Application of the IBE-UNESCO Global Competences Framework in Assessing STEM-focused, Global Collaborative Learning within a Digital Makerspace Environment

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Abstract: This paper utilizes the UNESCO International Bureau of Education's seven global competences framework for assessing a global, computer-supported collaborative STEM learning project. The discourse from a meet-up between students in Kenya and the U.S was coded with these global competences. Epistemic network analysis (ENA) is used to evaluate for meaningful connections between the codes. Upon analysis of the data, lifelong learning and trans-disciplinarity exhibit the strongest connection, which supports the fundamental goals of the project – fostering critical thinking among students globally through media-making and discussion of STEM subjects. Furthermore, the two groups of students – Kenyan and American – demonstrated different strengths; the Kenyan students focused on self-agency and using diverse tools, while American students were content-driven. These complementary behaviors collectively exemplify the seven global competences and are an example of building skillsets for future workforce environments.

Introduction

In the context of a rapidly changing world, future workplace environments demand evolving needs and skillsets. In 2015, the United Nations adopted its 2030 Agenda for Sustainable Development, comprising 17 Sustainable Development Goals (SDGs) to address global social and economic issues. SDG #4 identifies quality education as a means to improve quality of life and empower talent to develop solutions to the world's problems. In particular, Target 4.4 within this quality education goal seeks to "substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship" (United Nations, n.d.). Target 4.4 advocates a call for education to better prepare future generations with the skills and knowledge for anticipated workforce needs.

This paper focuses on a project that involves global, computer-supported collaboration within a network of informal, digital makerspace clubs focused on science, technology, engineering and mathematics (STEM) learning. The network is comprised of adolescent youth participants overseen by teachers that provide oversight for the club sites. Participants engage in developing multimedia artifacts around STEM topics and engage in online global meet-ups in their collaboration efforts. In fostering an intersection of learning, technology and cross-cultural collaboration among the future generation, this project offers a unique opportunity to address competency needs related to SDG4 in the context of a changing industry and workforce landscape. The global competences identified by the International Bureau of Education (IBE) at the United Nations Educational, Scientific and Cultural Organization (UNESCO) are used as a framework for this analysis.

The global competences framework was synthesized following extensive consultation with internationally recognized thought leaders in education, technology, industry, and the workforce. Published in 2017 under the title "Future competences for future generations," the framework seeks to address the anticipated needs of the Industry 4.0 future, which involves navigating a more complex integration and optimization of technology in the work environment and social life (Marope, 2017). This evolving industry outlook calls for a shift in the learning paradigm to develop capacities to "interactively mobilize information, data, technology, knowledge, skills, values, and attitudes, and then use them ethically to engage effectively and act across diverse 21st century contexts for individual, collective, and global good" (Marope, 2017, p. 86). These capacities are reflected in the framework's seven global competences to address the need for "multifaceted, transdisciplinary, technology savvy, and integrated competences" (Marope, 2017, p. 86). Within each global competence (also referred to as macro-competence) is a subset of micro-competences that are adapted based on context. The global and micro-competences are illustrated by utterances from the transcript utilized for this paper:

- **Lifelong learning:** The adaptive micro-competences include curiosity, creativity and critical thinking. This is exemplified in the project as a willingness to learn through curiosity, creativity, critical thought, seen in devising projects, while curiosity and critical thinking are expressed through interactions, such

as asking questions and expressing opinions during video conference calls. Sample utterance from the transcript data: *"Please I don't know anything about Scratch and you claim (it) is the most basic coding language…will you please explain the Scratch a little bit?"* [Kenyan participant]

