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Coding, Computational Modelling & Equity in Math Education
Working Group C Equity, Diversity, and Inclusivity
Report

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Presentation of the Aims of the Working Group

Coding and computational thinking (CT)[1] is being integrated into K-12 mathematics education around the world. Researchers have identified numerous potential benefits for integrating CT with mathematics including "make[s] abstract mathematical concepts concrete" (Wilensky, 1995, p.257), dynamic modelling to develop mathematical concepts and relationships (Gadanidis, 2015) , support transfer of learning from the classroom to real-world settings (Lunce, 2006). Other researchers suggested: motivation to experiment; the development of mathematical intuitions; critical reflection; and working with abstraction and different representations (Howson & Kahane, 1986; King et al., 2001; Marshall & Buteau, 2014).

However, this rapid integration of CT & mathematics raises many potential equity issues, including equitable access to technology for coding, equitable access to quality instruction and instruction that makes coding attractive to a diverse range of students.

Equity, Diversity, and Inclusivity

This working group addresses the issue of quality equitable pedagogy as the benefits of coding for mathematics learning are based on instruction that promotes problem-solving, computational thinking and connections to mathematical thinking for ALL students. Incorporating this equitable pedagogy is difficulty for most teachers who have 1) little to no prior experience learning coding as problem-solving, 2) little access to quality teaching materials (Wu et al., 2020; Yadav et al., 2016) nor 3) no vision of integrating & connecting between CT / CM and mathematics teaching (Gleasman & Kim, 2018).

This working group explores equity issues around quality pedagogy for coding and mathematics, developing strategies and vision to make coding more inclusive. Participants will then examine existing coding and mathematics activities through an equity lens before modifying the activities to develop mathematical reasoning for all students. In this way the workshop hopes to develop equitable math and coding activities, and develop a vision for future adaptations. In creating more equitable coding and mathematics activities, and a framework for modifying other activities, this workshop hopes to harness "the power to change pedagogies and students' experience of mathematics learning" (Ford, 2018, p. 27).

This working group aims to support the participants to:

1. Develop a vision of equity, diversity and inclusivity for coding/computational modeling education;
2. Improve teaching strategies to make coding more equitable, diverse, and inclusive;)
3. Build a framework to adapt coding activities to make them more inclusive.

Developing Shared Understandings of EDI in Coding and Computational Modeling

Our first goal was to develop some shared understandings of EDI in the domain of coding and computational thinking. Our participants were from a wide range of backgrounds (schooling, subject matter, countries of origin), so we realized the need to share and develop participants' perceptions about EDI.

Equity, Diversity and Inclusion

Developing a vision of equity, diversity and inclusivity for coding/computational modeling education means to present some definitions of these concepts. Equity is defined as fairness for all, especially about different identities such as "race, class, ethnicity, sex, beliefs and creeds, and proficiency in the dominant language" (Gutiérrez, 2002, p. 153). Weissglass (2002) raised important questions for educators about how racism, gender, sexual orientation, and culture affect student learning. He highlighted the role of the curriculum developer in engaging students and challenging inequalities. SSHRC website helped us to the following definitions[1]. In short, while equity refers to offer the same opportunities to each person (Auclair et al., 2022), diversity is defined as having people presenting different identities mentioned above, while inclusion is defined as everyone (diversity) being respected, values and supported.

Several graphics were shared with the working group to promote discussions around equity, diversity and inclusion. Figure one was cited as influential by participants. It contains two important additions to a oft-seen graphic: an image to represent Inclusion and written explanations of how each graphic illustrated the stated principle. Diane noted that these descriptions were important to learners: her pre-service teachers struggled to see equity and justice in the illustrations without support.

