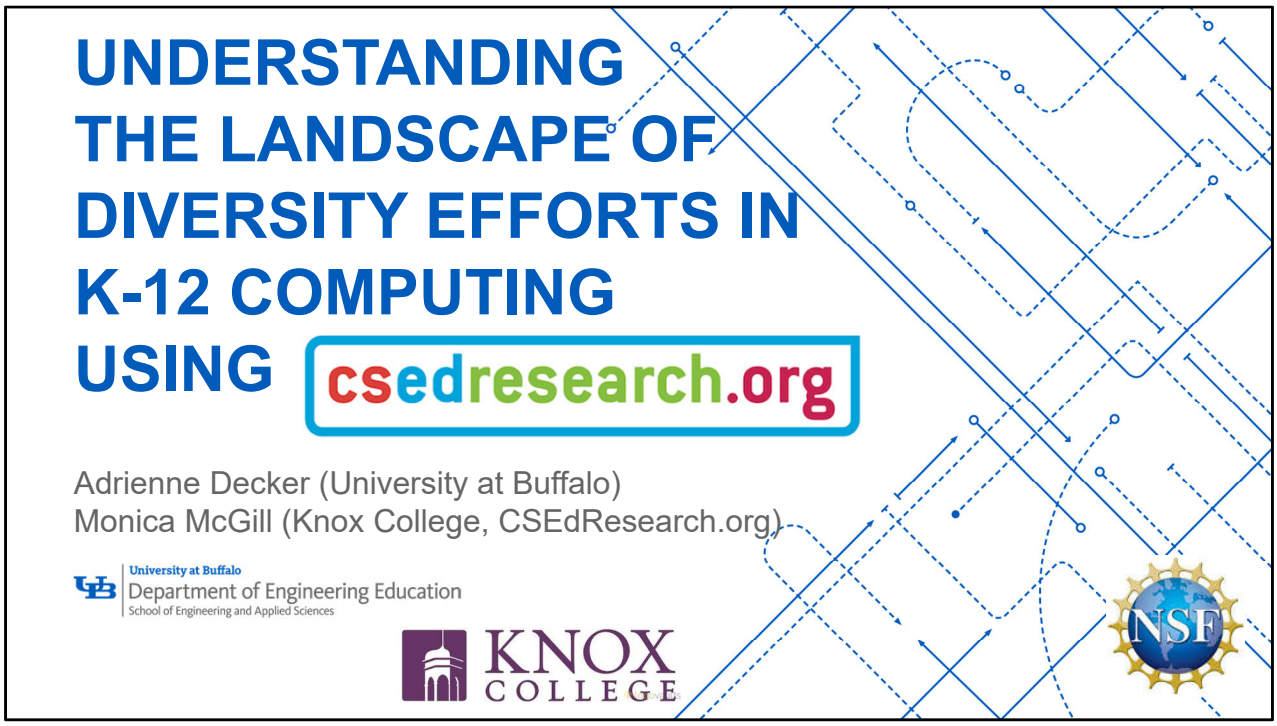
Understanding the Landscape of Diversity Efforts in K-12 Computing Using csedresearch.org

Dr. Adrienne Decker, University at Buffalo, SUNY

Adrienne Decker is a faculty member in the newly formed Department of Engineering Education at the University at Buffalo. She has been studying computing education and teaching for over 15 years, and is interested in broadening participation, evaluating the effectiveness of pre-college computing activities, and issues of assessment, particularly in the introductory programming courses. She has been actively involved with the Advanced Placement Computer Science A course since 2011, first serving as a reader, and as part of the development committee for the exam since 2015, serving as higher ed co-chair since 2018. She has received more than $1M in NSF funding for her work in computing education. Active in the computing education community, she is currently the ACM Special Interest Group on Computer Science Education board chair (2019-2022), has served as SIGCSE board treasurer (2016-2019), was program co-chair in 2014 and general co-chair in 2015 for the SIGCSE Technical Symposium on Computer Science Education, and has served on various other program and review committees.

Monica McGill, Knox College

Monica McGill is an Associate Professor of Computer Science at Knox College. Her areas of scholarship are computer science education research with a current focus on diversity and improving the quality of research to examine effective practices on a large scale. She oversaw the recent development of _____, a website with manually curated data from over 500 articles and a list of over 90 instruments for evaluating computing education.



Good morning (afternoon). I am here to present my work on analyzing the data curated in the resource center csedresearch.org. The plan is to have about 10 minutes at the end of this presentation for questions, but please, feel free to ask questions during the presentation if there are instances where I can provide additional information about our work or process.

Overall, we are viewing this presentation as an exploration of data. We are hoping to start/continue a dialog, but don't consider this presentation to be about presenting results, but rather the beginnings of the explorations of what this collected and curated data may be telling us.

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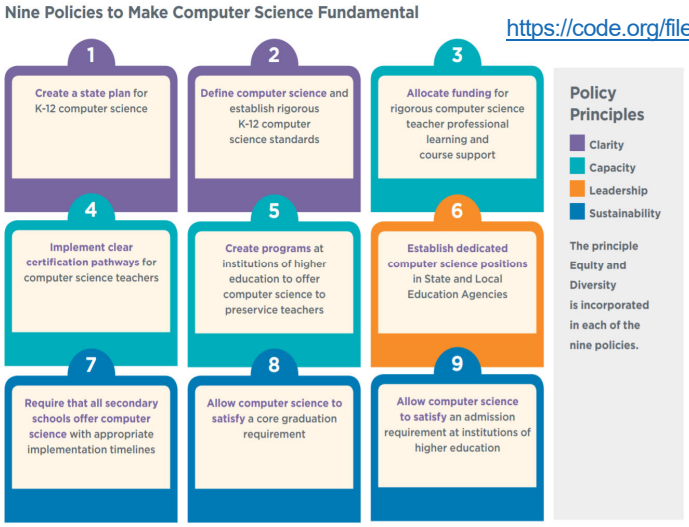
K-12 Computing Education is Growing



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I don't think it comes as a surprise to anyone to say that computing education in K-12 is on the rise. One of the largest players in this push to bring more computing into K-12 classrooms is Code.org. In their 2018 State of Computer Science report (can be accessed from this URL) we see them advocate nine principles that if adopted would ensure access to computing for all students. This is a snapshot of these policies from their report and as you can see they encompass elements of capacity building and leadership and thoughts about how to sustain the programs long term.

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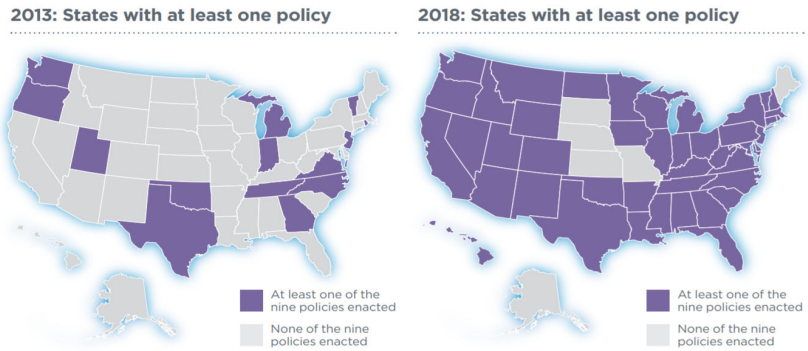
K-12 Computing Education is Growing

- https://code.org/files/2018_state_of_cs.pdf



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One of the things Code.org has done is track how well the states are doing at adopting any of these policies. They are devoting much of their efforts to advocacy for these ideas and in 2018, they were very pleased to report a huge growth in the number of states that have at least one of the policies enacted. In 2013, there were 14 states with one of these policies in place, and in 2018, they reported 44 states with at least one policy in place. Many states had many more of the policies in place.

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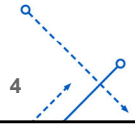
2019?

- https://advocacy.code.org/2019_state_of_cs.pdf

- All 50 states are now enforcing, or are in the process of implementing, at least one of the recommendations for integrating computer science in K-12!



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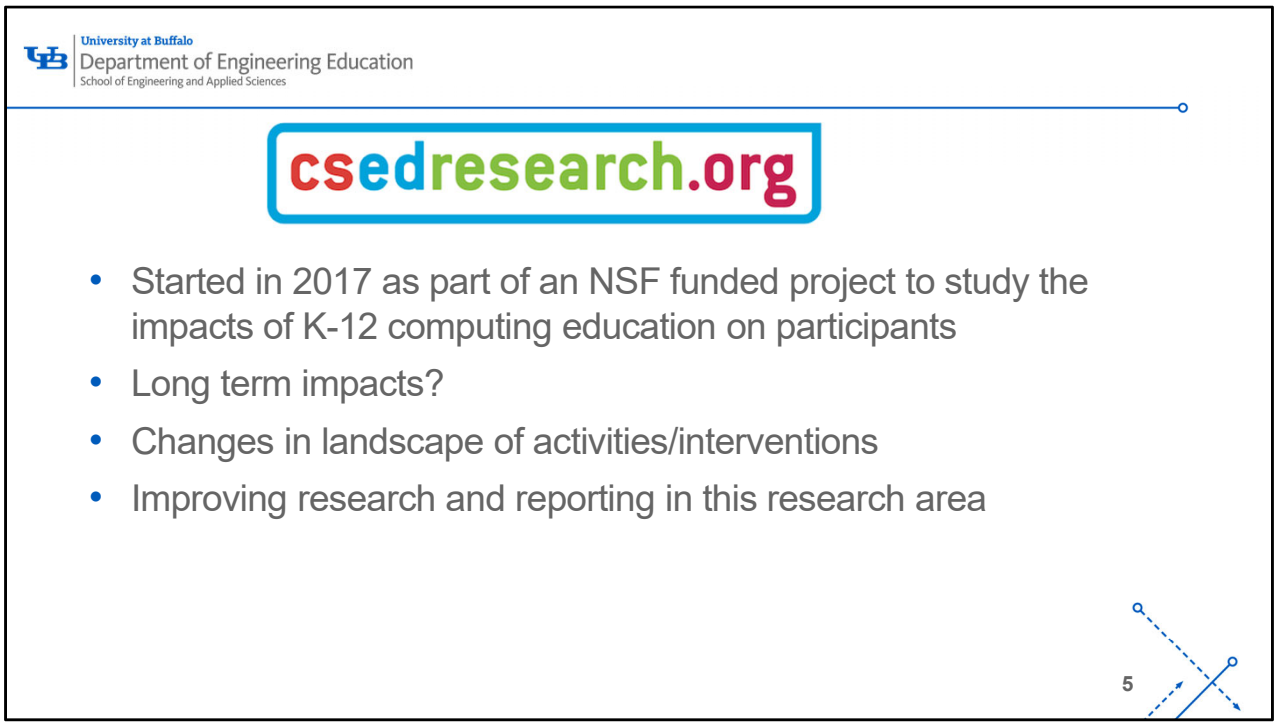
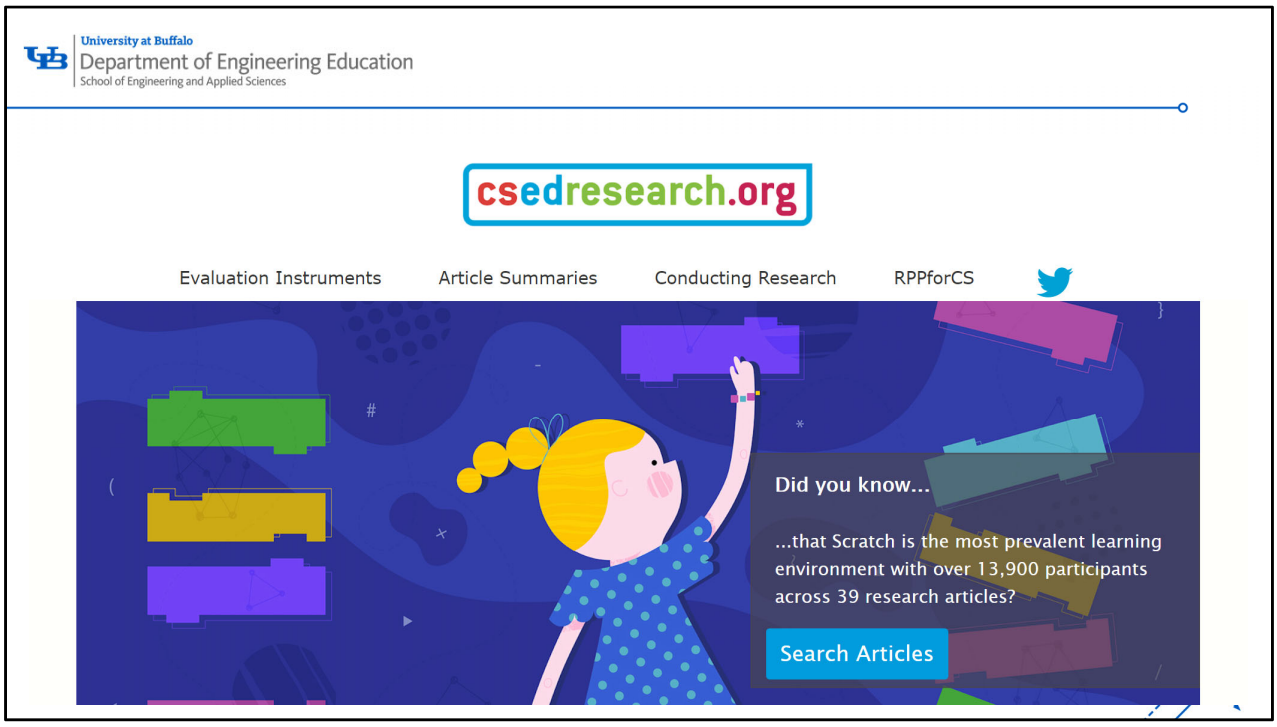
A big update happened very recently (in late 2019) [click to show slide contents].
All 50 states are now reporting to have implemented or are in the process of implementing at least one of these policies.
This is a huge jump in just 6 years. What this particular soundbite of data doesn't tell us is exactly who is benefiting from this increase in access to computing in the K-12 space.
The 2019 report does go into this from Code.org's perspective, so I encourage people to look at that report if you are interested in that information.
For this presentation, I want to focus on the idea that computing is growing in this space and that leaves us with questions of what that means.

