**Justin Weinberg 0:00**
Hello, everyone. Good afternoon or good morning, wherever you may be joining us from. Welcome to the first of a two part webinar series on assessments in chemical education. This is the first session with Dr. Marilyne Stains. Really excited to have her today.

My name is Justin Weinberg. I am one of the founders and CEO of Aktiv Learning. Some of you may know of us as our former name Chem 101, but we build a platform that provides instructors with the ability to support in class and out of class learning as well as assessments in both first year and organic chemistry courses. As I mentioned, we recently did change our name from Chem101 to Aktiv chemistry while changing our company name from 101edu to Aktiv Learning. And we did this in order to more strongly convey our mission which is really to support faculty such as yourselves in engaging students through active learning experiences.

Firstly, I'm a chemical engineer and a former educator and I know that I personally learned better and talk more effectively when students were problem solving and discussing concepts both during and outside of class sessions. So it's been important to me to make it easier for faculty to offer these kinds of experiences to their students, and one way I help to do that is with events like this one, with chemical education researcher and educator, Dr. Marilyne Stains.

Another one is of course to our platform aktiv chemistry itself. If you are familiar with our platform, I would like to invite you to join me this upcoming Friday for our virtual unveiling of our latest updates. We always try to improve our platform all the time every year. We have a specific session upcoming this Friday on math remediation, and a new adaptive learning feature is coming up if anyone's interested in that. Feel free to click on the link that my colleague Dvora just posted in the chat. So if anyone's interested, look forward to seeing you there.

But today we are here to talk about formative assessments and formative assessment specifically as it occurs within the class. This is something near and dear to my heart since our platform was started based on this case. One of the things that really excited me when we got started was the ability to use technology to bring chemistry specific activities as a way to deliver formative assessments during class.

So over the years, we've enabled faculty to push out activities for their students during class or recitations or any sort of group live meetings in person or online and enable them to actually go in and draw structures, or build dimensional analysis. This is an example where students take advantage of our instruction module. It enables both instructors and students to receive feedback on how the class is doing as a whole, the common misconceptions, as well as giving students feedback on this exercise. I personally had the fortune of visiting classrooms across the country where this has occurred, and really see the impacts that this can have on students.

This is going into the heart of what Dr Stains is going to be talking about today. So I would love to introduce her now so she can give us a really exciting presentation. Really grateful to have Marilyne with us today, who is an expert in formative assessment, peer instruction and chemical education. She's going to be sharing her research and explain how we can engage students in formative assessment experiences that include problem solving and discussion.

Marilyne Stains is an associate professor in the department of chemistry at the University of Virginia. As a chemical education researcher she focuses on characterizing the extent, nature and factors involved in the gap between chemical education research and the instructional practices in science college classrooms. Her work has been published in the Journal of Science by scientist education and the Journal of Chemical Education. And she has received funding from the National Science Foundation including a career award in 2016. In 2019, she was awarded the Presidential Early Career Award for Scientists and Engineers and the American Chemical Society Women Chemists' Committee Rising Star Award. Dr. Stains earned her Bachelor's in Chemistry from the University of Sciences in Lumini, France, Master's in chemistry from the Paul Sabatier University in France and a PhD in chemistry from the University of Arizona. She also conducted her postdoctoral studies at the University of Massachusetts in Boston. So with that, I'm going to hand over the screenshare to Dr. Stains. Marilyne, please take it away. We're looking forward to your presentation.

**Marilyne Stains 4:47**
Thank you so much for having me. I am very excited to talk about a particular instructional strategy that fits really well with the Aktiv Learning platform as Justin has described. And so I'm going to focus specifically on unpacking one particular pedagogical tool that works really well with platforms like Aktiv and others. And so the strategy that we'll be talking about today is both an active learning strategy and a method of assessments.

And so before we go into the particular strategy, first I will describe to you what I hope you will get as a result of this session, and then I'm going to have you think for a minute about assessing and the purpose of assessments. Just to take a step back, by the end of this session I hope you'll be able to describe and implement this, hopefully new formative assessment strategies for you. That you'll be able to describe its benefits for you and for your students. And that you will know where to find resources to help you implement that pedagogical approach.

So it's very focused on the practice side of the strategy and I'll talk a little bit about the research behind it and supporting it, but I just want to help you see how the strategy can be effectively implemented. Before we start to dive into the technicality of that strategy, I want us to think about assessments and why do we assess? We all do it throughout our courses, because we have to, because of institutional requirements, and because we need to in order to help our students learn. So I want to take 30 seconds to think just for yourself about why you assess in your course. What's your purpose when you're assessing?

