CONTEXTUAL FUTURES FOR SMART PERSONAL DEVICES

Interaction Archetypes in Global Teamwork

FALL 2016

UPDATE

mediaX at
STANFORD UNIVERSITY

Interaction Archetypes in Global Teamwork

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Project Description:

This team proposed Arche, a concept-proving project aimed to uncover interaction archetypes in global teamwork in a project-based learning context that educates the next generation workforce. The Arche project leveraged quantitative and qualitative data from global project team meetings to explore and develop innovative analytics, indicators, visualizations and feedback mechanisms. The Arche project integrated team members' biometrics and psycho-physiological sensor data in order to formalize interaction archetypes and improve team dynamics and well-being. Statistical analysis and machine learning algorithms were used to detect patterns and uncover better ways to quantify and analyze interactions in global teamwork. Arche researchers identified and visualized mood, arousal, valence, movement and temper at individual and group levels. Researchers developed performance indicators for productive, disruptive, and less effective interaction archetypes. These powerful interaction archetypes can provide a fresh lens through which researchers and educators examine distributed PBL education programs and distributed knowledge work settings. These investigations can serve to improve collaborative distance-learning and knowledge work, and provide recommendations for further developments of smart devices, applications, and workspaces to improve learning, teamwork, and productivity.

Acknowledgement:

The research-in-process reported here is underway at Stanford University under sponsorship by a mediaX Themed Research initiative, made possible by a gifts from mediaX members and strategic partners. This research initiative began with an inspiration from mediaX members that grew to include an international business community and an interdisciplinary group of researchers. Building on a firm grounding in fundamental science from previous research, Stanford's world-class expertise has been brought to bear on a real-world challenge.

Arche

Interaction Archetypes in Global Teamwork

Project Report Submitted to MediaX: CONTEXTUAL FUTURES FOR SMART PERSONAL DEVICES

September, 2016

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Project Context and Research Question

*Meet **Arche**:*

*It is 23:30PDT in California. Jim just concluded his weekly two hours, virtual project meeting with his team mates in Mexico, India, Denmark, Germany, and Poland. There were times when his heart rate was skyrocketing as he was leaning forward, making highly animated gestures, trying to convince his team mates that his proposal is the best way to address the problem at hand. Satisfied by his presentation he launches **Arche** on his smart devise after the meeting and asks:*

<u>Jim</u>: "How did I do?"

<u>Arche</u>: "You were engaged, stressed, and dominated the discussion. You need more space around you since you get excited and gesture a lot when you speak. You could have used more artifacts to express your ideas."

<u>Jim</u>: "But how did we do as a team?"

<u>Arche</u>: "It was an unbalanced participation in the team meeting."

<u>Jim</u> looks at the informative and colorful team interaction map displayed by Arche on his smart device and ponders… "Did we miss an opportunity to harvest other team mates' ideas?..."

Imagine having ubiquitous wearable sensors and smart devices that continuously track, measure, and integrate diverse biometric, physiological, emotional states and provide feedback to augment global team interaction, improve team dynamics, and unlock new team potential. Figure 1 illustrates an Arche-Jim feedback mock-up GUI vision showing a snapshot of a team interaction map of archetypes on a smart mobile device.

Figure 1. Arche vision mock-up GUI on a smart mobile device

Globalization and advances in information and communication technologies have led global teamwork across geographical and cultural boundaries to become a common practice in both education and industry. *Jim's* interaction scenario is typical for both project-based learning (PBL) education programs and corporate knowledge work. Global teamwork exposes learners and knowledge workers to five discontinuities - time, space, culture, discipline, and technology (Fruchter, 2014). Although they may first seem unrelated to learning, the five discontinuities put new interaction and cognitive demands on learners in terms of participation, engagement, and knowledge creation. Interaction and cognition depend on the psychophysiological state of learners and knowledge workers, and their learning or work environments.