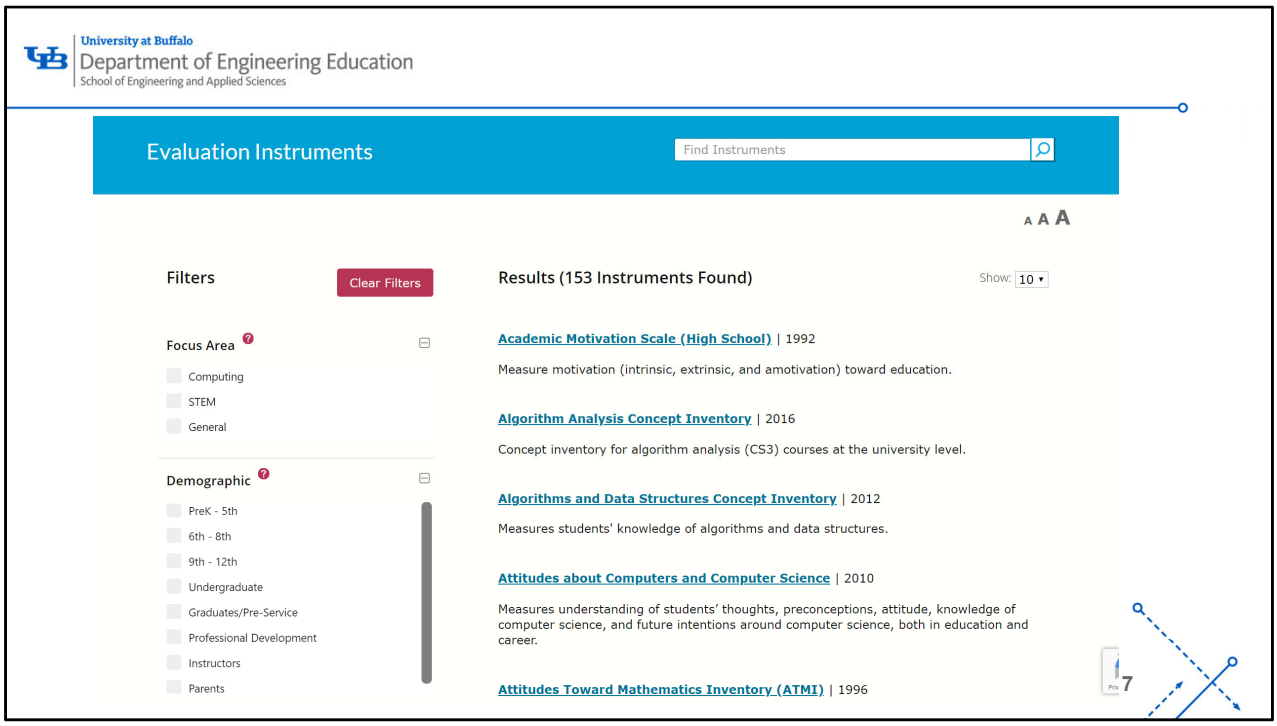


Which brings me to csedresearch.org. Let me give you a bit of background about the project.
[CLICK] It is a project that was started by Monica and I in 2017 as part of an NSF grant to study the impacts of K-12 computing education on participants.
[CLICK] We were originally interested in long-term impacts, or more accurately the lack of long term impacts reported in the literature up until that point. Some of the work of the grant and the resource center that is csedresearch.org is to help position our field to better understand and study those long-term impacts.
[CLICK] However, given what is happening in this area since we wrote the grant and started our work, we are very interested in looking at the changes that are happening and will continue to happen as computing continues to spread in K-

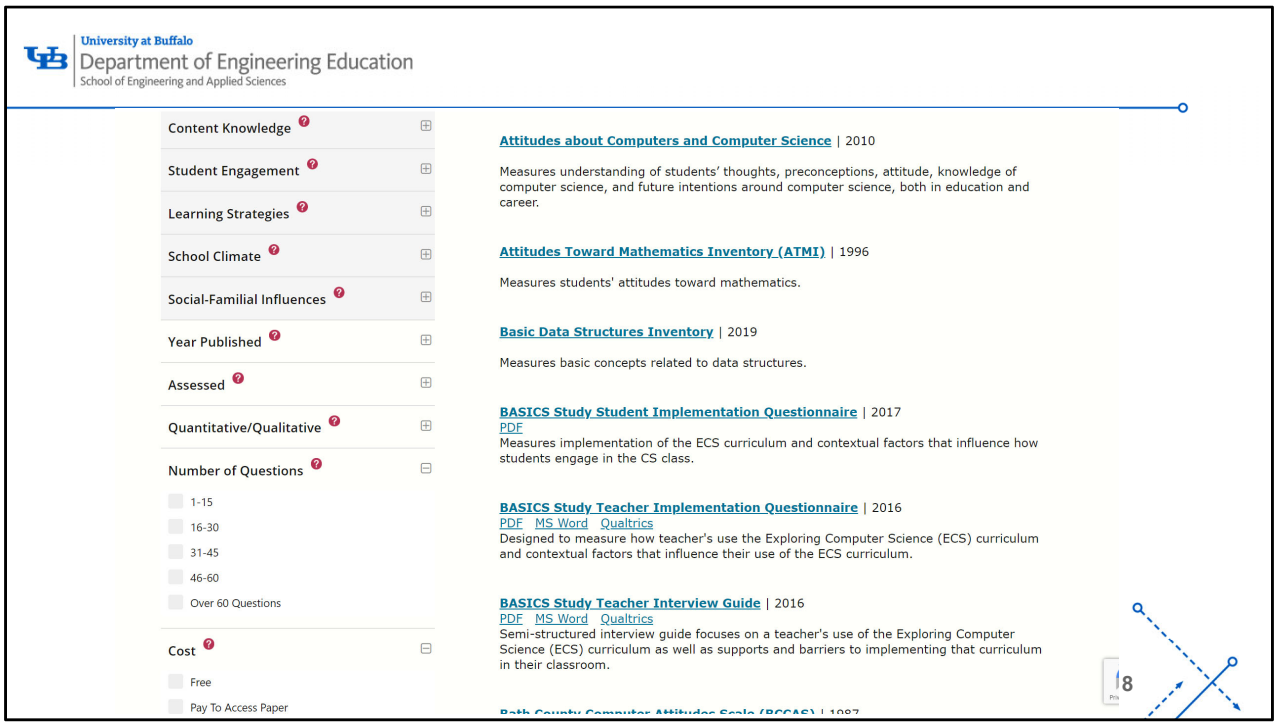
12. As an example, the new AP course, AP Computer Science Principles, had its first administration in 2017 and was the largest launch of an AP course in the history of AP with over 50,000 students taking the exam in the first year. The numbers for the 2019 administration are 98K (almost a two fold increase in three exam administrations). That is a lot more students taking a course in computer science than previously
[CLICK] And lastly, we are interested in improving the rigor of the research and reporting in this area of computing education research. While not the focus of this presentation, our work has uncovered gaps in the methodology and reporting of results in the research in this area. We are calling on the community to improve this so that we can better understand the impacts all of the good work is having on students. Let's take a look at csedresearch.org briefly so you can get an understanding of where the data we are about to show comes form.



[NOTE: Ideally, I would be able to simply go to the website live and show the following slides on the site, but I have included them here in case the Internet doesn't work and so that you can see what will be shown in the live demo.]
This is the opening page of csedresearch.org and as you can see, we have three main sections: Evaluation Instruments, Article Summaries, and Conducting Research. We also have a link to the RPPforCS project where we are a contributing partner. And yes, you can follow us on twitter to see updates and information about our project. Let's begin with Evaluation Instruments.