[1] https://www.sshrc-crsh.gc.ca/funding-financement/apply-demande/guides/partnership_edi_guide-partenariats_guide_edi-eng.aspx#appendix-a

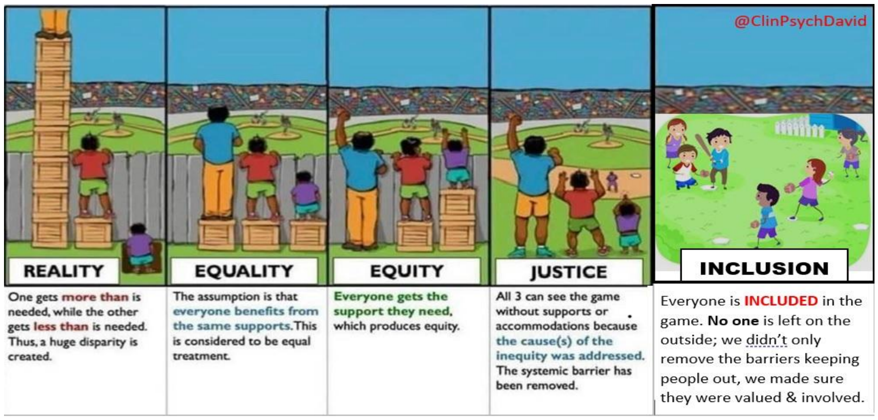

Figure 1. Graphic Illustration of Equity and Inclusion (Murphy, 2021)

We posed two tasks to participants to develop shared understandings. In small groups, participants discussed, "What lenses do we need to consider for teaching coding/computational modeling equitably?" After a whole group discussion, participants were asked to consider examples and counterexamples of equity, diversity and inclusion in the coding/ computational thinking area. From these discussions, the following themes arose as EDI concerns within teaching coding and computational thinking:

Equity concerns that arose from the discussion were providing opportunities for all students to learn. Equitable access to technology and opportunities to learn were highlighted given the important learning and job possibilities that computational thinking provides (McCandless, 2018). Only providing coding instruction in summer camps and more affluent schools were areas of concern. Additionally, participants thought it was important to understand how artificial intelligence could be designed to perpetuate racism and stereotypes.

Diversity discussions centered around principles that all learners could "*see themselves in*" coding and computational thinking, remembering that individuals transcend categories of race, gender (intersectionality). Participants discussed bringing in culture, language, celebrations, but warned against superficial attempts such as making a Rangoli for Diwali. Diane shared that Scratch allowed students to code in multiple languages.

Related to equity and diversity is **inclusion**- ensuring that everyone is included and valued. Inclusion discussions included strategies to make the learning activities accessible to diverse ways of thinking (neurodiversity). Groups discussed implementing a variety of teaching strategies and representations. Creating learning communities where students support each in collaborative knowledge generation was stressed by several groups. Also important was allowing students choice: choice in tasks, and in strategies for approaching planning and problem solving.

The participants also discussed a variety of strategies to make all learners feel valued including tasks that are relevant to a variety of learners to encourage engagement and motivation. They stressed the importance of supporting students who are struggling and the importance of discussing the emotions that often accompany coding- even professional coders experience frustration and develop strategies to work through the frustration. Finally the participants stressed the importance of educators to build relationships with students.

Connecting EDI to the 5A's

After these initial explorations of equity, diversity and inclusion, we aimed to strengthen their connections to coding and computational thinking in mathematics education. We chose to use Gadanidis's lens of the 5As- 5 affordances of CT (Figure Two).

In planning the working group, we struggled to find a lens that would help us analyze and work with BOTH EDI concerns and computational thinking. We decided on the 5As as a framework (Gadanidis et al., 2020) to connect computational thinking to Equity, Diversity and Inclusion issues. To that end, we considered the 5A models of affordances of computational thinking. The affordances are: Access, Agency, Abstraction, Automation, and Audience. In summary, Access refers not only to access to tools in socioeconomic terms, but also to the "low floor & high ceiling" design of tasks in which young students can be engaged with minimum prerequisite knowledge to investigate complex/rich mathematical ideas. Agency "allows students conceptual freedom to investigate ideas and concepts of interest" (p. 200). Abstraction regards fundamental characteristics and/or processes of concepts, emphasizing the emergency of tangible feel in coding. Automation, as a process that operates automatically related to algorithmization, highlights the dynamicity of coding and modeling and brings up the joy of surprise and insight in mathematical activity. Audience refers to the possibility and relevance of sharing codes and models with others, who can re-use/re-mix them as well as improve the performance of codes and models.

