge, right? And depending what's your background, what's your disciplinary background? Right. You consider something that is a solution, but others will not consider it all that this is a solution. Mm hmm. And I'll give you an example if you have a certain phenomena. Whether biology doesn't matter what. Right? And a physicist looks at this phenomenon, right? And he manages to write a mathematical equation. I think that describes this phenomena. He solved the problem. Because he found a rule. Right? That can be applied again and again and again. Right. And this equation will work to describe a certain situation. But and if you are and and if if this has to do with and so this can be some power

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load that explains, I know how people learn something or how population expands or whatever. But if you're a psychologist or you're an anthropologist, and what you're interested in is not that there is a rule you don't care what you care is, what are the underlying mechanisms that make such rule happen? Mm hmm. So the physicist helps you better, maybe to define the problem. Mm hmm. Right. But that's not the solution that you're interested in. Indeed. Right. So if we know that no and people age exponentially right for insurance company, use it, solve the problem because they know based on this curve how to calculate life expectancy and therefore, you know, insurance policies. But you know, if you're someone that is interested in the health of people, right, and you want to understand how you can improve the lifespan of people so they can live no longer if this is your target, right? The fact that it's an exponential doesn't have to wait on individual, how to communicate and how to understand what is what is a solution. Accepting that, you know, solution for one person. No objectively solution for someone, or it's not subjective, right? Is objectively not a solution for someone who is depending on his discipline, but being able to understand. What's the significance of this of a solution in general? That's sort of a third level of, I would say, sort of metacognition or capacity again, infinity of communicating. Mm-Hmm. Indeed. Yeah. And so in all this know there's a lot of communication. And I think that, you know, in general, no major skills that are needed for interdisciplinarity have a lot to do in finding common ground for communication. Mm hmm.

00:12:05

*Speaker 1:* Great, so let me just. That's a lot of information, obviously.

00:12:10

*Speaker 2:* I'll just read the tape again, right?

00:12:13

*Speaker 1:* Yeah, I will. I will. I will read it again. I just wanted to assure that I understand correctly what you said. So basically, the ability to communicate is kind of a basic foundation on which a lot of other complex skills are interacting. But through communicating, for example, the first step is to be able to communicate one's disciplinary understanding of their, what we understand to the others, to non discipline people. The second is to communicate what they don't understand. Basically, I got a bit of understanding of the third part and the first part, the second part, especially this one. Can you give an example on what do you mean by how to communicate things that you don't understand in a discipline? How one can actually see that there is something that I don't understand. Basically, if I'm in a discipline and if I know everything, I obviously kind of probably looking at things, but I may not realize that I do understand or I don't understand. So I'm just wondering, how would that be? Yeah. Play out in an example or in real life in any way.

00:13:24

*Speaker 2:* I mean, I mean, I think that any any exemplars is good because research, right is about addressing something that is unknown. Right. So there are many, many, many, many things that we don't know. Right, I mean, you heard me tell you right when you scratch the surface after two or three questions of any expert, you reach a case instead where you know he doesn't know the answer. And that means that you were able to try to identify a question and communicate a question where the experts cannot answer this. But how to ask the question you can ask, sort of know metaphysical questions, right? That probably no one