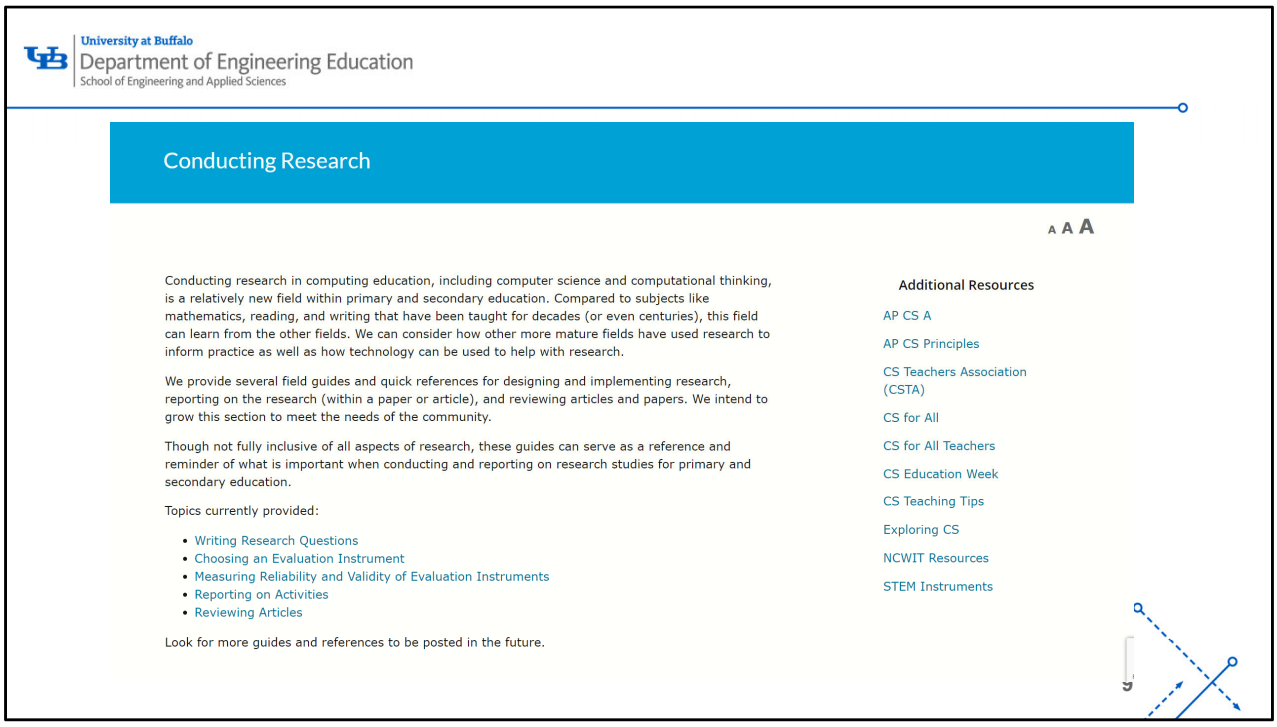


Currently we have 153 instruments available for viewing. We have tried very hard to make all instruments indicated available for users of our site. When possible, the actual instrument is linked directly. Users can search for instruments using various filters. For example, demographic of participants (mainly grade levels, but also demographics for non-student participants).



Other filters include content knowledge aspects that the instrument would assess, and several other factors adopted from the Lee & Shute model of constructs. This includes things like self-efficacy, intention to persist.

There is also a way to filter on number of questions and fee to use. If anyone is interested in the coding of instruments to the Lee & Shute model of non-cognitive constructs, let's discuss after this presentation.



Another piece of the resource center that speaks to our effort to help improve the quality and rigor of the research in the field is the conducting research section. In this section, we have guides for writing research questions, choosing an evaluation instrument, and reporting on activities. We have heard lots of positive response from the various guides on this part of the site and there are conferences that are pointing to them in their guides for authors submitting to the conference as a way to help them ensure the quality of the papers they are submitting. However, the part of the site that is most important to the work we are discussing today is the article summaries.

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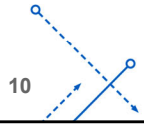
Articles

Inclusion Criteria (https://csedresearch.org/article-summaries-overview/)

- Venues
  - currently 10 peer-reviewed computing education venues [conferences/journals]
- Years
  - 2012-2019
  - Topic of Article
  - Describe or evaluate a computing activity or process
  - Target K-12 participants (students or teachers) and
  - Designed to teach computing or computational thinking



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The article summaries currently include 515 articles related to K-12 computing education. These articles come from 10 selected highly respected venues in computing education. All the venues (conferences and journals) are peer reviewed.
[CLICK]The resource center houses articles from 2012-2019, but the 2019 articles are not yet complete do to availability of the proceedings from later in the year.
[CLICK]An article is chosen for inclusion if it describes or evaluates a K-12 computing activity or process targeting students or teachers and is designed to teach computing concepts (including computational thinking)

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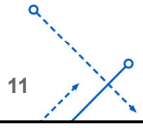
Articles

Data Extraction and Coding

- 24 variables coded
  - Focus area of study
  - Student demographics
  - Instructor demographics
  - Activity/Intervention Information
  - Information about the research conducted
- Undergoes a second review for accuracy



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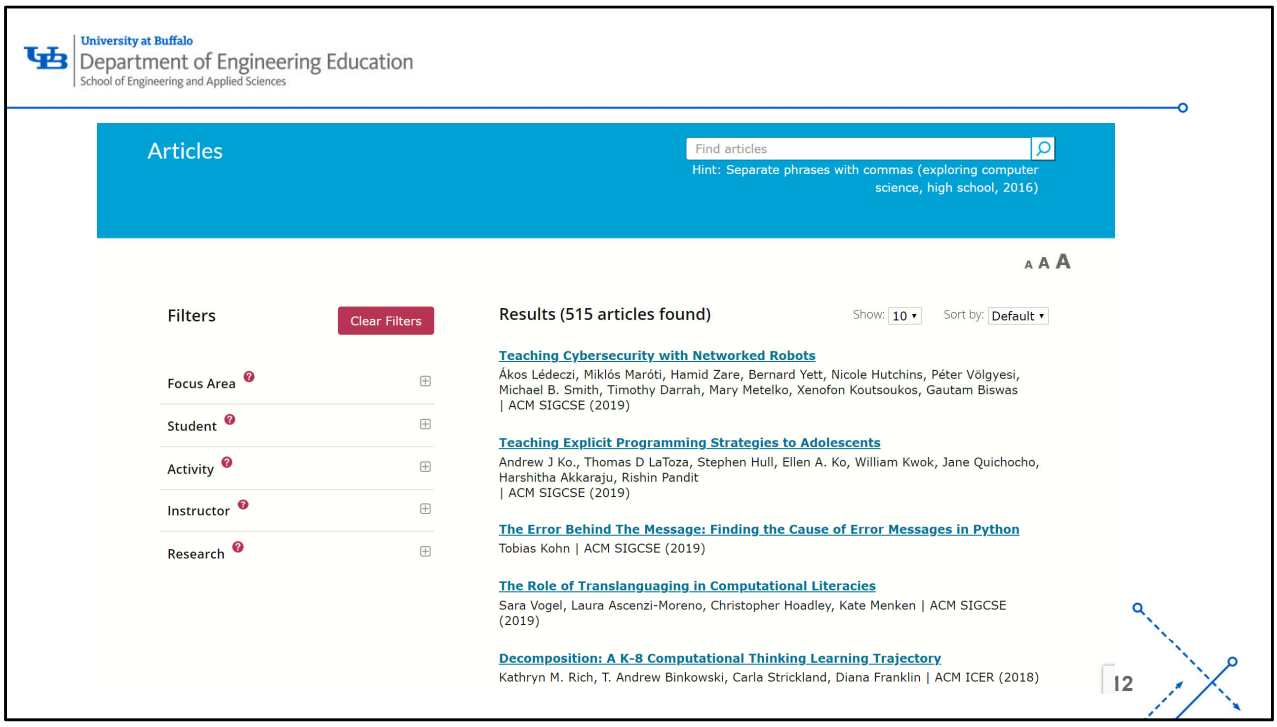
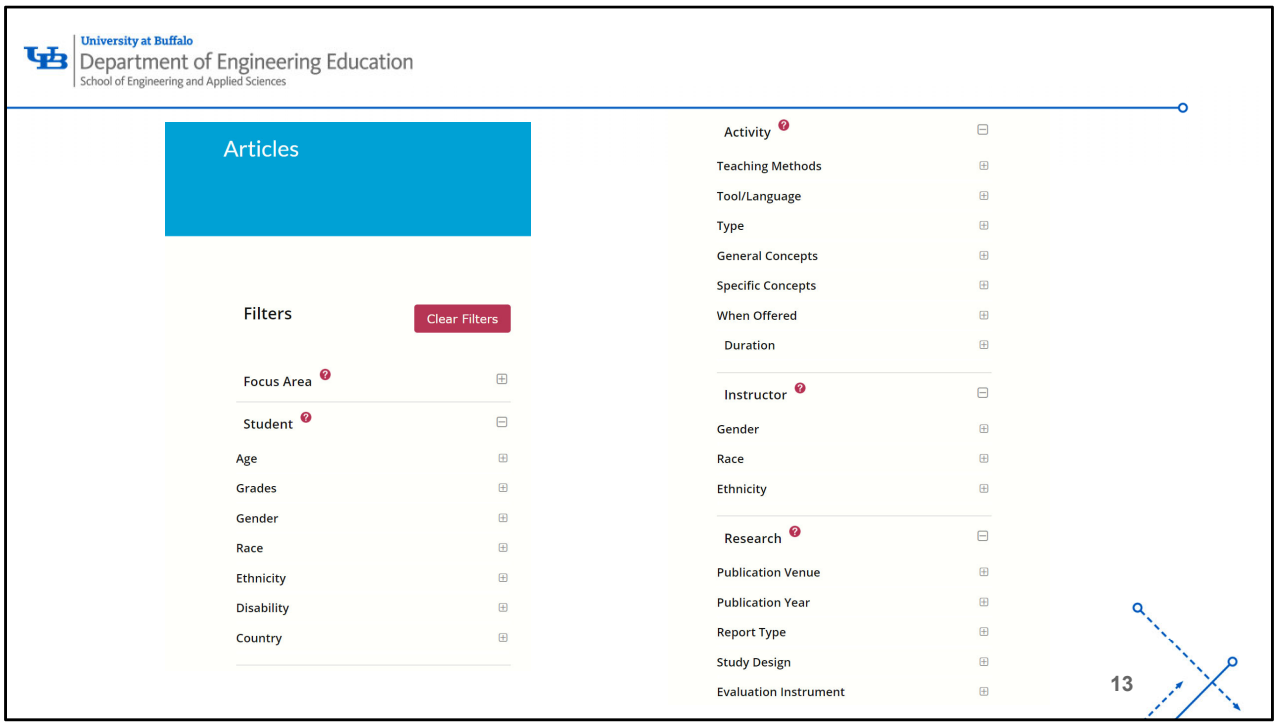
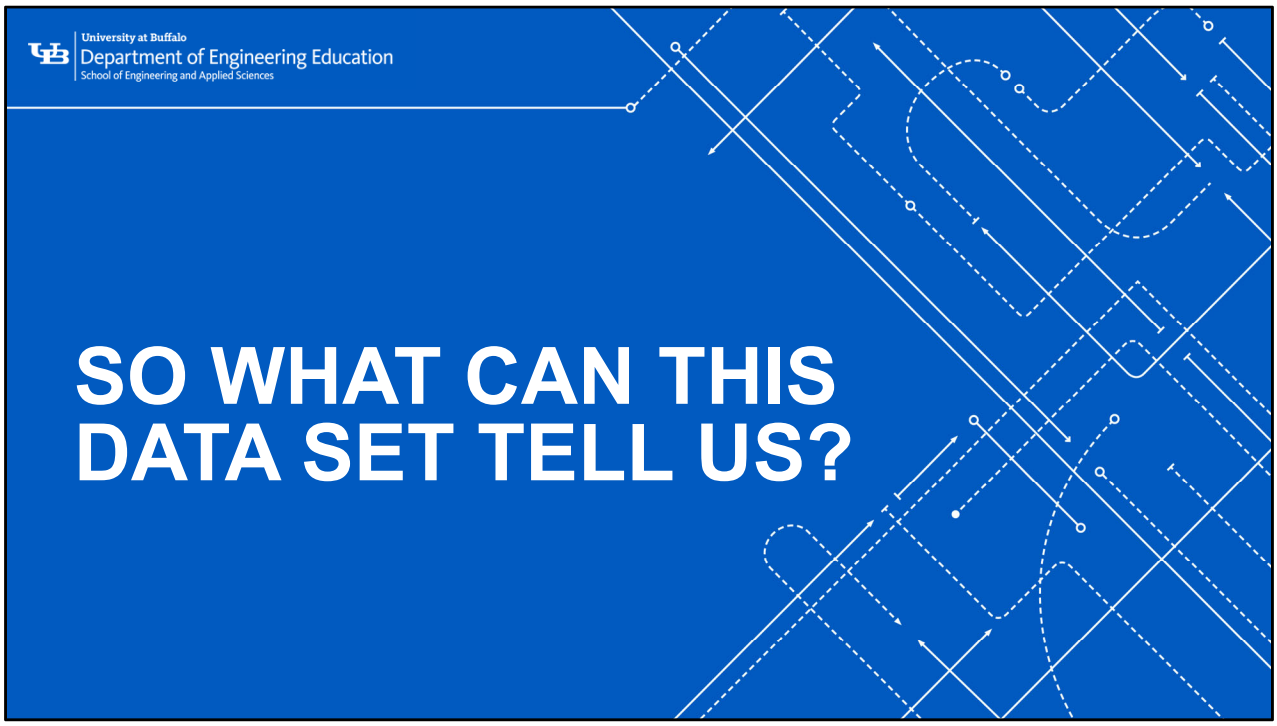
Once an article is deemed to fit the inclusion criteria, it goes through an extensive data extraction and coding process.
[CLICK] The article is read by a single coder to extract information about 24 variables that include student and instructor demographics as well as information about the intervention and any research conducted and described in the article – filters on the site show the variables – we will see that on the next slides and in the demo.
[CLICK] Most important is that the coding is then verified by a second coder before inclusion in the dataset.