- **Self-agency:** The adaptive micro-competences include initiative/drive, motivation, responsibility, and endurance/grit/resilience. This is exemplified in the project as participants' eagerness to act on their interest, as seen through the creation/execution of media artifacts, and expressed in dialogue in video conference calls. Sample utterance: *"Now I think okay you have the interests of making people to know coding and it's starts with you now that you've informed me now that you've informed me can I then inform another person and then…"* [Kenyan participant]
- **Interactively using diverse tools and resources:** The adaptive micro-competences include impactful use of resources, efficient use of resources, and responsible consumption. This is exemplified in the project as finding different ways to learn and accomplish a task (e.g. looking at ways to learn coding; making use of tools around them; discovering new ways of using resources available). Sample utterance: "*…I think the best language to use for coding is Python because just gives you a hint on how coding is done so if you have a phone you can just download a version…the online version of Python and start creating codes.*" [Kenyan participant]
- **Interacting with others:** The adaptive micro-competences include teamwork, collaboration and negotiation. Interaction is the heart of what motivates the students to participate in the project. This is further seen in interest to work together on projects, listening to one another and giving feedback, negotiating roles to accomplish a task, asking for expertise and offering help and suggestions. Sample utterance: "*Now…you have the interests of making people to know coding and it starts with you… you've informed me…I then inform another person and then…*" [Kenyan participant]
- **Interacting in and with the world:** The adaptive micro-competences include being local and global, balancing rights with privileges, and balancing freedoms with respect. This is exemplified in the project as raising cross-cultural awareness and recognizing and learning from what makes us the same and different (e.g. finding commonalities in subject matter regardless of context, such as finding commonalities in their education systems). Sample utterance: "*You are in an already developed country and we are in a third world country such as Kenya…what do you think should be implemented so that kids who are very passionate...to learn coding at a very tender age as you started?*" [Kenyan participant]
- **Trans-disciplinarity:** The adaptive micro-competences include STEM, humanities, and social sciences. This is exemplified in the project as a focus on academic subject matter, making connections to the practical world around them (e.g. how coding helps create games to promote learning in other subjects; exploring the science behind music). Sample utterance: "*We start with Scratch then we move to xSpace and then we move into Java or Python.*" [U.S. participant]
- **Multi-literateness:** The adaptive micro-competences include reading & writing, numeracy and digital literacy. This is exemplified in the project as learning expressed in action through creation of tangible multimedia artifacts that synthesize their knowledge and skillsets (e.g. videos, games, presentations). Sample utterance: "*What 3D coding is we code something that turns into a virtual object and then we run it through a software that makes it out of plastic and it turns into a physical object.*" [U.S. participant]

Methods

In order to meet the needs of an evolving future workforce, education will need to go beyond the acquisition of distinct pieces of knowledge, skills and experiences to foster environments where learners can "intelligently make connections across elements of competence, then integrate them and apply them interactively" (Marope, 2017, p. 86-87). Therefore, it will be increasingly important for educational research to examine the interrelationships that exist between cognitive, behavioral, affective and social competences.

In this context, this paper utilizes epistemic network analysis (ENA), a technique in quantitative ethnography that uses visualization and statistical methods to identify meaningful patterns in discourse. ENA is a methodology grounded in epistemic frames theory, which posits that "learning can be characterized by the structure of connections that students make among elements of authentic practice" (Shaffer & Ruis, 2017, p. 182). ENA operationalizes this theoretical approach by modeling the connections between salient constructs in the data, particularly by examining the co-occurrences of codes within conversations (Shaffer, 2017). ENA also allows for quantitative comparisons between epistemic network models through the calculated centroids, which are determined by the strength of connections between the codes. Furthermore, in its ability to capture complex

learning processes as they occur, ENA also provides an effective methodology for conducting learning assessments that are both summative and formative (Shaffer et al., 2009).

The data for this analysis was collected from an 80-minute video conference call (described in the project as a "meet-up") held in May 2017 between 12 participants from project sites in Kenya (4 students, 1 adult) and the U.S. (4 students, 3 adults). In the meet-up, participants shared knowledge and experiences about computer programming tools and languages, including Scratch, Python and HTML. The discourse data was coded using UNESCO's seven future global competences: lifelong learning; self-agency; interactively using diverse tools and resources; interacting with others; interacting in and with the world; trans-disciplinarity; and multi-literateness. A total of 235 utterances were coded by three raters for the presence of the seven global competences. This was followed by a process of social moderation undertaken for each utterance, which allowed the three raters to reach consensus on the coding of the data (Frederiksen et al., 1998; Herrenkohl & Cornelius, 2013). The ENA web-tool was used for visualizing and analyzing the coded data.

Results

Figure 1 presents the ENA model of all participants in the meet-up, where nodes represent the global competences and the thickness of the edges indicate the strength of connection between them. The strongest connection can be observed between lifelong learning and trans-disciplinarity. During the meet-up, participants from both Kenya and the U.S. frequently exhibited a keen desire for learning—as reflected by their curiosity, creativity and critical thinking—along with interests in acquiring skills and knowledge in a variety of domains and topics. Other significant associations can be found among self-agency, multi-literateness, trans-disciplinarity, lifelong learning and the use of diverse tools and resources. However, the two interactional competences (interacting with others, interacting in and with the world) have relatively weaker connections to the other constructs.