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will ever be able to ask, right? But how to ask a question and something that you do not understand in a way that the question is solvable. Mm-Hmm. Is an art. Mm-Hmm. I think that's the sort of the single most important art for a researcher and an engineer. OK, so I'll give you I can give you many, many and can give you many, many examples. You pick up the field and I can come up with and pick up. Probably come up with an example, right? Yes. So if the question is, I know how, how to cure cancer. Mm hmm. Right. This is not something that you can address directly with an answer. Mm-Hmm. But you know, if you start asking, you know what in cancer progression are potential weak spots where we can tackle cancer? Then you already pave a role for how to solve the problem. Because, right, it's it makes the hypothesis that in the progression, the weak spots, it's an hypothesis. Maybe it's right. Maybe it's it's not. You can try to address it if you manage to find some right and then you can say, OK, I've proven my first hypothesis, right. Therefore, I can go to my second one, which is, you know, if I d block this point right, would it change the progression? Is that right? So there's there is a way to pass from the capacity of asking from different levels of hierarchy of questions, right from something that you're passionate about or that you want to solve into questions where you know there is an action or a theory that can be developed in order to address it. Mm hmm. And when you go there, then you see, well, you know, for this in my discipline, maybe I'm I do not know how to do this, but I know, I know to do partly. But maybe there are other tools, other methodologies, other ways of looking at this problem that that will enable me to do this. But you are able to describe your problem, which is something we have no clue how to cure cancer, to see in a way that maybe a physicist would hear would hear this and would say, Well, you know, in physics, in physics, we have no theories that have to do with no and no robustness of systems. Right. So you're actually telling me that in the progression, right in the in the progression of cancer, right, there are potentially parts of this progression that are less robust. Mm hmm. OK. I have the toolset, right? If you give me data right to try to see if I can find robustness or less robust patterns in your data, it right, et cetera, et cetera, et cetera. So maybe this is clear.

00:17:07

*Speaker 1:* Yeah, I got it, I just wanted to make sure that then as an educator or also researcher, would you say that the ability to ask questions and the kind of questions that would lead to understanding, answering and solving the problem is what at most important to you?

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*Speaker 2:* I would almost say yes.

00:17:35

*Speaker 1:* Thank you, because I just wanted to make sure this is what I understand from what you said.

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*Speaker 2:* I mean, I think that's that gives you that you made 80 percent of the way in order to solve the problem, maybe not 80, but 70. But I think that's the single most important is to learn how to ask a good question.

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*Speaker 1:* Indeed. So as an educator, would you say that this is something that you kind of expect from students to develop in your students during the class?

00:18:03

*Speaker 2:* It's the thing that they put the most effort on.

00:18:06

*Speaker 1:* Yes, indeed. Exactly. Thank you very much. And I know as a former student as a lot, I'm just asking for the sake of the interview to make it verbalize it. How exactly do you think or what kind of strategies methods are most helpful in achieving that in your classroom? Again, again, again, again. What kind of strategies and methods are most helpful in developing such skills in your students are in your trainees, research assistants?

00:18:40

*Speaker 2:* We use we use different methodologies and they get it right a target, mostly undergrad and graduate students. I don't know. But we do similar things also with younger kids and. The the first thing that we try to do is that, you know, that they try to do is never leave a student alone, which means that they always work together with someone else. And ideally not only with a mentor, but in a peer to peer situation. And if when you get it right, then the peer to peer interaction is between students that come from different cultures or just different disciplines. So because they have to work together, they are bound to pass the first language barrier that they discuss, right in order to be able to work together they have when understanding each other's language. The second thing is you give them a task. Where in order to be able to deal with this task, right, they need the skill sets of both of them. Mm hmm. So a classic example is you take, you know, an experimental, a savvy student and a theoretical savvy student, and you give them a work to read. That covers both both aspects. There was maybe a mathematical model and experimental setup and results. And if you do things even better, you don't give them, you ask them to find such a resource. So by engaging them to find a common that's a published paper meant that both of them are interested in. And that covers their main domains of expertise, which are orthogonal to each other. They are bound to discuss with each other, to share their passions, to share their questions, to share what they're interested in, and find this in find this paper. This unique paper that unites them. Which brings another important. I wouldn't call it skill, but a necessity, which is motivation. OK, so they're motivated because they found something that is uniquely common to both of their interests. Right. And they have a common challenge that they cannot deal each one by themselves because they cannot. Each one of them separately understand this piece of work. Mm hmm. Indeed. So you get to this the first one. The second one is to say this, to say, Well, you managed to explain it to yourselves. Now. Explain it to others it. OK. And if you really want to do this well, right, then you ask the experimental one to explain the theoretical physics of the work and vice versa. Mm hmm. OK. So you manage, it's sort of it's sort of a straightforward sort of no. And. Things in education that, you know, transferable skills, right? So if you if your managed to work with someone from another field and understand and understand him, that means that now you can explain it to someone else. And it's probably likely that if they're proud that you're going to explain it to our. Not from the original field, because you already did the translation into your field, you're likely to expand it even better than the original one and certainly the worst