Taking a look at the results of this on the site, we see our filters for the articles grouped into several areas (student, activity, instructor, etc.)



Drilling down into some of these, we see that there are various pieces of demographic information that we can filter for students, and instructors. We can look for articles focusing on a specific age range of students, or gender, or country of intervention. We can look for articles that describe the use of certain tools, languages or environments or articles that talk specifically about after school or summer programs. This is also linked back to our evaluation instruments and you can filter articles that use a specific instrument in their analysis.



So, with the wealth of data that we have collected and curated, we are at a stage where we are starting to ask questions about what the data can tell us. In this presentation, we will be exploring various questions about trends over time in this data, but I'd like to start up front with some of the limitations of our work. First, as we stated, the data is hand curated and coded. While we have a two-tier verification system in place, human error does occur and can impact our results. Also, our methodology is such to not assume anything about the articles, research, or activities. If there is not explicit information given in the article about a variable, we don't assume or draw conclusions. For example, if the authors do not state where an intervention takes place, we don't assume that it takes place in the city, state, or country where the authors themselves are from. There needs to be something in

the article that points to that being a valid piece of data for location before we make that assumption. There are several other examples of this type of thing in the analysis. Instructor is another example. Many times, authors are writing about their own interventions or studies, but unless they specifically state this fact, we don’t assume that is the case. There is a mechanism for authors to correct the data that has been curated about their paper on the site and we are grateful for any corrections to the data that we have.

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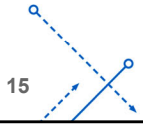
This work/analysis

- Looks at only the articles in the site
  - 2012-2018 due to incomplete 2019 data
- Gender
- Race/ethnicity
- Socio-economic status
- Disability
- Instructor demographic
- Activity information



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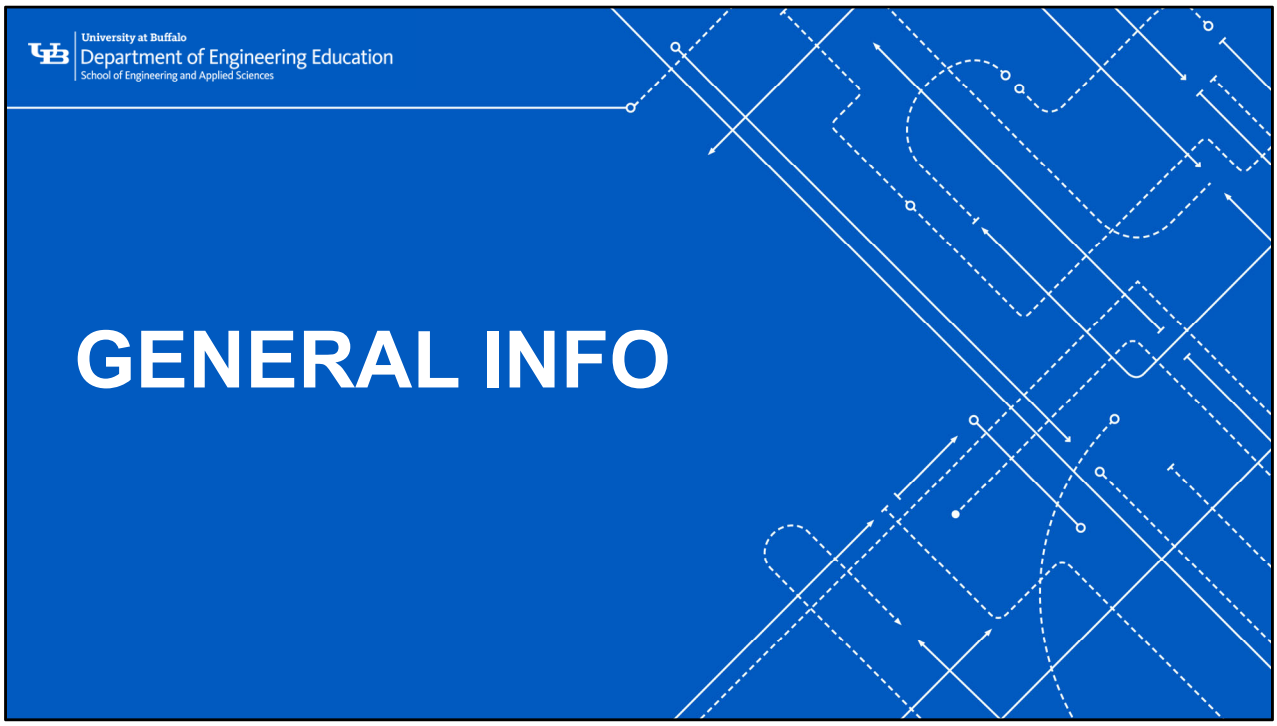
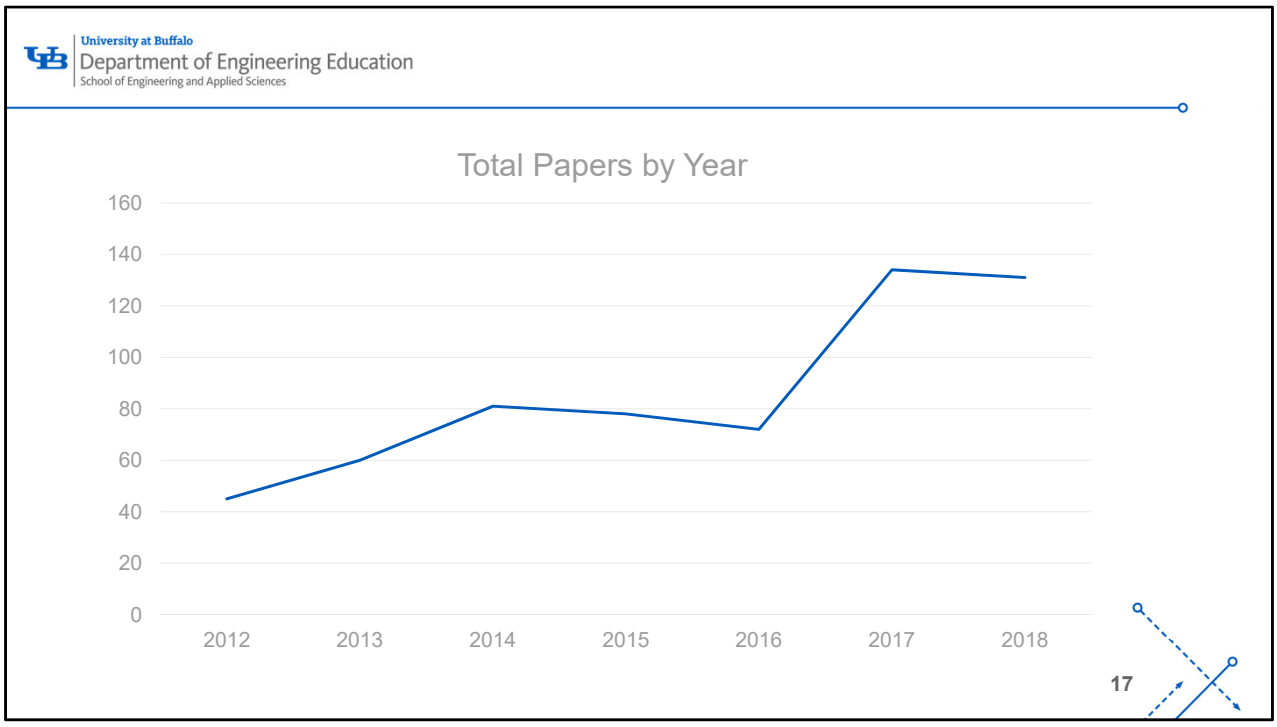
For this analysis, we are looking at only the articles in the site from the years 2012-2018 (the last complete year of data).

We have focused on several areas to look at including gender, race/ethnicity, socio-economic status, and disability information about the participants (students). We also want to look at instructor demographic information that was reported as well as information about the activities/interventions themselves.

For this analysis, we queried the database in the resource center through a series of SQL queries, the results of which were exported into Excel spreadsheets. The data was aggregated and graphs were generated using Excel to produce the results we are about to present.



I want to start out by talking about some of the types of things that exist in the articles in the dataset before we get into demographic specifics about the participants or instructors.



This graph shows the total number of articles in the data set tracked by year. As you can see, there is a clear upward trend of the number of articles in these venues. We started with just over 40 articles in 2012 and that number has tripled to over 130 articles in 2018.

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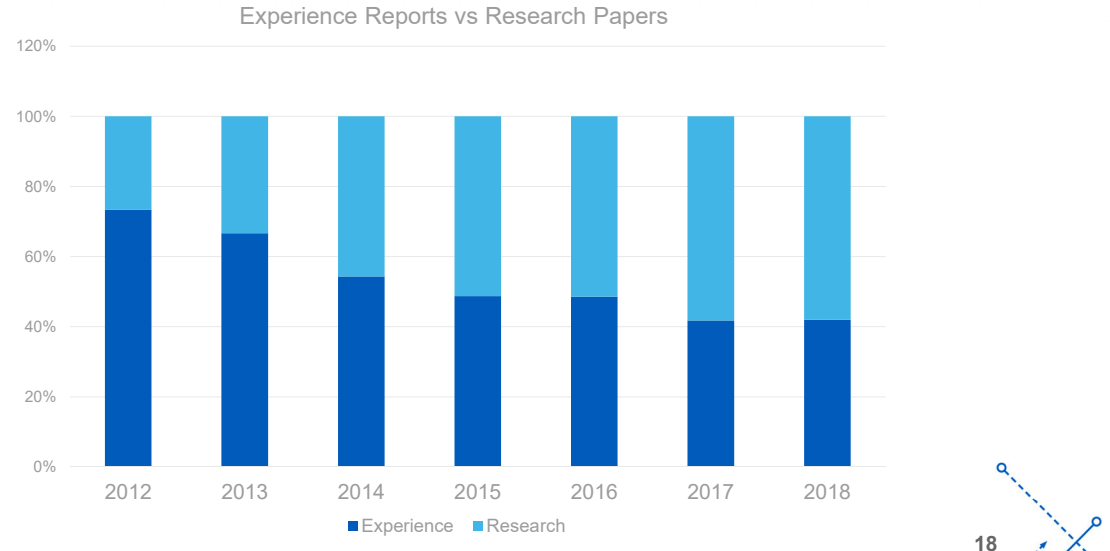