The PBL Lab research team worked on a number of **Arche** rapid concept-proving prototypes to explore and uncover interaction archetypes in global teamwork in a project-based learning context that educates the next generation workforce. This is part of an on-going research effort in the PBL Lab aimed to address the following research question: *How can we use wearable sensor technologies and smart devices to find the story of who we are and what our team interaction dynamics is?*

Arche was an interdisciplinary research effort between the Project-based Learning Lab (PBL Lab) in Civil and Environmental Engineering Department in SoE and the Learning Design and Technology (LDT) program in GSE at Stanford during the Summer Quarter 2016. It connected educational scholarship about project-based learning with big data analytics, visualization, and design principles of collaborative global teamwork from engineering.

Education research has focused on identifying optimal learning scenarios for increased engagement. However, there are only limited post-facto qualitative approaches to assess engagement. Learning engagement in education is a highly researched topic (Education glossary, Craig & Silverstone, 2010; Schaufeli at al., 2006). The aim of these studies is to better understand when and how students engage in learning processes. Initial engagement is a predictor for learning success and productivity. Engagement is defined as effort without distress (Tattershall & Hockey, 2010), a meaningful contribution (Fletcher, 2005) enabled through vigor, dedication and absorption (Schaufeli et al., 2006), and a state of high focus under complex demands. Researchers seek to identify how education should be designed in order to better engage students. Questionnaires and observations are typical tools used to collect data on learner engagement with a focus on long term participation. However, these methods only provide qualitative subjective data at the individual level. Engagement at the individual learner level is necessary but not sufficient. We need to better understanding the interaction dynamics between learners in PBL global teamwork, and between learner and instructor.

We are experiencing an explosion of physiological and behavioral biometric smart devices that are coming to market due to advances in sensor technology. Sensor data is big data. It is richer and more complex, potentially enabling us to gain more interesting and valuable insights beyond what we can even realize today. It will allow us to make the learners' invisible state visible moment-by-moment and potentially nudge them to change behavior. To date most research and commercial smart devices and applications focus on individual's performance and well-being. **Arche** focused on team performance by leveraging and integrating team members' biometrics and psychophysiological sensor data to detect and formalize interaction archetypes to augment team dynamics and well-being.

Research Approach and Preliminary Outcomes

We used a multi-method approach combining qualitative and quantitative methods that enabled methodological triangulation. We focused on two units of analysis – individual team members and project team. Building on findings by Mehrabian and Ferris (1967) indicating that spoken words represent 7%, voice and tone represent 38%, and body language represents 55% in communication among participants, we focused our Arche R&D on:

1. Developing multimodal interaction analytics that integrated contextual video protocol analysis with quantitative speech and biometric body movement analytics and indicators focused on weekly two hour virtual project meetings.
2. Formalizing interaction archetypes in global teamwork focused on body movement, speech, tasks/activities and roles.

3. Using interaction archetypes to identify indicators that can improve participation, engagement that lead to high team performance and productivity.
4. Designing mock-up prototypes to explore ways to provide relevant interaction feedback to visualize team member interaction archetype and team interaction maps.

We utilized the existing large, rich data sets of global project teamwork readily available at Stanford's PBL Lab collected in the CEE222 course "Architecture Engineering Construction (AEC) Global Teamwork" thanks to past partial sponsorship from NSF and MediaX. The course engages architects, structural and mechanical engineers, construction managers, and life cycle financial managers in a building design challenge. The duration of the class is 4 months, from mid-January to mid-May. The AEC multi-disciplinary teams were globally distributed at 12 partner universities worldwide (http://pbl-new.stanford.edu/AEC%20projects/projpage.htm). The AEC global teams used a 3D virtual world collaboration environment (TERF from 3DICC Inc.) and biometric/physiological sensor instrumentation to capture data during the course offering in 2014 and 2015. The data sets include: weekly two hour recordings of global project team meetings, and rich biometric/physiological data of brainwave collected with Neurosky Mindwave (Zhang and Fruchter, 2015, 2016), heart rate variability (HRV) collected with FirstBeat sensor (Frank et al, 2015), and body motion Kinect sensor data collected with PBL Lab's eRing cloud service (Ma and Fruchter, 2015). The 2015 digital learning data set was used for a first experimental pilot to develop and test the **Arche** interaction analytics, archetypes and indicators.