Of note, Gadanidis and colleagues write extensively about the affordance of CT to support mathematical thinking- here represented by abstraction. Students can make a conjecture and then test it with code, receiving immediate feedback to whether their conjecture worked.

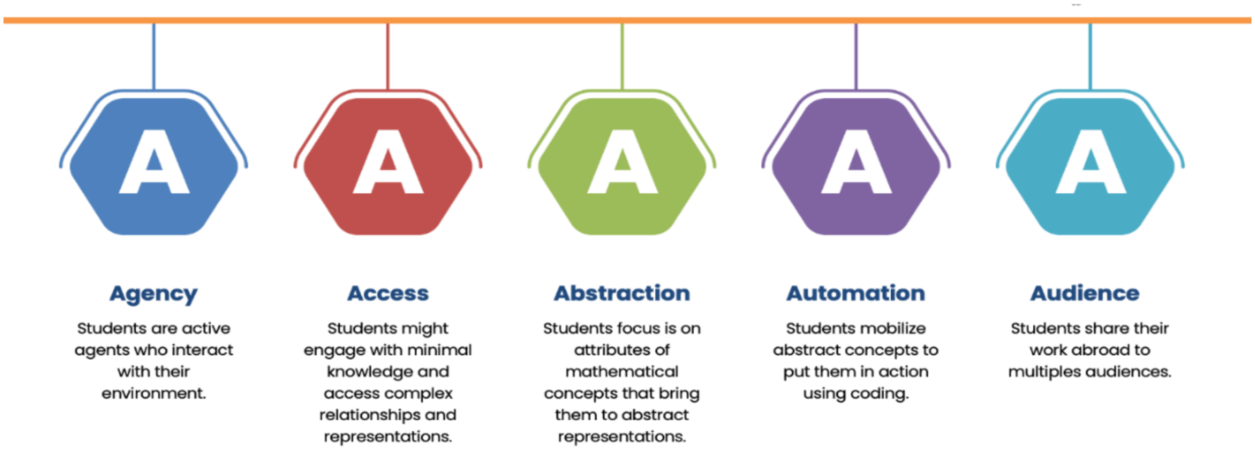

Figure 2. 5As: Five affordances of CT to Support Elementary Mathematics Education (Based on Gadanidis, 2017)

After a brief introduction of the five affordances, groups were asked to connect EDI concepts to one A on white boards for a change of modality. Groups embraced the challenge, using the 5A lens to categorize EDI concepts discussed previously, while raising new issues and developing practical strategies. Two groups graphics and subsequent discussions are discussed here to illustrate the nature of the small group discussions.