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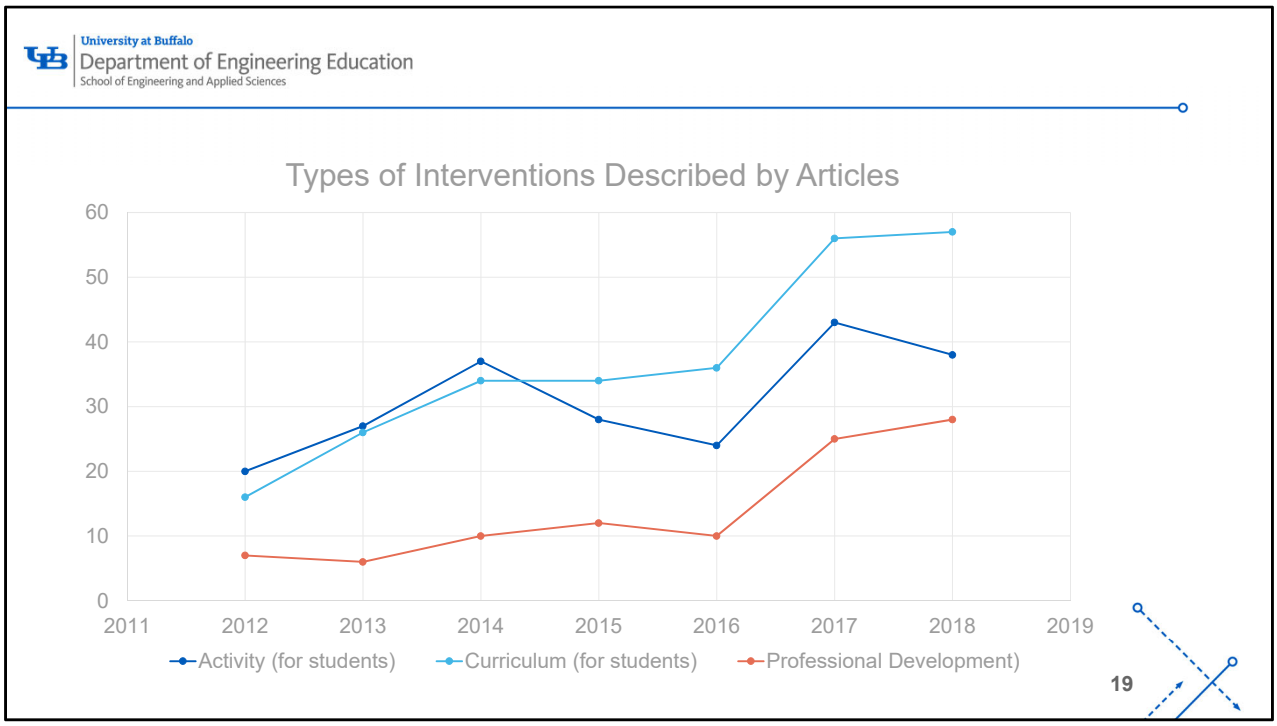
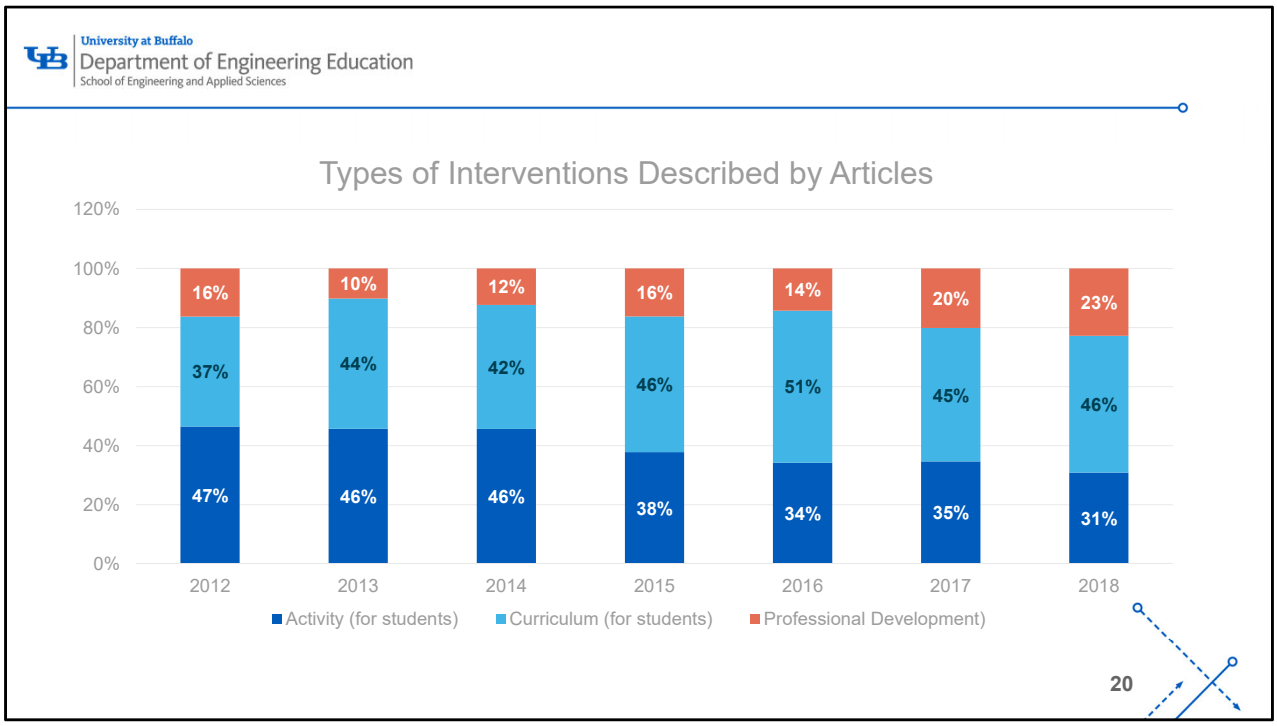
In terms of what type of articles we are seeing, in 2012, the overwhelming percent of the articles were classified as experience reports, that is, no rigorous research conducted or reported. The paper simply talked about an intervention and described it. There was no assessment or analysis of the effectiveness. This trend has changed over the years and now we are seeing research papers making up over half of the articles in 2018.



Looking quickly at the type of intervention described, we are seeing a modest increase of articles discussing curriculum and professional development over time with activities remaining steady.



However, looking at this same data in a percent of the whole in a stacked bar chart, we see a decrease in percentage of articles describing activities for students with an increase in the other two types.

So what these pictures are telling us is that the landscape is changing. There is more research being done in this area and an increased emphasis on professional development for teachers and curriculum. This isn't surprising given both the launch of AP CS Principles in 2017 and the increased number of countries, states, and municipalities working to integrate CS in the K-12 space.

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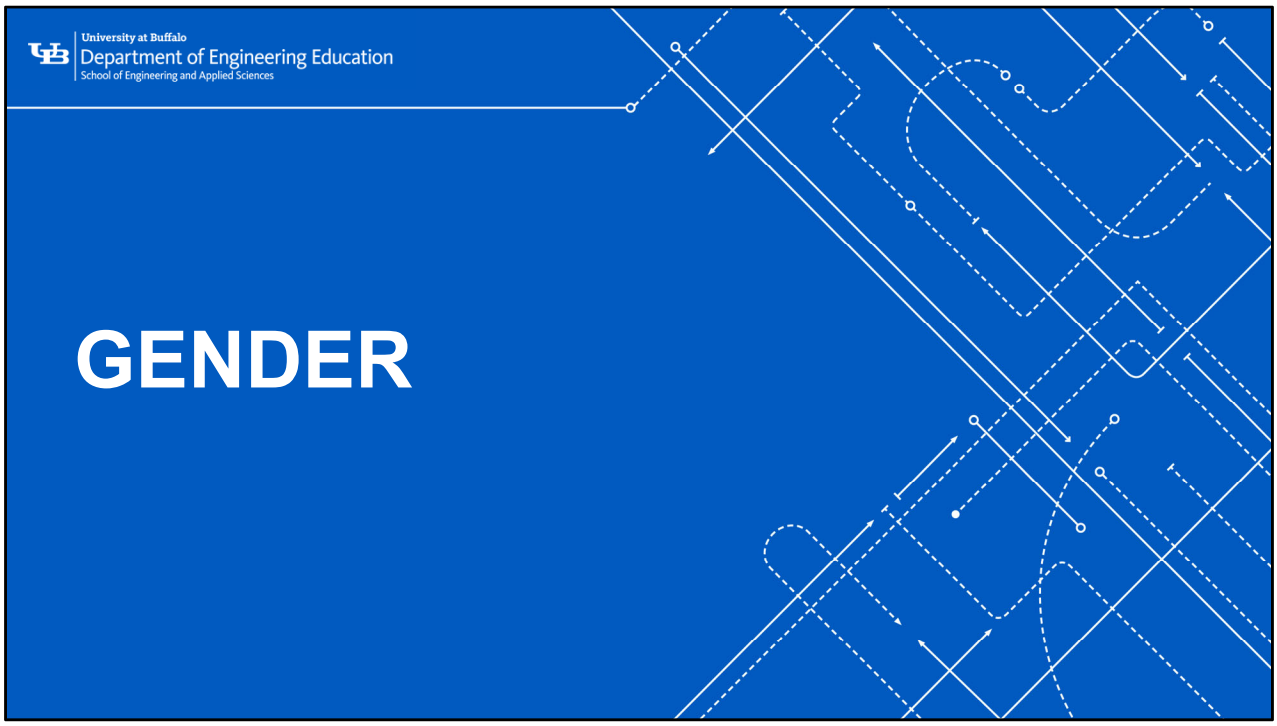
Speaking of countries…

- 30% of the articles do not adequately specify where the intervention takes place
- Of the 70% that do, 58% of those interventions described are from the United States
  - Next closest is Brazil with 4%

Our data is incredibly US-centric despite many of the venues for publication in the data set being global venues (including journals and non-US based conferences).



Let's explore what we can find out about gender of participants from our data.

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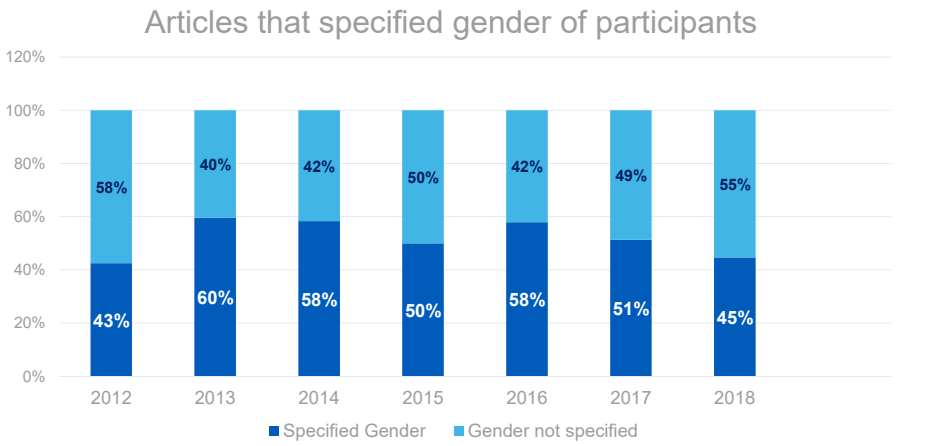
Reporting of gender



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There is a lot to unpack about gender identity and we do not attempt to work on that problem here. With almost all of our work, we are collecting the data reported by the articles and as such gender is reported primarily in binary (male/female) terms in the articles, save for exactly one article that does discuss the number of transgender participants. However, our first chart here is showing the breakdown of articles that actually do report the gender breakdown of the participants in the intervention/study. As you can see, we are reporting this information roughly 50% of the time, in fact overall, it is being reported in 52% of the articles. We looked at this data by year to see if there were any trends with the hopes that increased publications would yield better reporting rates, but it does not. In fact, 2018 saw a decline in the number of articles actually reporting the gender of the participants.