**Marilyne Stains 7:24**
I'm going to share answers that we gathered from a group of about 19 general chemistry faculty. We interviewed them last summer and asked them exactly that question. Why do you assess? What is the purpose of assessing in your course? They identified five different purposes and I will show them to you based on their popularity or the distribution across our sample.

So the most common reason our faculty indicated assessing was for evaluating whether the students had learned. The second purpose was to probe whether students were prepared to move on to the next course. So at the end of Gen Chem, after the first semester, are they going to be successful in the second semester, or whatever follow up course it is. A certain rationale that was provided was they are assessing so that they can provide feedback to students about their learning. So students have a sense of where they're standing. Assessments are also used to provide students with the opportunity to evaluate their own learning. And then last but not least, although that was not a very popular reason that came up, assessment is also used by faculty to help them reflect on their instructional practice.

The strategy I will talk about today will really help you leverage these goals and a lot more. And so out of these five different goals for assessing we can kind of group them in the following way. We can have one group to the left that focuses on measuring the extent to which students achieve learning outcomes. And then we're going to call this group the “assessment of learning.” Then on the right side is assessing the extent to which students are learning and collecting feedback and addressing the gaps that we might be seeing through our instruction, so we're going to call this “assessment for learning.”

And so let's unpack this a little bit more. So the assessment of learning, it's the common strategy that we all conduct in our courses. Those are what we call summative assessments. So they are like midterm exams and final exams. And they are intended to demonstrate to the instructor, the students, and also potentially to the institution that your students have achieved a particular set of learning outcomes that you have defined at the beginning of the semester.

The assessment for learning is happening as your learning is taking place. We call those formative assessments. And the goal of this assessment is to provide feedback to you and the students about the learning that is taking place and the extent to which your instructional practices are effective at promoting that learning. And so you can leverage that feedback to modify your instructional practice.

And then there's a third one, “assessment as learning” which I believe is the next session, at the end of the month when we'll talk a little bit more about that. This is about helping students assess their learning processes, and really reflect on the extent to which they are achieving the learning outcome and what they could do to help themselves further. So this is what we address at the next webinar.

The way to think about summative and formative if you're unfamiliar with this terminology, you may have heard of high stakes and low stakes assessments and this is how they break up. Summative assessment or high stakes, which means that students are very much penalized for getting wrong answers. Versus a low stakes, formative assessment. That's when students can make mistakes and learn from them and not be penalized for it with their grades. Formative assessments typically have participation points associated with them. A little bit, maybe a point devoted to correctness, but it's really these assessments that are really intended to be part of the learning process and assessment of it.

**Marilyne Stains 11:36**
So the assessment for learning in our experience, in our research, we see that it's not often used. What we saw in our study is that assessment of learning: so midterm exam, homework, are the most common assessment tool employed. But assessment for learning, there's a significant lower amount of faculty who are using them.

But assessment for learning actually aligns really well with what we do as chemists in the laboratory. So if you're thinking about a particular compound you want to synthesize, you're not going to assess just at the end of the process, to see whether or not you actually made the compound you intended to make. You're going to collect data all the way throughout to monitor that you make your progress towards making that particular compound. And that's what assessment for learning is doing is monitoring your students as they are learning to make sure that everybody is on the right track to achieve the learning outcome that we have that we wish for them to have.

And so, there's extensive evidence in the literature demonstrating the positive impact of formative assessment in general and assessment for learning in particular. So this Black and William study is a hallmark study. They did an extensive literature review of 200 or so studies that employ different types of assessments. They found a pretty large effect size 0.4 to 0.7 which is pretty good for social studies. So a pretty large effect size for student learning whence assessments are implemented in a particular way. And so they identified five key factors in implementing an assessment.

The first one is that formative assessments are effective when students are provided feedback. And the feedback should not just be corrective, like yes, you get this right or get this wrong. It should be feedback that provides them with guidance as to what specifically they did wrong and provide guidance on how to resolve that problem. Those assessments are effective when students are actively involved in the learning process. And so, we will see that the strategy that we'll be talking about in a minute really leverages these particular factors. Formative assessments are only as good as the feedback that is being used by the instructor. And so if you're collecting some formative assessment, but you're not reacting and responding to the the result of that assessment then it is not going to be effective, and so it's essential to adjust the teaching based on the results of the assessment that you provided. And then it's important to recognize that whenever we assess there's the affective part of the students that comes into play. Depending on how the assessment is set up, you may be measuring more of the affective state than their understanding of the topic. Recognizing the influence of assessment on their psyche is extremely important. Then if the assessment helps students realize where they stand with their own understanding, it's going to help them improve and achieve their discerning outcome.