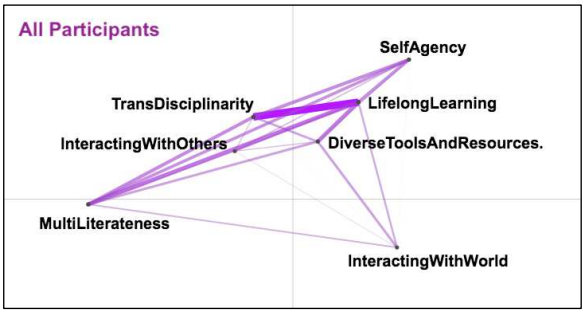
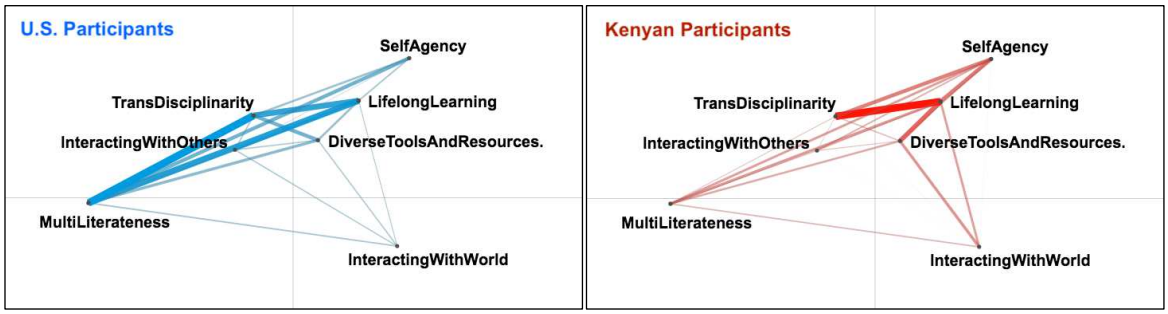


Figure 1. ENA network model of the meet-up discourse for all participants.

Figure 2 shows the ENA network models for the Kenyan and U.S. participants, respectively. While key differences can be observed between the two network models, the link between lifelong learning and trans-disciplinarity remains prominent for both groups. The x-axis is defined by connections to multi-literateness on the left and connections to self-agency and interacting in and with the world on the right. For the Kenyan participants, the discourse pattern shows a heavier presence on the right, with relatively stronger connections to self-agency, lifelong learning, trans-disciplinarity and use of diverse tools and resources. This is indicative of the initiative, motivation, and resourcefulness demonstrated by the Kenyan participants in the meeting. In contrast, the discourse pattern for the U.S. participants is situated more to the left side of the ENA space. Multi-literateness is heavily associated with both lifelong learning and trans-disciplinarity. This may be reflective of the students' experiences with STEM-related activities at school, emphasizing problem-solving in an interdisciplinary setting.



(a) (b)

Figure 2. ENA network models of the meet-up discourse for (a) U.S. and (b) Kenyan participants.

Discussion

The discourse pattern of the computer-supported meet-up shown in Figure 1 demonstrates the strongest connection between the lifelong learning and trans-disciplinarity global competences. Without the use of ENA, the overall connection between these two competences would not have been clear through their frequencies alone. Furthermore, the connection between lifelong learning and trans-disciplinarity exemplifies the fundamental aims of the IC4 project. The baseline goals of this project are to foster conversational and critical thinking skills coupled with STEM subjects between students across the globe. Lifelong learning–curiosity, creativity, and critical thinking–best showcases the aforementioned conversational and critical thinking skills; trans-disciplinarity covers conversational topics related to STEM subjects, humanities, and the social sciences. The strong relationship between these two global competences as shown in the ENA models align these basic learning and topic-related aims of the project, meanwhile giving the project a path towards the development of more collaborative and interactive competences in the future. While this meet-up does include conversation between Kenyan and U.S. participants, the two groups of students demonstrate differences in their contributions to the conversation as reflected in their ENA network models: while the U.S. participants supply content-driven commentary (coded for as multi-literateness), the Kenyan participants show a stronger inclination towards self-agency and the use of diverse tools and resources. Ultimately, both groups of participants typify the global competences through relatively complementary behaviors, each bringing something different to the table.

In a broader context, this project examines global collaboration in the context of a STEM-focused digital makerspace community as way to develop and identify future learning environments in a changing workforce industry. As the global competences represent a framework to address the needs of future workforce environments, this paper is an initial attempt to evaluate how this project can address such competences. Participants demonstrated critical thinking and awareness that would not have necessarily been observed without involvement in this project. Particularly, the students' computer-supported collaborative discussion of coding demonstrates Target 4.4 of SDG #4 as the students educate each other on technically relevant skillsets. The results discussed in this paper provide a preliminary validation of the use of the global competences as a framework for assessment. In future analysis, ENA can be utilized to examine how the competences are addressed and how the relationships between concepts change as the project progresses, giving rise to youth gaining skills to solve problems globally and collaboratively together for the future.

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