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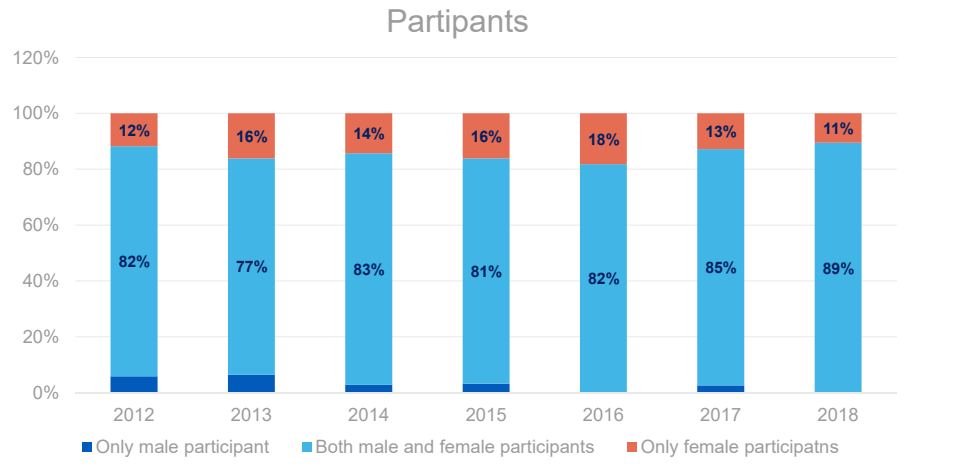
Participant Genders Reported



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When genders were reported, we see that the studies were predominantly made up of both male and female participants. Less than 20% of the studies each year focus on strictly-female participants and at most 2 studies per year report that their participants are strictly males. What this doesn't tell us (and we don't track) is the percentage of males and females in the studies that report both genders. However, to be fair, that data would be less complete than what we have because many of the studies only report that there were "both male and female participants" without breaking down the specifics of how many participants fall into each category.

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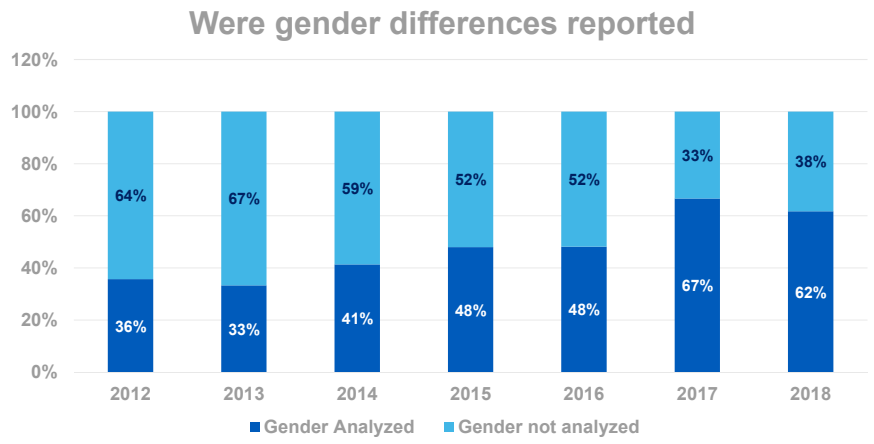
Analysis of differences by gender



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Another piece of information that we track is whether or not the study reports on the analysis of differences by gender. That is, whatever the study is trying to determine, is difference in gender reported upon. We once again broke this down by year and for those studies reporting more than one gender participants, we actually see a substantial increase of the number of studies analyzing data by gender in 2017 and 2018. If the statistics were reported well, we could actually get the exact gender breakdown of these studies, but the data we have curated in the resource center doesn't support that at this time.

Let's explore what we can find out about the race/ethnicity of participants from our data.

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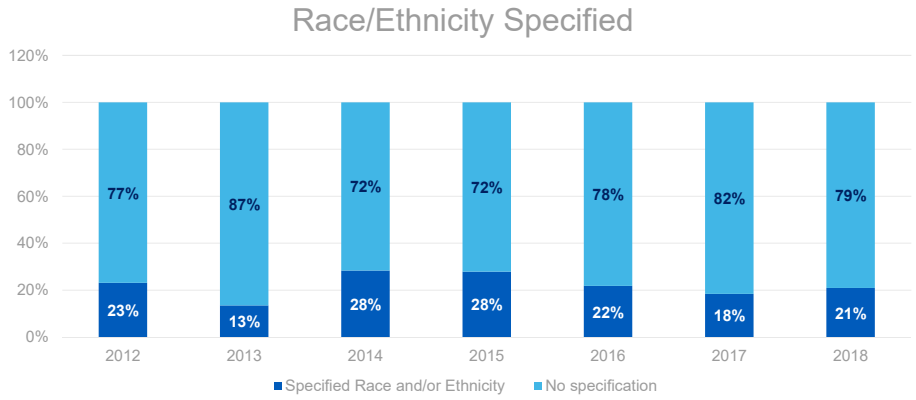
Race/Ethnicity Reported

- Only 22% of the articles overall reported on the race and/or ethnicity of the participants



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We only have 22% of the articles in the dataset reporting on the race and/or ethnicity of the participants. We combined this notion for this presentation, but within the data, race and ethnicity are coded separately. We are using the US Census designations of race/ethnicity within the dataset. The story of reporting of this demographic piece of information is the same here as with gender, it is simply not being reported, even when we look at the trend over time. It may not be being reported because it is not being collected, but that is also problematic.

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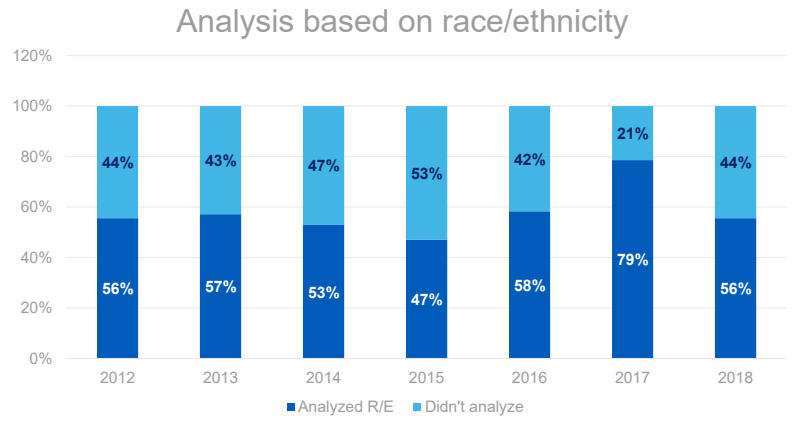
Analysis of effectiveness of intervention based on race/ethnicity



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When we look at the studies that did report/record race and/or ethnicity of the participants, we see that over half of them consistently looked at race/ethnicity as a factor in their analysis of their results.

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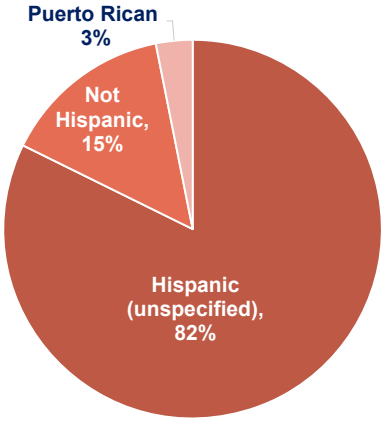
Ethnicity Reported