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one when you do the exercise well. Mm hmm. And the last part of asking question is, having identified, read understood together a certain piece of work because science is never ending. You can always take this piece of work as a jumping board for what's the next question? Mm hmm. And so if these students work collectively in order to again define the unknown, which is what the question is about, right? Then they went, they went through this exercise and they and they and they gained this metacognitive skills and doing it on your own is a must. But the seeing other is how, but seeing also others, how they deal with it and how they do this on different fields that none of them are your fields. You learn from this as well. Mm hmm. That's where a collective comes, where you do this exercise on your self, but you see 10 other double No. 10 or 15 other couple of students, they're doing the same exercise. So that's one classic course that I've been. I'm still teaching for over 20, almost 20 years now.

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*Speaker 1:* And I must say I've been very fortunate to be part of that group as well.

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*Speaker 2:* And you're teaching this course as well?

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*Speaker 1:* Yes, indeed. And it's one of the most stimulating courses that I've ever taken that I'm ever teaching as well as, I think, ever again. So the other part is that, yes, I understand because I've also been through the process, how it actually develop such skills and stimulates questioning abilities. But how do you assess as a teacher the levels that you expect if a student has reached the expected level or not? And what is the expected level for you? So if you could shed some light on that, that would be great.

00:24:21

*Speaker 2:* So evaluation is very, very hard to and. The way I deal with it, which I'm not sure that's the that's the ultimate optimal solution. And. Is addressing three different parts. And which are which are subjective. And the first is when I see a work of a student, right, is to clarify first to myself and then to the student. What I understood from the work. I mean, in a sense, the way you do the interview. Thumbs up, thank you, is to make sure that you know that you understood what I'm saying, so I can assume that I understood something, but actually maybe what I understood is wrong. Mm-Hmm. So communicating back to the learner? This is what I understood from your achievement or this is what I learned from your experience, from your from your from your work. Right? Allow us to make sure that things are on the right level, right? And the student can come and say, Well, you got me wrong. And then we can try to understand why I got them wrong. So I think that it's not a one way street. There a when there is a communication on this and based on based on this, I can then say no, what did I appreciate? So no, did they appreciate the capacity of knowing that, for example, in this exercise, which many others think I did, I did. I appreciate the way that they that they work together. Did I appreciate that they're contributing their mutual contribution, right? Maybe one student over took the work from the other, maybe one was weaker and one was stronger. you can. You can. At least you can. You can easily evaluate easily. Some experience you can. You can evaluate this right. How clear was now? How clear was their explanation of the paper, right? It also has to do with the first thing great degree if I see that they did not understand. Right then, it's good that they explain to me again, but



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that means that with some problematic, right, with the way that they explained before and and then no. How well did they ask the question? Did they ask a question that is addressable? They ask a question that is too trivial, but needs not to be asked. One question that is too vague, right, that no one can actually answer the. And and then based on these two, the others are I understand, know what I appreciate. And the third one is what can be improved. OK. So in what can be improved right? It's an evaluation of saying OK with my expertise, I think this and this and this would have been better done better. Now the way you from communication skills in the classroom to addressing key fundamentals in the discipline that maybe were not understood well and could be understood better and therefore explain better. Etc., etc., etc.. Mm hmm. So why do I say so? This is subjective because, you know, as much as I want to be interdisciplinary, I mean, I have my my home base, which is sort of more life science and chemistry, right? When we do this well, right? And we tend to do this well, they're two always teachers. In a classroom that come from different disciplines. And so what we do is just like the students do the work. Right of exchanging between them and preparing things, we prepare this evaluation usually take a half a page, something like this, right? And few phrases, few paragraphs we prepared together. Yes, or maybe I did not understand something. But my colleague did. Right, and I can understand why I did not understand and vice versa, so we can actually explain what could be improved better and also the exercise of giving feedback or evaluation that if it's on an interdisciplinary project, it's done best when you have an interdisciplinary team of teachers that deliver this. And so you probably noticed there is a big. Interchange in what they say between what's the feedback and what's the evaluation? Mm hmm. And this is because I strongly believe in feedback. Yes. And I do not believe an evaluation so much. Mm hmm. Because evaluation per se means putting things on a scale. Mm hmm. And I don't think that these scales exists. Indeed.