So what is an example of assessment for learning? The strategy we're going to talk about today is peer instruction. It's a very easy active learning strategy getaway. I have done 10 years of workshops with faculty on these particular strategies. And this was the most popular strategy that our STEM faculty wanted to learn about at my previous institution. If you have never done active learning in your classroom, this is really a non destructive way for you to start doing active learning. So I will unpack what it is and its benefits and how to implement it to the rest of this conversation.

**Marilyne Stains 15:49**
So peer instruction, it's a pedagogy and what you do is you teach for 10-15 minutes about a particular concept and then you start the peer instruction activity by asking a student a question. It doesn't have to be a multiple choice question. However, traditionally, that's what it had to be. But it can be a question provided with many different types of answers.

So, you ask these conceptually challenging questions and you have the students respond to it individually. And then you monitor the responses and you look at the distribution in your classroom. Hopefully, if the question is well worded, and it's challenging enough, you're going to see a lot of confusion among your students. Then you're going to have them turn to their neighbor and provide reasoning behind their answers and have them try to convince their neighbors that they have the right answer. And then you have them share their response again following that conversation. And then you talk about their results. So you should show them the distribution of answers and have a conversation about the concept and then if needed you adjust your lessons. So even after this process, the students are still confused about the concept, then you know about it, and you realize that you need to do something else to help them move further along and overcome that obstacle.

I'll give you an example of the strategy implemented in my class and what the response of the students look like and the impact of this process on student learning. When I teach general chemistry, as many of you may be doing, we all teach about the photoelectric effect. You know, we talked about radiation and their relationship to the work function of the metal and the kinetic energy of the electron escaping.

We talked about it a lot, conceptually in my class quite a bit before we get into the equations. And so this is our conceptual approach and I follow this with this question. So which of the following metal has the highest work function? And so I go through the peer instruction activity, so I have them respond first by themselves. And this is very typically what I get for these particular questions. Which indicates to me that it's a good question, because the class is confused. You know, they picked the highest and lowest. And then, after they have their peer conversations, and they are voting again, then you see this shift, and it's important to know that I have not said anything, at this point. The growth in understanding is solely due to them talking to each other. And I emphasize that to them a lot. I tell them that my beautiful lecture that I provided to them was not nearly as useful as them talking to each other. That brings up their confidence. And that makes them more comfortable in the future to talk to each other recognizing the benefit of that conversation.

This is typically how the lesson involving peer instruction activity goes. In this particular scenario, because I'm still only 71% of the class understanding the concept, I will go back to my simulations, and you know, this conceptual thinking of work functions and ask another question afterwards to make sure that we are over the bump here and that the students have understood that concept.

So if we look at this strategy and map it to the benefits that are related to the critical features of the effective formative assessment that literature has found, we see that we need all of them. And clearly through this process students get real time feedback in the classroom as they are learning about the concept, whether or not they are understanding it.

Students, through their conversation with their peers, their individual's thinking of the question are actively involved in their learning. The pedagogy itself includes the need to adjust for your teaching. You do it twice, you do it as you're collecting responses here and at the end of the process by deciding whether or not they need to move on.

Through this process, you can really help students feel comfortable talking with each other. Some students that may have otherwise been shy, that didn’t volunteer for a question in front of the class, are more comfortable sharing their answers with their peers and they may realize that they actually understand the concept better than someone else in their group that they felt maybe was better at this chemistry in general. And so that will enhance their self esteem. And usually as you show the drastic difference between solo response and peer response, it really boosts their motivation to engage in talking with each other, because they see that they can learn a lot from each other.

**Marilyne Stains 20:47**
Obviously, this provides them an opportunity to assess themselves and through the process, they're identifying ways that they can improve their own learning of that particular concept. So, beyond the alignment of peer instruction with the literature on effective formative assessment strategy, what is the evidence supporting this particular pedagogical approach? And so there is an extensive amount of literature that has tested this particular pedagogy, and we summarize it in this paper here.

Tricia Vickrey was a postdoc in my lab and summarized that literature up to 2014. And so there's key findings that came out from this literature review. So first, it's clear that peer instruction is going to promote conceptual understanding. It was designed for it and there is extensive evidence to demonstrate that it does so. And this has been done in chemistry, but all kinds of STEM disciplines as well.

Peer instruction can help with problem solving both qualitative and quantitative and that's why I think that fits well with the Aktiv Learning platform which promotes problem solving skills. So combining the platform with this particular pedagogical practice can be very beneficial.