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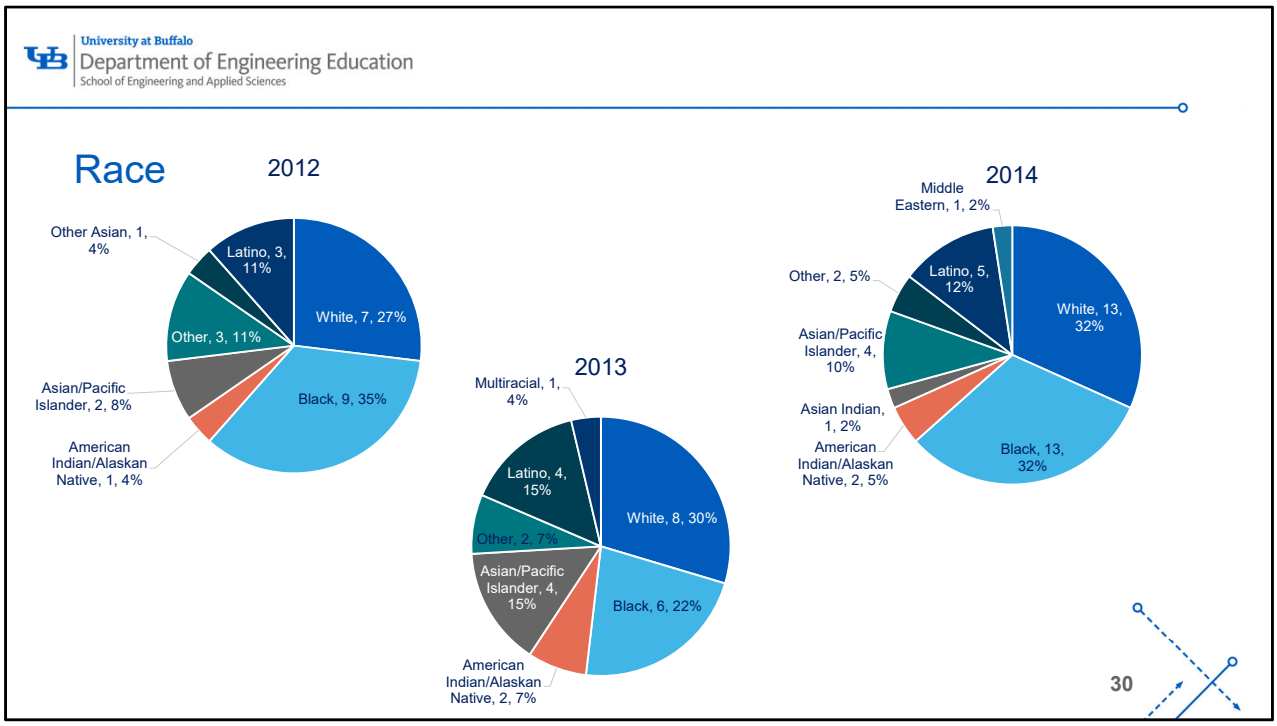
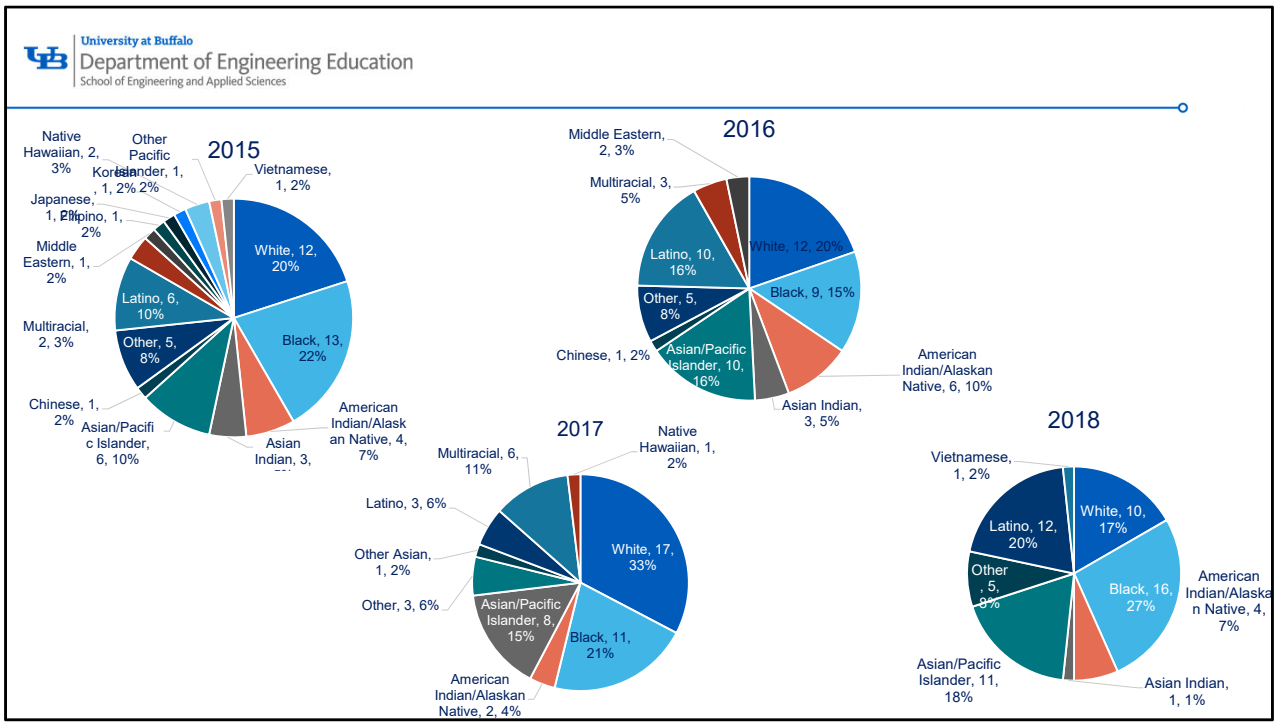
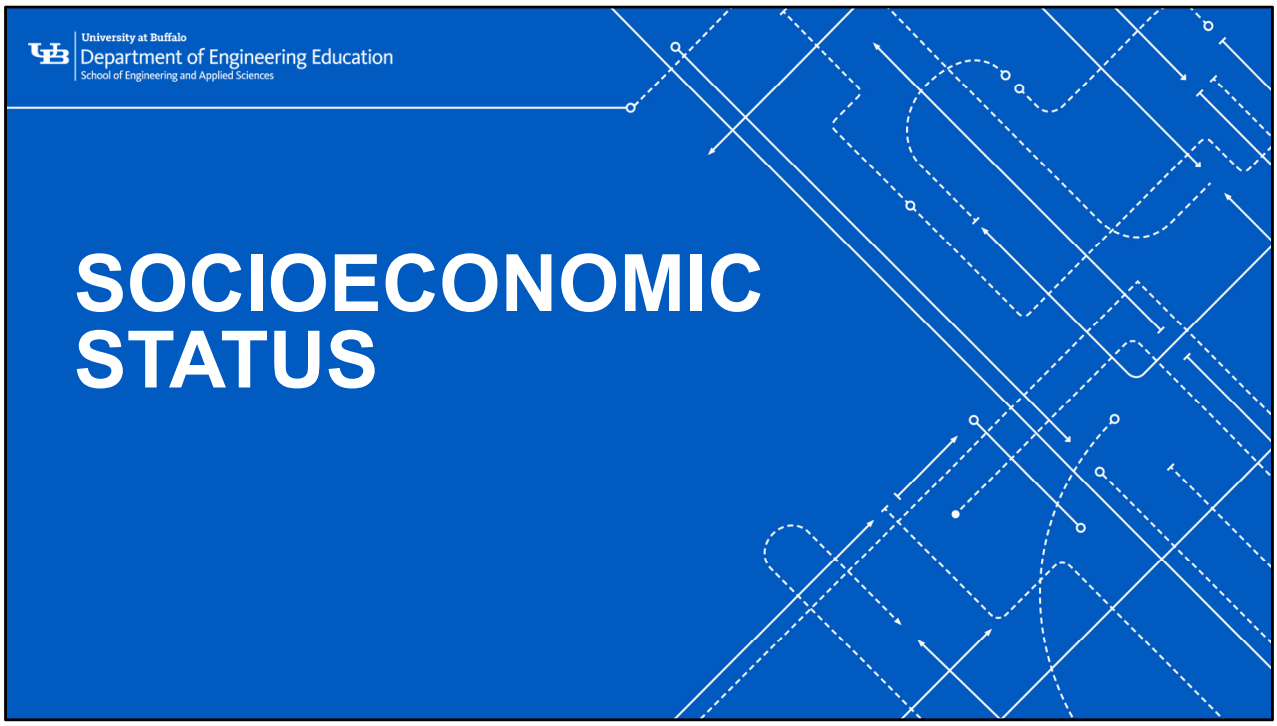
In terms of ethnicity reporting, we don't have a lot of data. 15% of the articles that report on ethnicity report that the participants are not Hispanic, with a majority of those that are reported as Hispanic not being any more specific than that. However, there is a small percentage of the studies that reported working with specifically Puerto Rican participants.



We have broken down the races reported by the articles by year to determine if there were any noticeable trends in the number or types of races reported. For the purposes of our dataset, we use the US census race designations. Those may be far from perfect, but it allows for some standardization of the reporting. The first three years have a mix of mostly white, black, Latino, American Indian, and Asian/pacific islander.



When we flip to the last four years, we see an increase in the number of races reported in the articles. We see an increased use of multiracial identity and simply more groups identified as taking part in the interventions described by the articles.



Let's explore what we can find out about socioeconomic of participants from our data.

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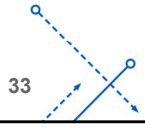
Socioeconomic Status

Only reported in 18% of the articles which was fairly consistent over the years.

- 50% of participants receive free or discounted lunches.
- "31% of students coming from economically disadvantaged households and 16% of students schoolwide designated as English-language learners"
- Of 24 girls who reported SES, 46% were eligible for free lunch and 25% had mothers who did not complete high school.



The report rate for socioeconomic status was fairly low at 18% and consistent across the years. That is, we are not getting better at reporting this information.

Highlighting some very nice reporting of this information here. (Animate quotes after first bullet)

While it may not be something that is collected from every participant, this information is generally known about overall SES of the K-12 school (particularly within the US). We don't see a mention in the data of Title 1 schools at all – information that would be useful in setting the environment in which the intervention is situated.

Let's explore what we can find out about disability of participants from our data.

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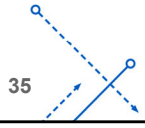
Reporting of Disability

4% of the articles report any information about participant disability including receiving disability services and disability instruction.



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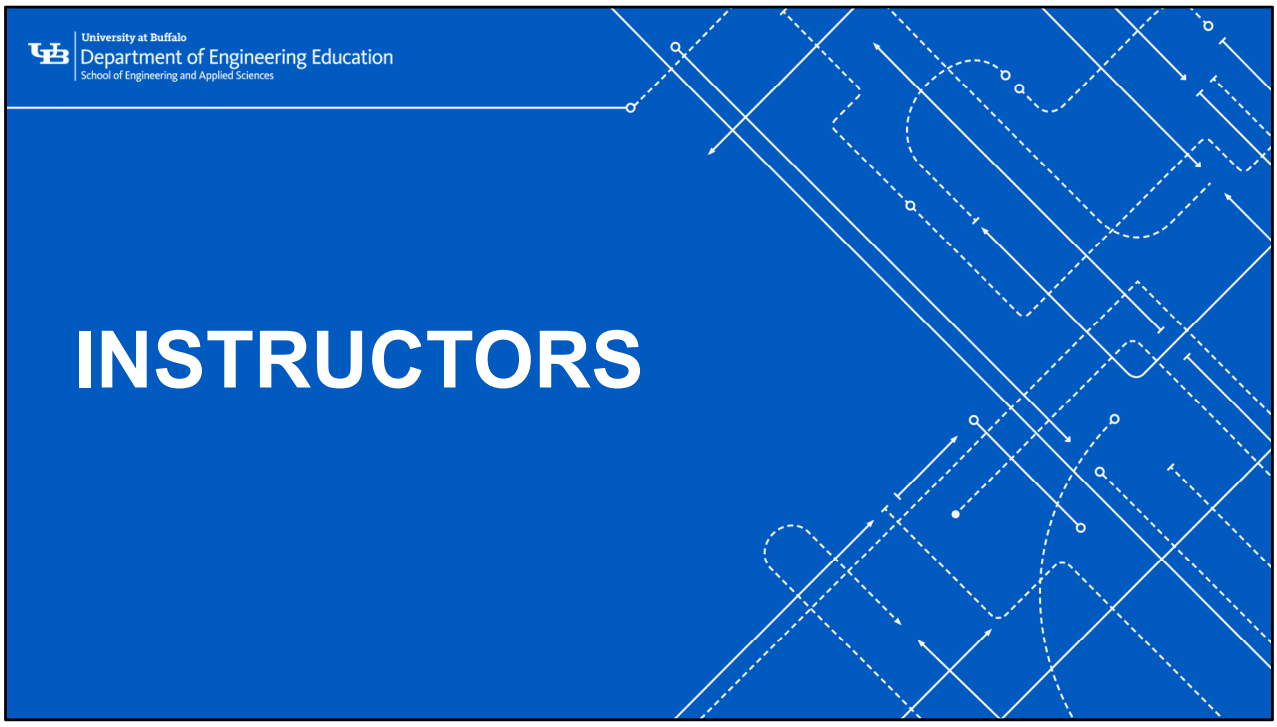
The reporting of disability status of the participants is shockingly low. Given that 14% of students in the US are reported to have some sort of disability, it stands to reason that some of the students in some of the studies would have some sort of disability diagnosis. It is currently a severe shortcoming in the literature that we aren't examining this aspect of the student experience in computing.



Let's explore what we can find out about instructors from our data.

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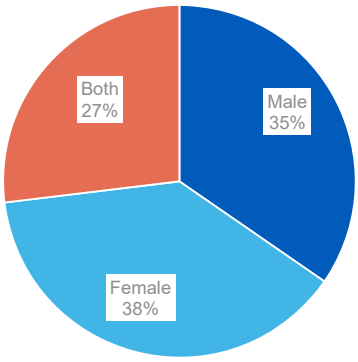
Instructor Gender

- Specified in only 22% of the applicable articles



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The gender of the instructors is only specified for 22% of the applicable articles and when we look at the reported genders (which were only recorded and reported in male/female terms, we don't see any clear pattern. Many interventions have both male and female instructors reported (over one quarter).

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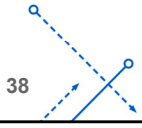
Instructor Race/Ethnicity

- Race reported 14% of the time
  - 10% – American Indian/Alaskan Native
  - 19% – Black or African American
  - 15% – Latino
  - 23% - White



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We use the US Census designations for race/ethnicity within the data set. However, for instructor race/ethnicity, so little is reported (only 14% of the articles report) that there is not a lot of useful information to be gleaned from it. Interestingly, when reported, we see a mix of races identified within the data.

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Instructor Background / Experience

- Only reported by 23% of applicable articles
- Have previous experience "with similar workshops and their main duty is to instruct the children and facilitate the process."
- All were novices, with 4 having seen or used Scratch or Blockly before. One had used a markup language for a webpage. Only half of the teachers had developed a webpage using WordPress, Sitebuilder, or DreamWeaver.

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Another area where information would be helpful is in instructor background
First quote not great, but is better than no information.
Second quote much better and gives a richer picture of the instructor in the classroom.

Let's explore what we can find out about the activities themselves from our data.

