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FRAMEWORKS AND AFFORDANCES FOR INTERNATIONALLY DISTRIBUTED COLLABORATION (IDC) BETWEEN SCHOOL-AGED STME LEARNERS

Eric Hamilton*, Danielle Espino, and Seung Lee
Pepperdine University, Malibu CA 90263, USA
eric.hamilton@pepperdine.edu

This paper engages multiple strands of interest, including sociocultural studies of STME, cognitive and affective studies of STME, and Language, Pedagogy, and Curriculum in STME. It originates in but does not limit itself to a US-based project for middle grade through college students in SubSahara, Finland, Brazil, Iran, India, and the US. The students collaborate on digital makerspace projects through video conference and through asynchronous virtual tools. This type of internationally distributed collaboration (IDC) with school age learners, while currently rare in educational settings, is likely to become more ubiquitous in coming years. The paper introduces the project as an exemplar of IDC involving school-age learners, and reviews two aspects of its research methodology.

INTRODUCTION

For the purposes of this paper, Internationally Distributed Collaboration, or IDC, refers to computer-supported collaborations that are both synchronously and asynchronously virtual. Scenarios of interest involve teams whose school-aged participants (or teachers) reside in different countries or cultures and who collaborate on specific science, mathematics, or technology education (STME) challenges or projects in the context of formal or informal educational settings. A multiyear research effort supported by the US National Science Foundation (NSF) serves as exemplar for a discussion on IDC more generally, and for the theoretical frameworks they entail and the affordances that they provide. The session will include results from that IDC, involving students in the US and counterparts in Brazil, Finland, Kenya, Namibia, and Mexico.

IDC in the Workplace Versus School Setting
IDC in the *workplace* is common. Cross-national workplace teams come in all varieties, and include members not only from different countries, but also different cultures, economic backgrounds, and generations. Contemporary video- and tele-conference technologies enable shared virtual presence for synchronous collaboration and communication in the workplace. Virtual presence enables participants to cross geographic, cultural, generational and other boundaries. Virtual teamwork across international boundaries is already a ubiquitous part of many work environments, and certainly integral to the work life of many, if not most, attendees of the biennial epiSTEME conference, for example.

Extensive IDC, however, remains relatively impractical in most current *educational or school settings*. The two most salient differences are age (young person versus adult) and setting (workplace versus school or

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learning environment). Logistical, privacy, and technological limitations impose practical impediments to widespread implementation. Additionally, complex IDC does not currently have the driving force in school practice that characterizes the need for adults to collaborate in the workplace so increasingly defined by globalization.

Yet each factor limiting such collaborations between young people in learning settings is manageable, and the expansion of social connections in global society will inexorably drive distributed teamwork in learning settings (Hamilton and Owens, 2018). One indicator that IDC ecosystems in STME settings can be realistically anticipated in the near-term future involves the agency funding the project appearing below. NSF recently supported a series of nine workshops to garner insights from prominent scholars in the areas of learning technologies and learning sciences. The agency sought to formulate long-term strategies for its research funding, and positioned IDC and other forms of collaborative "boundary-crossing" as one of a small number of areas to support for consideration for coming research funding (Hamilton, 2018).

International Community for Collaborative Content Creation (IC4)

The agency currently supports a prototype effort, called the International Community for Collaborative Content Creation (IC4) (Hamilton and Culp 2016). This multiyear research project has reached its midpoint as a network of school-based clubs in Kenya, Namibia, India, Brazil, Finland, and the US. (A small club in Iran does not affiliate with any school.) As an effort funded by the US government, about one-third to one-half of the participants participate in US clubs. NSF, along with various other organizations support clubs in the other five countries.

IC4 operates with the dual goals of offering rich learning experiences through its after-school club structure while carrying out design research emphasizing a blend of informal science and mathematics learning and makerspace collaboration across national, income, and cultural differences.

Makerspaces, as much or more than any current approaches in education, are often defined by physicality and by the opportunity they provide learners to manually experiment and construct artifacts that embody social cognition and obligate or spur intellectual growth (Peppler, Halverson, & Kafai, 2016). Among the most prominent makerspace domains are robotics, circuit board experiments, and 3D printing. A subset of the makerspace movement, though, involves digital activities. Among the best-known activities involves videomaking, games, coding, and commercial products such as Minecraft (Rippa and Secundo 2018).

This larger view of makerspaces encompasses the past decade's revolution in user-created digital media content. Because it takes place over internationally distributed virtual spaces, the IC4 project primarily (but not exclusively) falls into this subset of the makerspace movement. Figure 1 depicts the students in several countries sharing videos and other presentations that they have co-produced in what is called a global meetup – a synchronous videoconference.