There is an extensive study that shows that it increases your student's retention, so they will be more likely to move on to the next course and it lowers failure rates. And students usually don't dislike it, and sometimes they even like it. It's all about how you sell them about the pedagogy, but usually they recognize the benefit over time of this strategy, even though they may be a bit reticent at the beginning.

So there is extensive empirical evidence for the effectiveness of this strategy. This strategy also aligns with how our brain works. So this is the information process model. This is one model that describes how we are learning how our brain is functioning. It's thinking of our brain as a computer. And so the limitation of our brain and computers are short term memory. We can only hold so much information in our short term memory, and it won't last very long. And so as students are presented with 10, 15, 20 minute lectures, there's a lot of information that they have to process and they can only deal with a small chunk at a time.

Peer instruction allows us to help them encode that information more effectively now through memory because we are chunking all the concepts smaller. We are presenting all the concepts one at a time assessing them at that time. Rather than presenting you know five different concepts in a row. So it's helping in that way.

We also know that students have limited attention spans because of this working memory and its limited capacity. And so there's a study that was done by Diane Goths in General Chemistry that showcases that, in general, over 12 minute lecture segments, students pay attention intermittently for about seven and a half minutes. So students are very distracted. That's just human, that's how we are. And so lecturing for 15-20 minutes at a time your students are not going to be able to grasp all that information.

A peer instruction strategy can kind of disrupt the lecture enough that students are provided time to process and refocus on the information. And finally, we know that students are not very good at evaluating themselves. You may have seen it during your office hours. And so there is this study done by Pazicni Lab that replicates a lot of studies that have been done in another discipline in which he asked general chemistry students to estimate their grades after an exam. And then you plotted that perceived performance against the actual performance.

So the perceived performance is in red here and the actual performance is in black. And as you can see, the lower students have a tendency to overestimate their understanding, while the strongest students have a tendency to underestimate their understanding. In general, and that’s not just students, we as humans are not very good at evaluating ourselves. And so with peer instruction, it provides them an opportunity to realize where they’re understanding lies. And so hopefully it helps align this red line more parallel to the black line.

**Marilyne Stains 25:40**
There's also two other principles about how people learn with respect to literature. One is that we learn better by talking to each other. Learning is actually an active process that occurs best when we do it with other humans. So it's a very social endeavor.

And we know that providing explanations and articulating explanations is really a powerful way to learn. And so true to the peer instruction process students are engaged in both of those. They are talking to our students and they have to explain their thinking to others, which is good to have to learn.

So how do we effectively implement peer instruction? And so one thing I want to make clear is that peer instruction sometimes is confused with a clicker question, and it is absolutely not a clicker question. They have very different characteristics that make it not a clicker question. First peer instruction is a pedagogy is not a technology and so clickers just technology, and it can be implemented badly.

Peer instruction is a pedagogy. And so I want to showcase a clicker question, versus a peer instruction implementation, so you can see the difference. And I'm not saying that questions where we are polling students, like a clicker question, are not useful. I'm just saying that it's not peer instruction. It does not representing that particular pedagogy. So I'm going to show you first a typical clicker question scenario. And then I will show you a peer instruction scenario and this is actually Eric Mazur, who's the developer of that strategy that you will see here.

**[YouTube Video #1]**
**Youtube Instructor 27:31**
All right, as you're settling in, why don't you take 10 more seconds to answer the clicker question. This is the last question we'll see in class on the photoelectric effect. So hopefully we can have a very high success rate here to show we are all ready to move on with our lives here.

Okay, good. So most of you did get the answer correct. For those of you that didn't, you, of course, can ask your TAs about this in recitation. They'll always have a copy of these slides. But just to point out the confusion, we've actually switched what the question is here, what the information we gave was the work function which is what we've been giving before, but now we gave you the kinetic energy of the ejected electron. So you just need to rearrange your equation. So now you're solving for the incoming energy, which would mean that you need to add those two energies together. So hopefully, everyone that didn't get this right can look at it again and think about it's just asking the question in a different kind of a way

**Marilyne Stains 28:33**
That was asking a clicker question: you probe your student about, in this case, some algorithmic problems, and then you show them the distribution and then you move on. And so let's look at how peer instruction is implemented.

**[YouTube Video #2]**
**Youtube Instructor 28:55**
A parallel beam of light is sent through an aquarium. If a convex glass lens, as shown in the diagram, is held in the water, where does it focus the beam? 10 seconds left. Okay, we're close to 70%. Let's see if we can get to 100%. So go ahead, talk to your neighbor.