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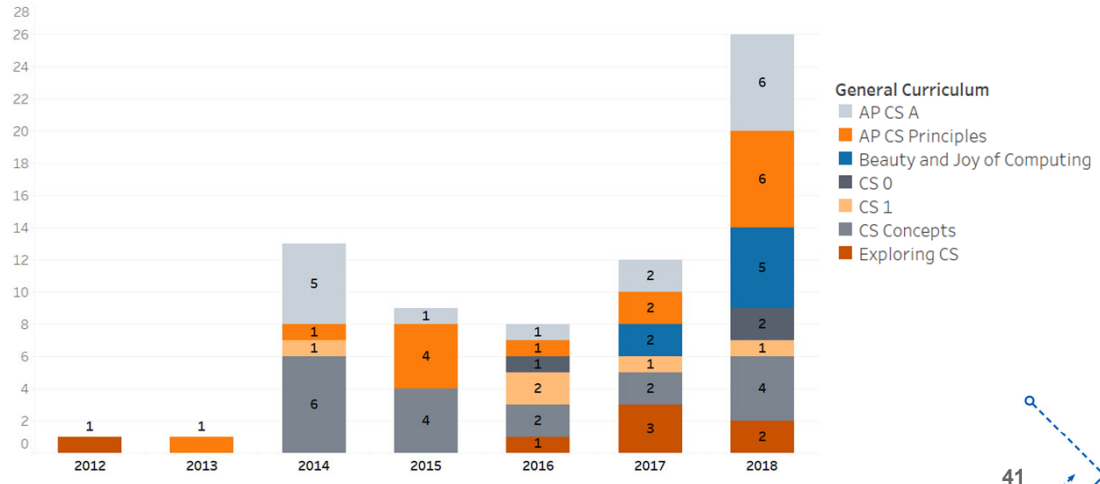
Curriculum Used



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We have seen a dramatic increase in the curriculum cited and used in the articles over the past 7 years. With just 1 curriculum reported in 2012 and 2013 respectively, we now see seven different curriculums cited in 2018 with the three most popular being AP CSA, AP CS Principles, and Beauty and Joy of Computing (which can be used as a CS Principles Curriculum. The launch of CS Principles as a formalized and official AP course in the 2016-2017 may have been a cause of this upsurge in these two curriculums. However, we see steady representation for Exploring CS (ECS) and CS Concepts that pre-dated the AP curriculum and are different from those courses.

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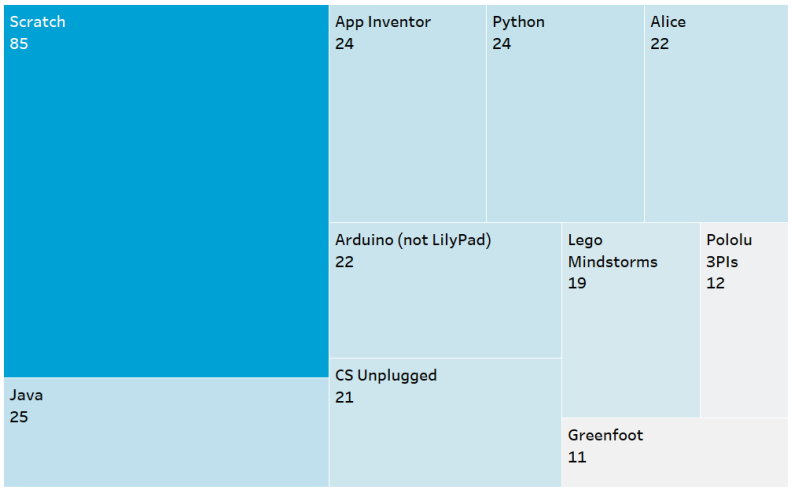
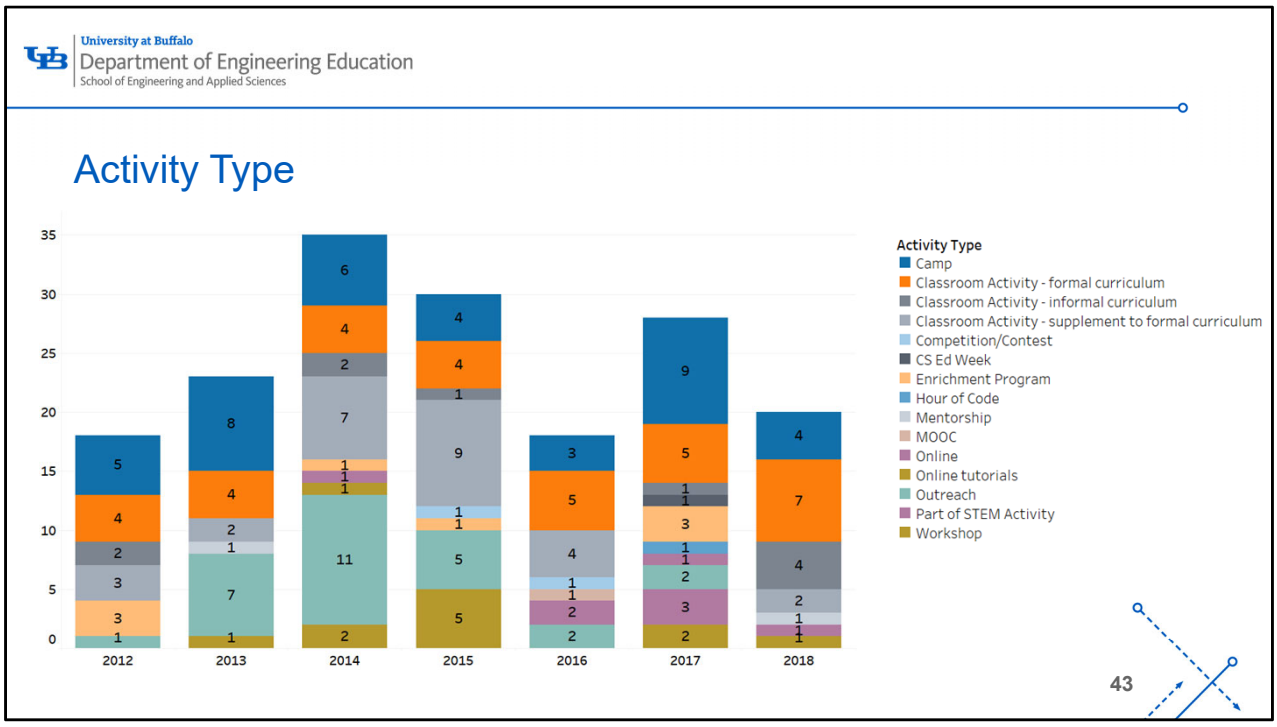
Languages/Tools Used



Looking at languages, we see clear trends with regard to blocks-based languages with Scratch and App Inventor together making up a large percentage of the languages mentioned in the articles. However, it is important and interesting to note that CS Unplugged has 21 mentions across the seven years. CS Unplugged is a series of exercises that students engage with while not on a computer.



When we look at types of activities that are described, we see that the first half of our data is dominated by camps and outreach activities and these quickly start to fade after 2015 to be replaced by an increased number of formal curriculum activities and other more formalized classroom interventions. We hypothesize that this is due to the increased rate of creation and adoption of K-12 standards across the US and likewise an increase in the funding of K-12 projects including the NSF RPP projects that began in 2017.

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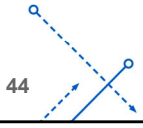
Conclusions

- Increasing area of research and publication
- Still lack of good reporting of information on participants and activities
- Trends are shifting towards more curriculum provided in the classroom as opposed to afterschool or summer
- Don't have enough data reported to understand instructors



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So, what do we know about looking at our data so far.
[CLICK] We are definitely seeing an increasing area of research and publication. The numbers are going up. More people are interested in, working in, and publishing about things going on in K-12
[CLICK] However, we are still underreporting (or under collecting) information about participants and the activities themselves
[CLICK] What we can see about the activities is that there is a movement towards activities that are happening in the classroom and using formal curriculum. This is a distinct movement away from the "outreach" and after school clubs and camps that dominated the earlier part of the decade
[CLICK] We really don't have enough data reported on instructors of these interventions. The instructor could be key

in understanding what is working and what may not be. It should be reported.

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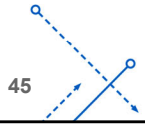
Challenge

- Submit an article to csedresearch.org
- Examine your own practices for collecting and reporting
- Think about what we need to do to really be “for all”



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I’ll leave you with a challenge today
[Click] Submit an article to csedresearch.org that isn’t listed and involves work in K-12 to help grow this dataset
[Click] Look at your own practices for collecting and reporting and determine if there are processes you could improve upon
[Click] Think about what we need to do to really be “for all”

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Acknowledgements

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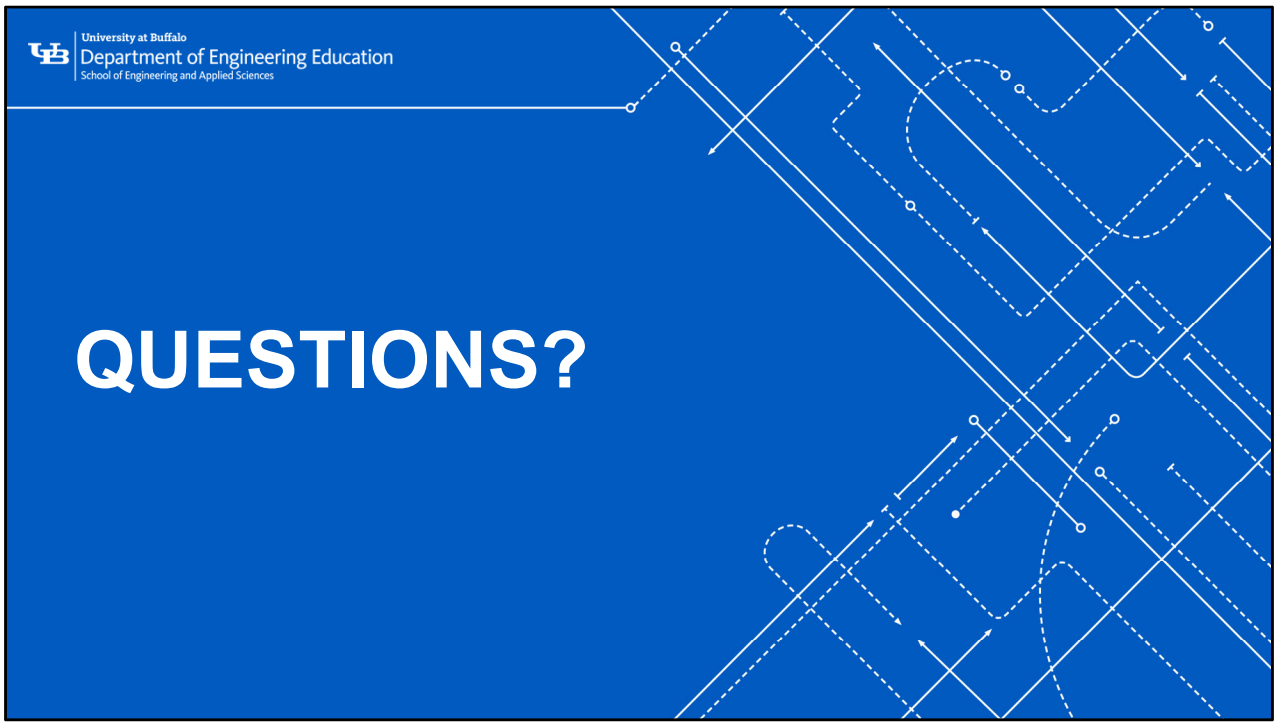
This work is funded in part by the NSF and we recognize their contribution and have the standard disclaimer about the information presented here does not necessarily reflect the views of the NSF.



And we have left lots of time for questions, [approximately 10 minutes], so please, questions?

[Authors Note] We feel that the presentation may be too long in its current form and have left off a few more pieces of analysis on the tools and activities. We are interested in feedback about possible cuts or additions in other places to help shape the final version of this presentation.