The online global meetups of the type that Figure 1 depicts have emerged as a key component in building the IC4 community. The opportunity for visual, synchronous communication both motivated and built social

trust among the participants, increasing the depth of interactions with time and experience. As more meetups have taken place, a shared understanding of the culture and behavior at meetups has emerged (Hamilton and Owens 2018). This includes a shared understanding of the roles within the meetups, such as a facilitator that guides the conversation and presenter(s) who share their paroject. With increased social trust built from meet-up experiences, comfort in interacting with one another across cultural and national boundaries has expanded. Makerspaces provide a rich context not only for innovative student learning experience, but also for research on learning and uncovering valuable insight for the effective design of future learning environments.

Figure 1: Students from elementary, middle, and university level settings in Finland, Kenya and the United States, in global meet-ups to discuss science and computing projects

Learning environments of the future will include routine and flexible, internet-mediated synchronous and asynchronous project collaboration (Dede 2010). Collaborations around making, or artifact creation in cross-cultural settings, obligate a variety of constructs and practices likely to alter and reshape future conceptions of learning. Among these constructs are three that IC4 emphasizes as an internationally distributed collaboration: social cognition, participatory teaching, and help-giving (Hamilton and Owens 2018, Hamilton and Kallunki in press). These types of phenomena are likely to emerge in dynamic and highly positive forms in the future.

RESEARCH METHOD

As a sponsored research project, IC4 yields multiples strands of data. Its flagship methodology involves

quantitative ethnography (Shaffer 2017) and the epistemic network analysis (ENA) software tool. QE and ENA allow the research team to examine changes in the epistemic frames (Knight, Arastoopour, Shaffer, Shum & Littleton, 2014) of participants that relate to multiple constructs of interest. We examine approximately 20 constructs. Epistemic frames are somewhat analagous to the construct of funds of knowledge (Moje, Ciechanowski et al. 2004), i.e. the totality of unique experience, enculturation, beliefs, experiences, etc., that an individual brings into a social setting. Some of the most prominent of these include curiosity, self-awareness, feedback, content-focus, participatory teaching, knowledge acquisition, cross-cultural awareness, and social disposition.

ENA software models the structure of connections in data based on subject discourse patterns. ENA assumes it is possible to systematically use discourse to identify and code the constructs of interest, that conversational discourse structures data, and that construct connections within discourse are meaningful and important (Shaffer and Ruis 2017, Shaffer 2017, Siebert-Evenstone, Irgens et al. 2017). ENA models the connections between codes as construct proxies by quantifying their co-occurrence within conversations, producing a weighted network of co-occurrences, along with associated visualizations for each unit of analysis in the data. ENA yields a graphic depiction of the networks simultaneously, resulting in a set of networks that can be compared both visually and statistically. This method is treated in more detail elsewhere (e.g., Espino, Lee,
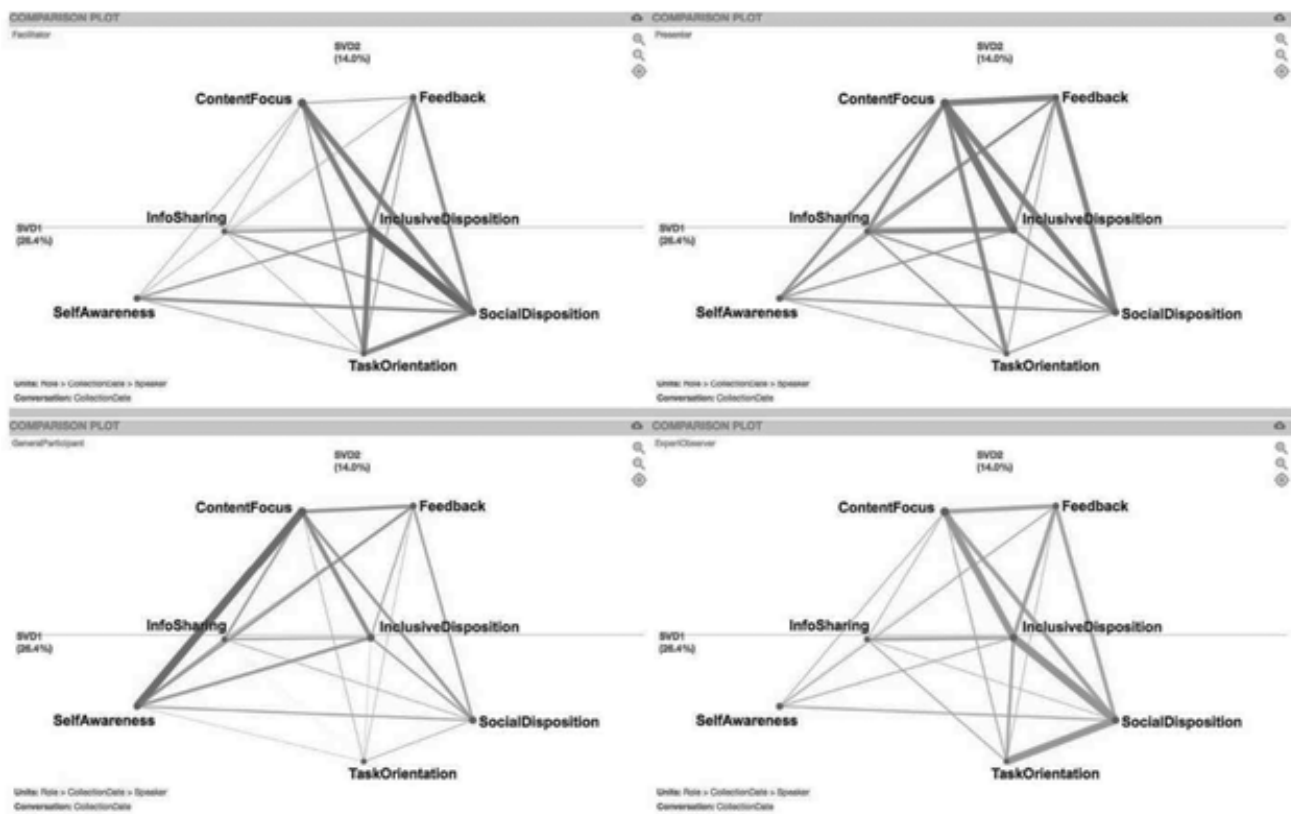