(Chatter among students)

**Student 29:39**
It's like you've got these parallel beans coming in, going air, glass, air, and so each of those changes is going to have a much higher magnitude, which means the ratio of the angles is going to be much higher. So you're gonna have more dramatic angle shifts, going air less air, you're gonna have going water, glass, water.

(More student chatter)

**YouTube Instructor 30:35**
We went from 69% correct, to 100% correct. Wow! This is amazing! I'm impressed. For those of you who got it right, you very effectively taught those who got it wrong and in the process, everybody really learns.

**Marilyne Stains 31:08**
Okay, and then he goes on. I hope you saw the difference. Students were provided an opportunity to think for themselves and come up with an answer for themselves. And then the question was challenging enough that only about two thirds of the class got it correct. And so they went on having a conversation and it's a very conceptual question, so they're having to draw diagrams and really talk to each other to work this out. And then at the end, all the students were able to answer correctly.

So why is peer instruction not a clicker question? You may have noticed, and I ended with the example previously, it has to do with the type of question that's being asked. The main ingredient of the instruction that makes it effective is the level of challenge of the question which results in conversation and between the students. So you want to promote that conversation. The best way to promote that conversation is to ask difficult and challenging questions.

This is a study that was done by Michelle Smith and co authors, who looked at the impact of peer discussion on students' performance. And so what they did was, they asked one question that asked about a particular concept and they had the students vote individually, and then they had them talk to their neighbors. And so we see, as we've seen in my previous slide, when you go from solo vote to peer vote, you can see an increase in understanding regardless of the type of questions.

What was most significant about this paper is that they asked a second question, which covered the same concept in the first question, but the question was worded differently. And the students have to vote on the second question by themselves. And what you see is a huge shift when the question is difficult, in terms of the percent of students who get it correct. When it's easy or medium, you don't see that big shift.

What this is telling us is that there's more learning taking place when you're having students talk about challenging questions. And so in chemistry, we can think of the different types of questions that we have, typically in our test banks that are provided to you by publishers. We have your typical recall questions where you just have to memorize something, algorithmic questions where we have a traditional plug and chug and then you have conceptual questions.

So, a recall question is not a question that should be used with peer instruction. There's no need to have a conversation, there's a right and wrong answer. It's either one law or the other. And there's not much conversation that can happen or learning that can take place. An algorithmic problem can be helpful and can be used depending on the complexity of the problems. Students can benefit from talking to each other. And peer instruction, again, was designed for conceptual questions. So that's really what we're targeting here.

**Marilyne Stains 34:16**
But those questions are harder to develop and harder to find. One thing I want to remind ourselves is that students' ability to answer algorithmic questions doesn't necessarily mean that they understand the concept behind it. And there was a study that demonstrated this and so this was a study done back in 2006 with General Chemistry students, and they asked the students to answer two different types of stoichiometry problems, one with limiting reagents where there's some algorithmic thinking going on, and one where they asked the students to draw a balanced chemical reaction based on these representations.

What they saw was that the students could do really well on the algorithmic also called, like, traditional questions, but performed really poorly under conceptual questions. And this was true even for the students that were quote on quote, the “good students” in the class. And so just want to remind ourselves that algorithmic thinking doesn't necessarily mean conceptual understanding and so that we need to assess both. And while it's easier to find algorithmic questions, we need to challenge ourselves in developing conceptual questions so that our students can benefit from them.

There's many different ways that we can ask conceptual questions. You can use venn diagrams, where you have students compare and contrast two different concepts or entities. I like to use data and so I typically use this graph. This is a boiling point versus different compounds and I white out this area right here. And I'm asking them to predict where, based on the trends that they've seen and their understanding of intermolecular forces, where they think the boiling point for water and ammonia will fall? You can do that with a lot of different types of data sets. You can give them a table and have them identify a trend or predict a trend from the table.

You can use simulations as well and PhET is a good resource because they already provide you conceptual questions that are associated specifically with each of the simulations so it's a good resource to use to develop conceptual understanding and in chemistry, you know, we can use figures we can show structure and have the students point to a particular area of the molecule. So there's many many different ways to ask conceptual questions beyond the typical ABCD multiple choice options.

So the question is important, the nature of the question is important in order to see the kind of learning outcome that has been reported in the literature, but also how you implement how you go about implementing peer instruction is important. And so this is the literature review that we conducted on peer instruction, we use it to develop a little cheat sheet on how to best implement that practice. And so I want to highlight some decision points that you may have as you implement this.