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*Speaker 1:* I would totally agree. Evaluation is obviously is assessing the level, not necessarily targeting the improvement of the learner. And whereas in the learning context it does, it should always be feedback oriented where it is targeted towards improving from where the student is.

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*Speaker 2:* And and so evaluation can come not on a single exercise, but can come on or on a temporary scale where you can look at the learning trajectory and then you can assess how this learning trajectory is compared to not to other students. And so what is important is the slope in the sense of right and not the beginning, not the beginning of the end right there. And someone knows fantastically well everything and you're nothing in the course, right? And that means you didn't get much out of this course. And that's why, for me, an evaluation is more important as a teacher, right? Which means that I did not manage to take the students and improve his capacities. Mm-Hmm. That's not the problem of the student. Mean, that's a promise of mine as a teacher. A pause for a second because I'm out of battery and I have to find the cable and thought they have here in the room, but. Great.

00:30:59

*Speaker 1:* Go. Yeah. So we were at a temporary scale and slope,

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00:31:04

*Speaker 2:* yeah, and about evaluation. And so they think the valuation is more interesting for the teacher as self-prospection and improving and giving and giving feedback back to the student with respect to this and. But this is I mean, this is a treatment, this is a this is a classic, right? I mean, you see kids going to school, right? They improve throughout the semester, but every exercise they do, they get it. They get evaluated and they get a grade. Everything is in a computer that then makes the average and gives you a score. Mm-Hmm. Right. Whereas, you know, when you learn mathematics and if you finish your final exam with a with a score which is twice bigger than the score you had in the beginning of the year in that, you know, mathematics now. Right? This should be the grade. This should be your grade, right? Yeah, that's not the case, right? They make an arithmetic average is unbelievable. Yeah. The rating?

00:32:07

*Speaker 1:* Yeah, of course. So from what you said, what I can understand is also that it kind of relates with your expectations, our understanding of higher order thinking skills, as you would explain in the assessment process. First, you try to understand are kind of, yeah, assess the communication part of they're able to articulate themselves well and then goes to obviously the questioning part which is communicating the unknown are what they don't understand and then going on to hypothesizing some solutions, which is also something that you. Yeah. In the in the in the explanation of your meta abilities, you explain the ability to communicate your disciplinary understanding and going to a communicating what you don't understand and then moving on to solutions part. So yeah, I think it looks coherent and well, obviously thought out by the teachers, thanks to you might. The next question is more about challenges. Obviously, in a class full of students, even all the bright students, if you put together, there are a few students who would actually find it difficult to go through this process or develop that abilities. What kind of challenges have you faced that? Ah, have you acknowledged that students faced in this type of settings?

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*Speaker 2:* So I find that. So I think that with this approach, there is much less difference between students And there are different there different reasons for this because when you teach such a class and you teach this in interdisciplinary settings, right, and students cannot easily compare themselves to each other, which means that I mean, as far as I see education, most of the problems of weak students score let's call it this way, come to the fact that throughout their lives, they were compared to others. Mm-Hmm. And the the nice example I know is that in French, which I find again, this reference, but in French students that were born in December, they perform less well in higher education, get less salary afterwards when they when they're in the market. And almost all in France, this phenomena exist. And so for me, the explanation is simple is because they were always the youngest in class name. And for every skill there were evaluated since there were three years, four years old, five years old, right? They were used to be in the bottom tier of their class. Mm hmm. But this was simply because, you know, the cognitive capacities of a four year old kid compared to a four month, four years and nine months, and there is a huge difference in this age. But they were already put in this lower tier. And so, no, they do less effort, I mean, everything comes out from there. So as long as you keep them in a disciplinary context, they