Figure 2: Discourse patterns demonstrated by different roles in IC4 online global meet-ups in 2017. The ENA models show how each role exhibited different patterns that are distinct from each other

Eagan & Hamilton, 2019), but Figures 2 and 3 furnish dual views of data. Figure 2 shows four ENA graphs representing teams from US and Kenyan sites from one of the IC4 global meetups in which students presented STME videos they prepared. These graphs document the emphases and connections that IDC students made in their conversation. The more saturated an edge between two nodes, the more frequently individuals in the group connected the associated constructs in the coded conversations. It can be taken as a given that groups will vary in their conversational emphases, though this type of analysis allows researchers to dissect conversations and visually depict with statistical frequency the connections that constitute the interactions.

Figure 3 provides data that more substantively illustrates the potential for visualization, beyond merely documenting differences between groups. It involves a case study involving one Kenyan participant's discourse patterns from over a one-year period. The student's contributions to collaborative conversations matured. The student evidences more integrated and expansive discourse patterns.

ENA thus depicts socio-affective, cultural, and academic variables – and, of crucial importance, the connections between them – that constitute epistemic frames of individuals and groups. Because they are sensitive to changes that discourse patterns reflect, they have proven valuable in assessing the nature and size of effects of IDC with school-age children.

Figure 3: ENA models depict discourse pattern changes by one Kenyan student in her interactions with peers in Finland and United States

ENA's underlying principle that discourse reflects the enculturation and cross-enculturation processes of internationally distributed collaboration with school-aged learners is complemented in IC4's use of cultural-historical activity theory (CHAT) (Greeno 2016) as another guiding framework for articulating how IDC for school-aged learners can function.

A common premise of the learning sciences is that activity mediates learning. Rather than preceding or preparing for activity, in other words, learning is embedded in activity systems. This is a key tenet of CHAT. The various constructs of actors, rules and norms, instruments, community, and outcomes form the activity systems that mediate learning (Greeno 2016).

Cross-Cultural Significance

More importantly, treating IDC through a lens that focuses on cross-cultural, cross-national shared activity in a virtual space, in pursuit of outcomes (such as STEM challenges or other digital artifacts) changes terms by which school-age learners form perceptions of self and others in parts of the world or in cultures that are remote to them. The virtual collaboration space, especially in synchronous video settings, enables visual communication with peers in other countries and cultures to take place from the familiarity of a student's own culture and context (Hamilton 2018). This neutralizes uncertainty, anxiety, or mistrust about those who live elsewhere. It does so by hybridizing physical presence - where the student is enculturated - with virtual presence in a collaborator's country and culture.