First you present your content for 5-10 minutes or so. Then you ask a conceptual question. And I often get questions from faculty about how long should I wait? How long should I give the students? If you're using an electronic tool to collect students' answers, you'll be able to see the proportion of students who have answered and I think once you have 80% of the class who have answered that first question, it's enough to move on and close the poll.

So just 80% of the class responding is good enough. It gives you a good sense of where the class is at. And then oftentimes, faculty kind of skip this individual's thinking and go straight to group conversations. And there's extensive evidence in the literature that students need that time for themselves to think. They need to process the question. Every student processes the question at a different pace. And you do not want them to be influenced by others in the group. And so it's very important to give them that minute or two, depending on the difficulty and the challenge of the question, for them to think and commit to an answer. They'll be better prepared to argue for it afterwards.

Once they have provided their individual answers, should you share the distribution of answers with your students? And the answer from the literature is no because of the herd instinct. So they're going to have a tendency to look at which answer is most popular. And then the discussion will be less effective and students will just have a tendency to pick the popular answer whether or not it is the correct one. And so you don't want to show the distribution of answers until after they have had their group conversation and vote.

**Marilyne Stains 39:18**
So once they have their group conversation, they vote again and then most of the students are correct. So at that point, there's a question of grading and how do we grade correctness versus participation? And again, this is a formative assessment. And so you want to give some credit for the correct answer. But you want to give credit for participation and you don't want to penalize them too much for being incorrect because this tool is used to help them learn. And if they feel penalized it is going to become a high-stakes tool and they're not going to engage in the same way. I typically give them 0.5 for the right answer and 0.5 for participating. That’s how I do it.

Last but not least, if the majority is incorrect, you may want to provide them with an explanation. Whether it happened after the second vote, or even before the second one you can give them a hint. But after the second vote, then you want to provide a detailed explanation. The question is oftentimes should I provide explanation or should I have my students provide the explanation? We say the first step is to have your students provide the explanation because that may resonate better with the other members of the class than your own explanations. So try to engage as much as possible with students in providing the right answer and explaining why the wrong options are wrong. And then you wrap it up with your own explanations.

In terms of voting methods, this has changed over the years. So this started with just ABCD cards or fingers. And now we have a lot more interesting technologies that allow us to ask questions with various formats and some of this technology are specifically dedicated to chemistry while others are more generic. But the type of question that you can ask and the type of answers is much better these days than it was 10 years ago, and so you have a lot of choices.

In order for peer instruction to be effective, we have to keep in mind a couple of pitfalls that have been reported in the literature that I have seen with faculty going through our professional development program, and the first one is to remember to align your learning objectives to your assessment and to your classroom activities. And so if your assessment is focused on conceptual understanding that should be aligned with your learning goals, you should have some learning goals that are conceptually oriented and your class should be focused on conceptual learning.

If you're focusing on algorithmic thinking, same thing, there should be an alignment between all of these. And so sometimes what happens is the formative assessment is saying, you know, high level conceptual thinking, but the classroom and a formative assessment were focused on low level thinking. So just remember to align all three in order to promote the most effective learning for your students.

Another pitfall of the strategy is that your students may not like it. The literature said typically they're neutral to it or eventually they actually enjoy it. And so there's ways to anticipate and address students' resistance. And one of those ways, which is true for any active learning strategy you're going to include in your course is to explain it to your students in the syllabus, on the first day of class, after the first exam, every time you use it and something positive happened, really reinforce to them the benefit of that strategy that is different from what I've experienced before, but showcase to them the learning that's taking place because of it, and that will really help with that students' resistance.

And so for me, every time I have this kind of situation with a question I ask, I remind them how much they've learned by talking to each other and that further encourages them to do this both in class and outside of class. And that really helps. You can see their enthusiasm and after they see these kinds of situations, it makes them very happy about their work.

**Marilyne Stains 44:02**
Another issue that is a little tricky to address is that I give you this chart about how to implement peer instructions. And this is omitted and omitted will need to be adapted depending on your context. And so there's a study that was done in physics that asked peer instruction users about

the extent to which they made a modification to peer instruction when they implemented it in their context.

The results clearly show that all the instructors are making some adaptations to it. It's hard to implement as is. And so, adaptations are okay as long as you understand and think through the adaptations that you are making. And as long as the adaptations are not diminishing the impact that you're hoping to see. And so the analogy here that I often use to explain this is: so I'm French so I do like my little croissant and so it's harder here to find croissants so I may want to do it myself and follow a recipe and for whatever reason I don't have enough butter or I don't have enough time, so I may use less butter, I may not follow the time as it was required and I may end up with this kind of croissant which nobody will ever eat in France.