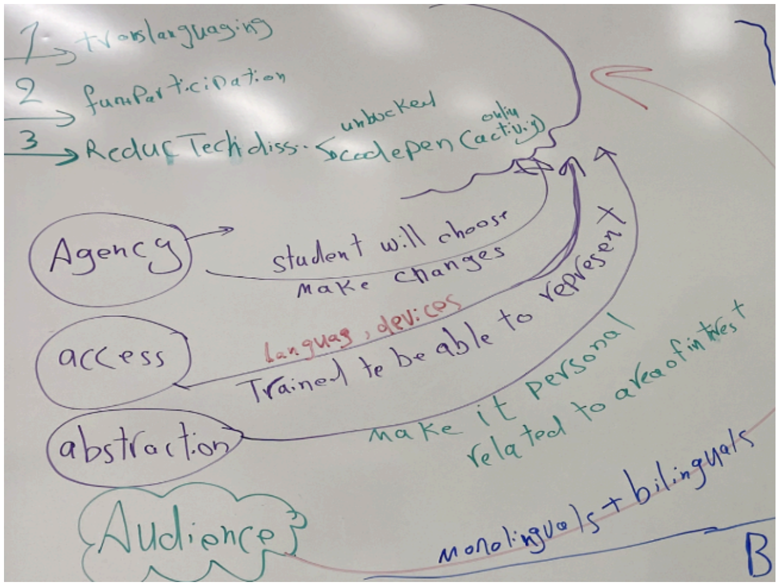

Figure 3. Connecting EDI and the 5 As - Group One

For example, under audience and access group one - a group containing many English language learners and a teacher of immigrants, discussed the issues of translation and monolingual and bilingual audiences (Figure Three). They also discussed access in terms of access to technology and the importance of unplugged activities.

Group 2, with many experienced CT teachers, saw many connections between the 5As as indicated in Figure Four by dotted lines. This group detailed classroom considerations and strategies. For example, for accessibility, they identified the importance of language capabilities, background knowledge and various ways to demonstrate learning. They also noted the importance of access to start the activity (low floors). For abstraction, they stressed links to mathematical thinking including generalisation and rules. They also noted the value of coding for creating multiple representations of the mathematical concepts and immediate feedback on those ideas.

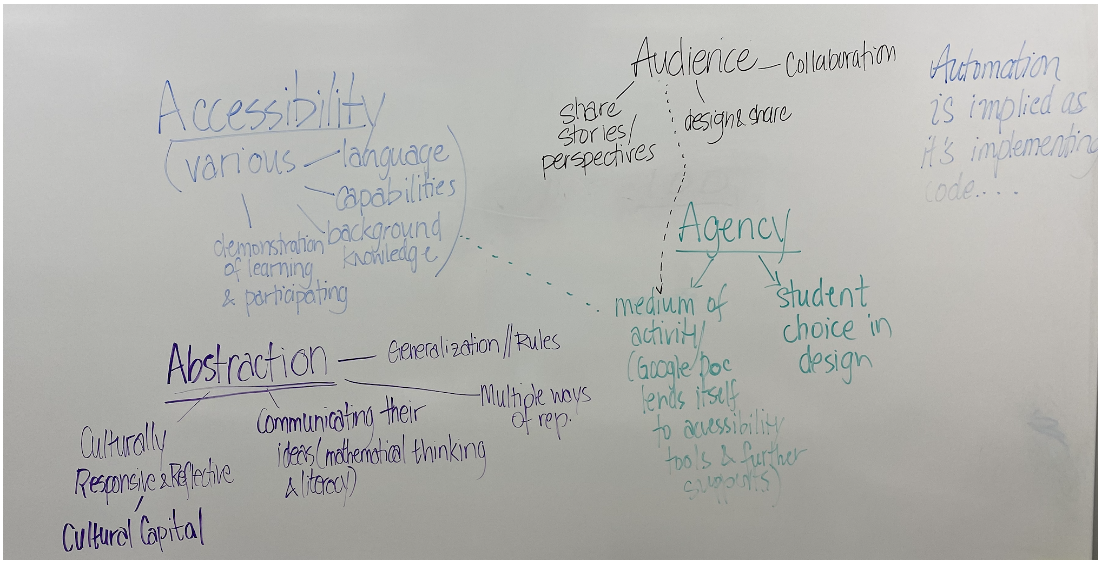

Figure 4. Connecting EDI and the 5 As - Group 2

Through discussion around the 5As framework, participants made multiple connections to existing knowledge frameworks. Sheree Rodney understood agency through Pickering's (1995) perspective. He defines agency as the influence of one thing onto the other (students and technology). He believes that in performing a task the human (students) and the non-human (technology) are engaged in a back-and-forth interplay of resistance and accommodation which he called “the dance of agency”. He argues that learning takes place within this dance of agency.