This phenomenon is familiar to adults accustomed to international virtual collaborations. For young learners, though, IDC provides opportunity to form understandings of the world by engaging those in other countries and cultures in an anxiety-neutral manner. In a world where strife and mistrust germinate because of geographical differences, there is opportunity to invent fresh ways for school-age learners to understand those who do not live near them nor like them. This compelling dynamic applies not only to geographic boundary-crossing, but to cultural boundary-crossing that can occur within a country, a region, or even within a city (Hamilton 2018). Displacing geographic or tribal perceptions imposed on a learner by parent or their immediate social system with productive collaboration as the primary basis for understanding those in other parts of the world may be an even more important contribution than purely advancing STME competences.

Forthcoming Directions

A recent "Rapid Community Report" (Hamilton & Espino, 2019) published by the Center for Innovative Research in Cyberlearning (CIRCL) defined several constructs foundational to IDC, including boundary-
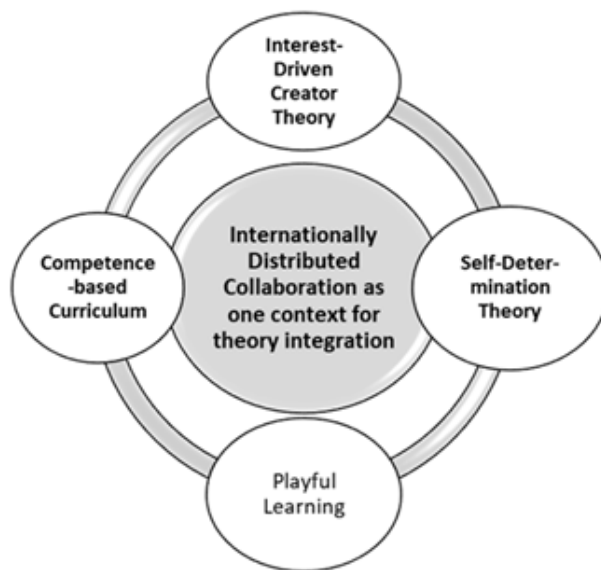

Figure 4: Research in Internationally Distributed Collaboration (IDC) can serve as a venue for synthesis and integration of important and emerging theoretical frameworks relevant to future education practice

crossing, virtual presence, interactional bandwidth, and social trust. Each of these play a critical and multi-level role in future IDC research. The Rapid Community Report also discusses the relationship between a) principles of cultural-historical activity theory reviewed in this paper; b) the emerging curriculum paradigm of interest-driven creator theory (another IDC acronym!) gaining traction as a coordinated focus of Asian researchers to reshape dominant test-driven policy patterns in their countries (Chan et al., 2018); and c) self-determination theory (Deci & Ryan, 2011) as a framework for understanding how IDC can simultaneously nurture three "primitives" of healthful personality integration, including relatedness, autonomy, and competence.

These each add definition and context to future research in IDC. Three other areas merit note in building a strong theory base for IDC research. Playful learning (Kangas & Ruokamo, 2012; Nousiainen, Kangas, Rikala, & Vesisenaho, 2018), emerging from Finnish educational research, appears to complement interest-driven creator theory from Asian education research. The international trend towards competence-based curriculum (e.g., Marope, Griffin, & Gallagher, 2017) surprisingly resonates strongly with interest-driven creator theory and playful learning in its emphasis on how to transition knowledge to effective functioning. The notion of a knowledge economy or a knowledge society increasingly appears obsolete or inadequate relative to the notion of competence across multiple domains as a step beyond knowledge formation. Figure 4 depicts the potential of internationally distributed collaboration (IDC, spelled out here to distinguish from interest-driven creator theory) between school-age learners as a rich venue for synthesis and integration of these theoretical frameworks. Such synthesis and integration in multiple venues will help to structure next generation and mid-century pedagogies

Finally, the fields of intercultural adaptivity or intercultural competence have garnered extensive attention and instrumentation in recent years. This literature, however, almost exclusively involves some variation of corporate, adult, or college populations. Similarly, it involves individuals who physically locate, permanently or temporarily, in cultures other than their culture of origin, or else are interacting with those from other cultures who now reside or work alongside them. Initial work in the area of intercultural competence formation among precollege adolescents, still in their earliest years of identity formation, has been undertaken by Schwarzenthal, Juang, Schachner, van de Vijver, & Handrick,(2017). One limitation attendant to surveys that track cross-cultural competence development formation is the suggestive nature of questions. Individuals may feel that parochial attitudes they hold do not align with expected normative responses. For this reason, one valuable direction for instrumentation for precollege intercultural competence assessment will be to develop survey questions that are embedded in other questions and in a way that minimizes implicit suggestions or priming of normative responses.

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