And so what this is showcasing is that I miss some steps that I didn't know are critical to achieving the outcome, the beautiful croissant that I wanted. And so this happens all the time when you do active learning and this is why we designed our chart to kind of guide instructors as to the type of modification that they can make that won't be the type of adaptation that could be detrimental to the impact of the practice.

So you can make adaptations, just be careful and monitor the extent to which these adaptations are actually not beneficial to your students. And finally, one of the most important aspects of this strategy and the most rewarding aspect of this strategy is to actually walk around and listen to your students as they are talking to each other during their peer conversation. It helps you really develop an understanding of students thinking that you will not have by just being in front of the classroom.

One day I was doing that when I was assessing student understanding of orbitals. And I was working in the back of the classroom as they were answering one of the questions and they had the students drawing an electron going around the contour of a p orbital and I would have never thought that this is something they could have come up with. And so that helps me and I was able to address it afterward with the class.

And so monitoring students, it really helps you as an instructor and enhances your expertise. It also obviously helps you develop some relationship with your students that especially in large classes, it's difficult to do otherwise. And it makes it a lot more fun for you as an instructor. It's really exciting to hear your students talk about chemistry with each other as they are struggling in making sense of those questions.

There are quite a bit of resources for you that are out there to help you implement peer instruction. One is in CBE Life Sciences Education. They have a whole guide on how to drum up your instruction. It's an interactive web page where you click on each of the boxes and they explain that particular aspect of the implementation and provide you a peer reviewed article to support that particular aspect of the implementation that's very useful.

There's also lots of resources for finding questions. So one of the most challenging aspects of implementing peer instruction is designing good questions. And so I provide you with different tools and people. A researcher you may have heard of, Vicente Talanquer, in a previous webinar that was provided with Aktiv, they have developed a lot of very good conceptual questions that you can just leverage and use in your classroom. With that, I want to thank Trisha, who helps me run a lot of the peer instruction professional development programs that we implemented at the University of Nebraska Lincoln and Dina for helping organize these webinars.

**Justin Weinberg 48:33**
Very informative presentation. I'm sure everyone here got a lot out of it. I know a lot of it resonated with me. And a lot of what you describe has been built directly in our platform things like think pair share mode to enable things like peer instruction and specific feedback. So, I think lots of folks can benefit from hearing about these practices and how effective they have been proven to be in literature.

I would love to open it up for questions. So if anyone wants to start posting things in the chat, we'll give you an opportunity to raise your hand. So we'll give you a minute or two to think about what you might want to ask Marilyne. I know I actually have one question for Marilyne. Some of you I know do professional development so we are providing certificates of attendance. So if you do need that from us, please email us directly requesting a certificate of attendance. Email is learning@aktiv.com. My colleague Dvora will put that into the chat in case it's easier for you to copy and paste. So just email us you, nothing special, just requesting the certificate, and we'll send that over to you.

Also, just to do one on one last call for anyone who is interested in attending our webinar to hear a little bit more about some of the practices that we embody in our platform. That's going to be happening this Friday, and Dvora will also post that link in the chat. And with that, you know, I'll open it up for questions. I saw at least one, now two in the chat. So we'll go over those and there's a third one. So it looks like we're gonna have a good conversation.

If anyone wants to raise their hand as well. If they want to ask a question out loud as well and have a discussion, please feel free to do that. Just hit the raise hand button in the bottom center of your zoom and we'll be able to do that. So I'm just going to take the questions here as they came in, and let Marilyne answer them. So Marilyne, I'm not sure if you're seeing the chat here, but there was one question from Judatha about how much is the percentage one can give I guess that is referring to the grade in peer instruction process.

**Marilyne Stains 51:04**
Right. So in terms of the grading scheme for the whole course, just like it's a formative assessment, so you don't want to give you know 50% of the grade should be devoted to peer instruction. So 10-15% That's typically what we see in the syllabus. With still the midterms and the final assessment being the core of the grades. So just 10-15% is enough.

**Justin Weinberg 51:30**
Yeah, and I think that is in line with what we see from other faculty as well and they implement Aktiv Learning into their instruction during class. There's another question in the chat about doing this for virtual classes, Marilyne. So do you have any tips or advice on how to implement this in a breakout room setting?

**Marilyne Stains 51:55**
Yeah, I mean, I've done it. You know, with Covid, we've all been teaching online, and so I've done it with just breakout rooms. You just, through zoom or teams, can assign random breakout rooms. So you don't have to assign particular groups. You don't have to strategize, okay, this person said this, or that person said that you can just randomly put them together. Groups of three or four are best. You don't want to put them in a group of five or six. It becomes too much. And two is typically not enough to have a fruitful conversation. So three or four in breakout rooms and it works really well.