This contrasts to Gadanidis’s agency that refers to students having control and choice (Gadanidis 2017, Gadanidis et al. 2019). Gadanidis and colleagues argue that this agency engages students and through that motivation leads to learning.

This in-depth exploration continued between workshop sessions and even after the symposium with participants continuing to explore how EDI considerations could push the affordances of learning CT. One participant, Sheree Rodnee, continued consider how EDI connected with the 5As after the symposium sharing the following graphic with the facilitators. Sheree concieved EDI as the center with connections to the 5As. Under Equity & Automation, Sheree listed equitable access to digital resources which the first author connected to Gideon Christian’s keynote about many inequitable use of facial recognition (Buolamwini, 2017)) and the use of banking apps where area codes are used to build racism (Beckles, 2021).

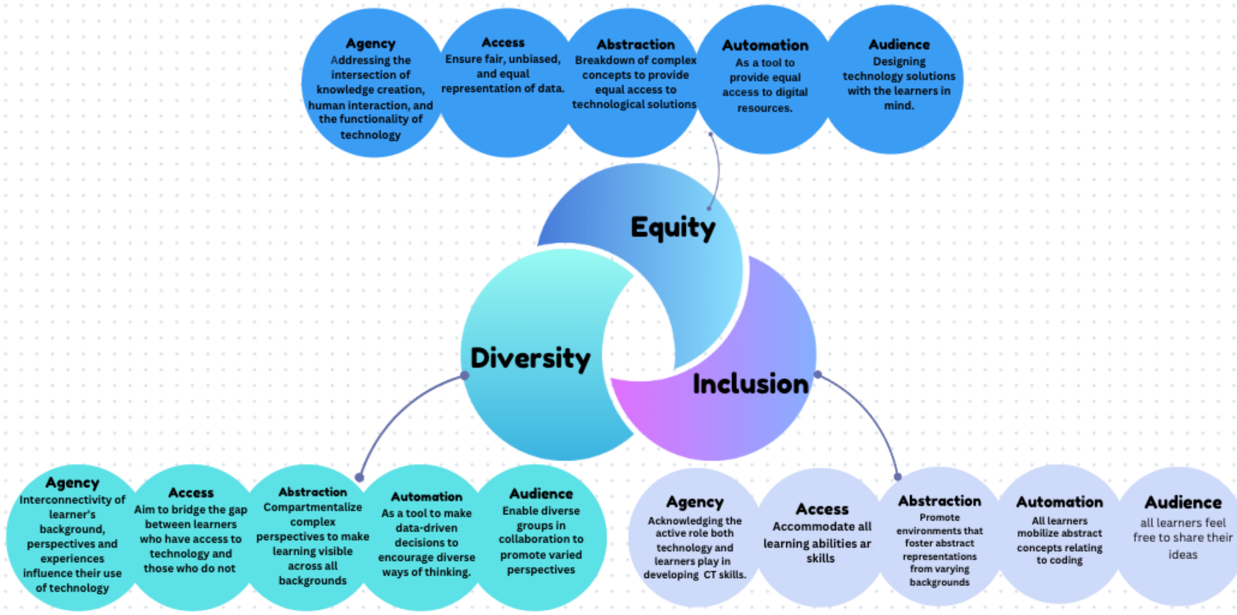

Figure 5. Ongoing exploration of the connections of The 5As and EDI - Sheree Rodney

This rich diagram is worthy of an extended discussion that is not possible in this proceeding. This need for extended conversations is characteristic of this working group. The discussions were productive, but participants noted they wanted to continue the discussions.

The Task Adaptation Activity

On day two, the participants were tasked with applying their understanding of EDI issues in coding/computational thinking to adapting a task. Some tasks were provided to seed the conversations as were resources on AI, unplugged activities, less colonial views of coding.

Some groups worked with provided materials; others chose tasks from their experiences. In all cases, all participants adapted our general task to their own interests and perceptions. **NO PROCESS was imposed** as highlighted as an important characteristic in our EDI conversations..