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will always feel that they're weaker and they're probably weaker because with time right there, they did have an enlarged gap of knowledge because they were less trained. Mm hmm. If you look at baseball players in the states, there's a good statistics for there. I think it's exactly the I mean, I think it's probably the same that, you know, there are more players that were born in January, February, than in November or December because there were since there were young kids, there were the strongest in the class who were always selected to the team history. So they got much more practice than anyone else, right? And they made it to the National League. Yes, education, I think, works the same way. So when you break this apart, I think that many of the problems that we traditionally have in teaching, we don't have because, no, it has to do with, you know, meta skills, et cetera, et cetera, that are, I think, less pronounced differences between deeper and certainly things that you can work on. But you do have big traits, right, you always have people in your class that know either are smart or think that they're smarter, but certainly know, speak louder and better and may be more eloquent in language, skills wise and than others. And if you're if you're aware of it, then you know how to make the couples not randomly. But you know you engineer the class in the sense of the the social the social network behind the class works with which with whom the right way isn't a. In another exercise that you know very well, right this year, where we asked students to work together, teams have been doing for days and come up with a research project, right? And there were times where rather than letting the students clustered by themselves or even do this randomly and sort of say OK, one two three four five one two three four five three exercise for a day or two. We see the personalities and we see the people right, and we regroup the students right. I remember it very clearly. A beautiful group like this time where we've put five very shy kids that spent two days in groups where they had absolutely no way of opening their mouth. And because there was always someone with a better idea that had to jump and say this and we've put them and put them in the same group. And I came to see how they're doing now. Three hours later. And there were there five for the kids students, right? And there were there no drawing something from their notebooks and. And so I sit on the side and I wait. And then suddenly one of them said. It's bizarre, no one is talking and they were hm hmm hm like this, and they said, well, then maybe I can, I can actually talk. And then they realized that they can actually talk to each other. And by far, they made the most brilliant project of the year. So then I think the lesson is that we have to remember that our students come with with with a history, right? And these meta skills a lot have to do with some of the social interaction, the kind of know where they listened to in the past or not, right? And if they have an occasion to explain something to someone else or maybe they've never done this before, maybe maybe they're fantastic students, but they were taught not to know, to listen to a teacher and right before the teacher was saying. Right. Where others had more occasions because no, maybe family in directions, not because of education had these possibilities right. And so when you're aware of it right, then you see how these exercises are. Exercises are important for people, and that's why I'm saying that what is important is the delta, right? How much they improve from this rather than if they perform well in it.

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*Speaker 1:* I totally agree with that, and thank you so much for shedding so much light on the compound factors that influences the learning and also the assessment that's really mind

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opening and then opens doors. Also one of my research directions. Thank you very much. Just a final question. I think we are almost at the end of the interview. And why do you think these skills are important and why do you invest so much time and energy in bringing that in students? Again, again, again, why do you think why do you perceive these skills are the most important skills? What is the reasoning behind your your your belief or conviction regarding these skills?

00:40:37

*Speaker 2:* I think that that sort of I think that, you know, you started your work by saying that these are important and how do you gain that right? And so you sort of go, go, go, go back there and. So I think that's not the. Looking for new knowledge is is a is a is a societal endeavor and very rarely can be done by individuals. And so that's why know collective intelligence is important and key to develop as early as possible and at all levels. So that's that's that's reason number one. Second reason is the classic reason that we all ran away. But I think it's true, right? Is real world is not disciplinary, right? And so in order to do things in an interdisciplinary way, you cannot just be shallow and understand a little bit and everything, right? You need to have a way that you can identify collectively the problem, but have a real skill set. Sort of not major skills, but skill set in order to deploy in order to be able to deploy to deploy this in an interdisciplinary settings. You need these metal skills. Hmm.

00:41:52

*Speaker 1:* Indeed. Thank you. I know that, but I just wanted to know and understand better why these reasons came into. Yeah, as a belief. Yeah, that's it. Then I will come to the end of the interview. Thank you very much, Ariel. It's been a wonderful session. I'm just stopping the recording.