The only trouble with it, it's harder for you as an instructor to walk around and listen in. It's easier with Zoom. It's harder with Microsoft Teams. But it's absolutely feasible, especially with all these online tools now, they can be responding on the tool and you can see what's happening and they can have their conversation in a breakout room.

**Justin Weinberg 52:55**
Absolutely. And, again, this is something we've seen implemented successfully. For our folks as well who have been teaching online, putting students into breakout rooms, making that peer learning moment and peer teaching moment happen when they're in the room. This is definitely something that's been successful.

And there's another question in the q&a section about how well is this implemented in a large lecture format? So Marilyne I'm not sure if you talked about the numbers of your students that you teach, but I'm assuming you're not dealing with small classes.

**Marilyne Stains 53:33**
No, I mean, I'm using 200 to 300 students and have seen these used with 1000 students in the same room. It can be done. It can be facilitated if you have undergraduate students that can be hired as learning assistants that help you with monitoring and answering questions. But this can be done with a large class and a small class, either.

**Justin Weinberg 53:58**
There's a question about helping students to learn chemical formulas. I'm not sure if that's like a nomenclature question, but certainly something that we can help out with. Have you had any experience helping students with things like chemical formulas or working with chemical formulas or nomenclature or things like that?

**Marilyne Stains 54:17**
I mean, it's all about the question that you are asking and giving your students the opportunity to write or use a tool to write, draw a chemical formula or chemical structure. So it can be used to help your students learn anything. It's best with conceptualized concepts, but yeah, I mean, there is no reason why you cannot help them learn chemical formulas with this particular strategy.

**Justin Weinberg 54:47**
Absolutely, while others think about what questions they want to post, Marilyne, I actually have a question for you. Because this is something I tend to ask all the educators I meet who are just really deep into active learning as yourself. You know, oftentimes there's sort of a hesitancy around implementing these strategies, because there's a fear of not being able to cover material that you have to cover in a particular semester. I just wanted to get your thoughts on sort of the balance between time spent doing these practices during class which we know are proven in the literature to be effective and just being crunched for time to cover material.

**Marilyne Stains 55:30**
It's a constant struggle and a struggle that comes from within ourselves and a struggle that comes from expectation from our field in chemistry. And my answer to that question is that you have to think about your learning goals. What do you really want your students to learn? What are the key concepts that your students have to have in order for them to be successful in the next course? And anything that doesn't fall into that bucket, you can cover it outside of class.

There's all this strategy like, just in time teaching, you know, you would do mini videos to cover some basic things, basic facts that you want your students to be aware of. You can have them learn that, or a definition, have them learn that through a video, give them a little quiz on it, and that will be enough and then spend class time focusing on the more challenging concept through all of these active learning strategies. It's all about thinking about if you're a general chemistry instructor, what do you want? What do your organic chemistry colleagues or your analytical chemistry colleagues want their students to know when they get into their course? If you can answer that question, that will help you think about what to cover in class versus what to give outside of class.

**Justin Weinberg 56:53**
Yeah, and as a follow up to that, is there any particular advice that you'd give to someone who was trying to make that jump, you know, is in more or less traditional lecture format, but is interested but is there anything you'd recommend trying first or any advice on there?

**Marilyne Stains 57:17**
Yeah, so that's why I chose to talk about peer instruction because someone calls it the getaway drugs. It's really easy and you don't have to overhaul your whole identity as an instructor. You don't have to change all of your lecture notes. I'm sure most of you instructors who lecture, ask questions to their students, you know, every 10-15 minutes or so. And instead of asking just that question, turn it into a peer instruction moment. It will just take five minutes of your class time

and you won't lose that much content. And it's a way for you to get your feet wet. To get a sense of how the students like to talk to each other? How does it work? And I'm sure you'll be surprised at how much you learn about your students' thinking and how much you enjoy more as a whole in teaching by doing so.

**Justin Weinberg 58:09**
Well, I want to do one last call for questions, put them in the chat, put them in the q&a, raise your hand. If you're not sure how to do that. Just look at the bottom of your zoom window and you should be able to find those options. So we'll do one last call. And if there's nothing else, I'd really love to thank Marilyne again for her time and her great presentations. It’s really insightful. And we look forward to continuing to host these types of events. So it looks like there are no other questions right now. So again, thank you, Marilyne. Thank you, everyone for joining us. I know this is a busy time of the year and we'll talk to some of you real soon. Talk to everyone later. Thanks Marilyne.