One group chose to examine an activity from Erica's class through the 5A & Equity lens. In this coding activity, students are scaffolded to draw a variety of polygons and spirals with lots of areas for choice and different processes. The group recorded their thoughts as comments in the google doc. As visible in Figure 6, the group noted the agency in choice and the access in low floors. Marja suggested diagnostic assessment to determine if more work is needed on mathematics vocabulary.

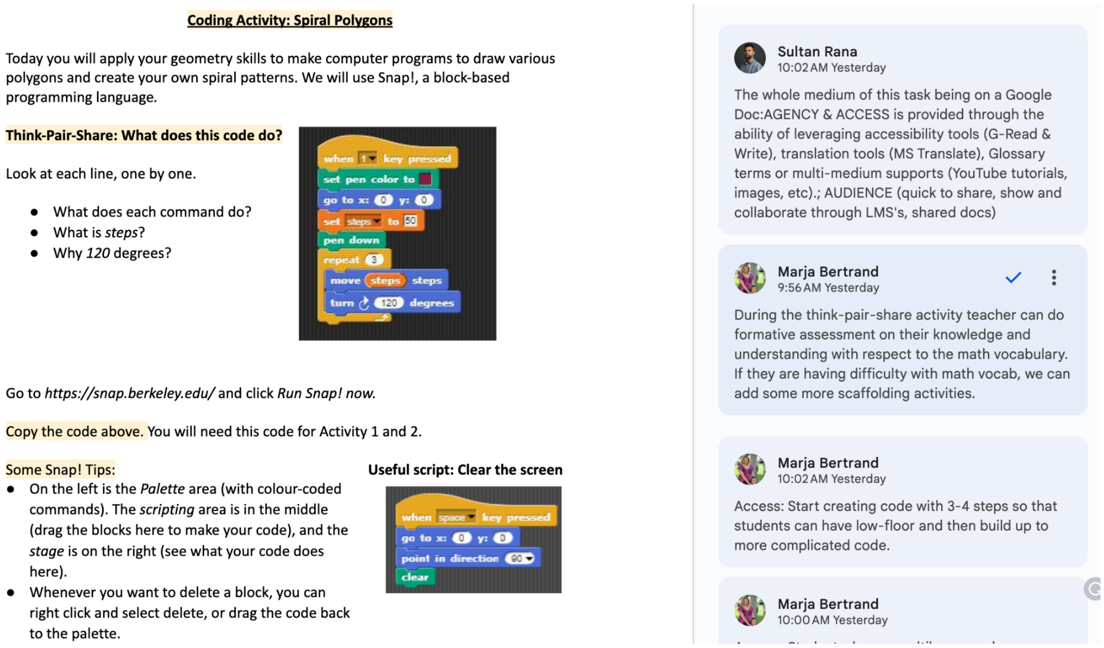

Figure 6. Analyzing a Scratch Task for the 5As and EDI considerations.

Another group examined an activity that Eleanor regularly uses with adults who have recently immigrated to Canada. Codepen is a Social Development Environment for creating web pages Social Development Environments are real-time collaborative programming tools with integrated social networking features.

Eleanor's group discussed how this tool allows many of the 5As and EDI while allowing new immigrants to develop important skills. The site provides agency in terms of choice, and access in low floors and many supports. In creating websites, the creators have immediate audiences.

One of the ongoing Equity challenges with coding is access to technology for all learners. Unplugged activities are often promoted to develop CT where learners do not have regular access to computers or the internet.

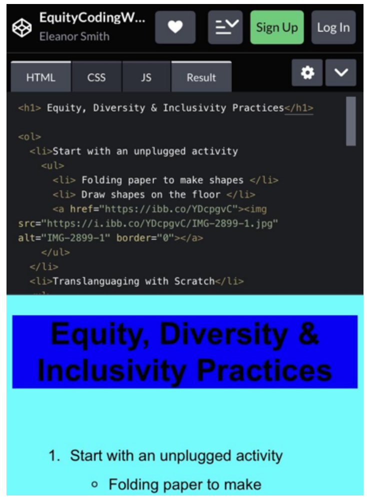

Figure 7. Analyzing a Codepen Task used with new immigrants

However, many of these unplugged activities lack the engagement and immediate feedback that is associated with coding.

Carolina's group explored some paper folding activities that transformed the shape activity into seeds.

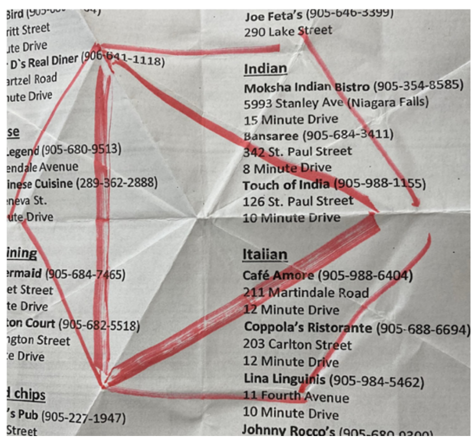

Figure 8. Example of a paper folding activity.

The purpose of the activity was to explore how we should fold and make a single cut in the paper to create regular polygons. Therefore, the idea was to work on the relationship between the central angle and the sides of the polygon, discussing mainly issues related to abstraction and patterns. In the image we can see an example that refers to the construction of a triangle and a hexagon, which in theory, when divided in half repeatedly, we have all polygons with 3, 6, 12, 24, 48,... sides.

This disconnected activity impressed the larger group as it quickly provided visual feedback.

Conclusion

In creating this working group, the facilitators aimed to create activities that not only discussed EDI in CT, but also integrated those ideas into all activities. With that focus on inclusive practices, we asked participants to co-prepare the report to the larger symposium. Below we share the summaries of two groups that were indicative of the whole. One group summarized their key learnings and how the working group integrated these concepts throughout:

Equity

- Each person starts learning where they are based on their prior knowledge
- Each person is given the time and choices to proceed
- It is not open, but supported
- To choose language and to access students' previous knowledge and backgrounds
- Choice is part of EDI versus telling then what to do

Diversity

- Brought together diverse interest and knowledge
- Activity itself allowed for diverse interest and knowledge
- Diversity in terms of
  - Demographics (eg. geographical region)
  - Ways of thinking

Inclusion

- All playing, not just watching
- All of us are participating and contributing in the activity in different ways
  - Gideon learning
  - Immaculate & Joyce working together
  - Laura supporting
  - Amy observing and reporting

Another group summarized their learning by examining the EDI considerations needed in planning, implementing, and assessing connecting to previous conversations about equity, Diversity and Inclusion in CT (Table 1).

Table 1. EDI considerations needed in planning, implementing and assessing

Planning the task	**Implementing the task**	**Assessing/Building from the task**
Building who and where students are. Reframing the task with EDI principles	Enacting the task with EDI principles. Observing students and create conditions for agency in regard to EDI.	Taking from where the students are and want to go.

Throughout the working group, participants were asked to share their insights and perspectives. Participants noted that the task connecting understandings of Equity, Diversity and Inclusion to Gadanidis's (2015) 5A framework was very productive. This task provided a rich framework for discussion and extending our understandings of EDI when implementing coding and computational thinking into the classroom as evidenced in section 4 above. Participants noted that the activities helped them better understand the terms equity, diversity and inclusion:

> "I Gained a better understanding of the differences between equity, diversity and inclusivity."
>
> "I found the extensions from EDI to Decolonization and Indigenization thought Provoking when applying the As from Gadanidis' work"

Group members noted they "found this group was very respectful of each other views and a safe space to share your ideas. I learned so much from both the facilitators and the group members" and the need for continued learning. This is "Only the beginning…"

Footnotes:

Our group chose not to define the term Coding and computational thinking (CT) as CT was the conference theme and we wanted to focus our attention on Equity, Diversity and Inclusion.

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