The rich data sets collected during the "AEC Global Teamwork" course allowed us to perform a longitudinal data analysis on different time domains from seconds to minutes, hours, days, weeks, and months to study team dynamics transformations.

AEC project team members determine the role of discipline specific knowledge in a cross-disciplinary PBL context. It is through cross-disciplinary interaction that the team becomes a community of practitioners. The mastery of knowledge and skills requires AEC students to move toward full participation in the socio-cultural practices of the AEC community. The negotiation of culture and professional language is critical to the learning process. By participating in a community of AEC practitioners, the students learn how to create discourse that requires constructing meanings of concepts and uses of skills (Dewey 1928, 1958; Greeno 1998; Lave & Wenger 1991; Wenger 1998). Key to this process is for each team member to build an awareness, appreciation, and understanding of the other disciplines (Fruchter & Emery 1999). "*Just because it is understood, does not mean it is understood*." – was a lessons learned by one of the AEC global students in this PBL course. How to effectively interact across time, space, disciplines, cultures, and technology are critical challenges global teams face as they aim to build common ground, develop new work processes, create a balanced team participation work practice to harvest everyone's knowledge and foster creativity.

To address such interaction challenges during communicative events in global teams, we aimed explored in the **Arche** concept-proving project the use of smart mobile and wearable devices:
- ubiquitous smart sensor devices and cloud-based services and applications that collect, track, and process in real-time body motion in real time;
- smartphones for real time voice streaming and emotion analytics, as well as feedback display i.e. individual interaction archetype and team interaction map.

To achieve these R&D goals we:

1. Developed a data collection and analysis protocol focusing on the two hour weekly project meetings.

2. Transcribed and coded weekly team meetings based on the constant comparative method by Strauss and Corbin (1990). The contextual video protocol analysis (VPA) focused on speech, roles, artifacts, tasks and activities. The coding method followed the approaches introduces by Fruchter and Courtier (2011). Coding themes focused on: (a) time participants spoke or were silent – talk/no talk, (b) discipline topic related to the five disciplines of the project, i.e. architecture, structural and mechanical engineering, construction management, and life cycle financial management, (c) artifacts such as plans, pictures, documents, etc. and (d) interaction type, e.g. brainstorming, problem solving, presentation, and negotiation. The aim of the coding was to interpret the dynamics of cross-disciplinary team interaction and identify interaction archetypes. Figure 2 illustrates the VPA results of one of global team meetings and an Arche mock-up GUI of these results on a mobile device.

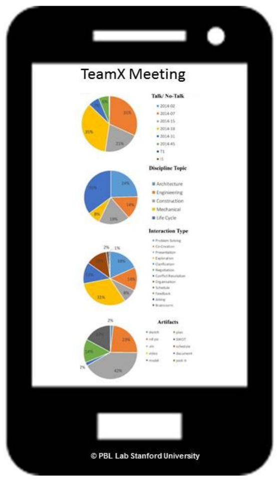

Figure 2. VPA results of one of global team meetings and
an Arche mock-up GUI of these results on a mobile device

3. Developed a talk/no talk feature taxonomy based on an in depth global meetings discourse analysis and produced an annotated/labelled meeting training data set.
4. Developed an algorithm to automatically identify talk/no talk features of any global meeting in our rich AEC Global Teamwork data set.
5. Developed a visualization tool to gain further insights and detect additional characteristics of the discourse interaction archetypes.
6. Tested the Arche visualization tool with the rich AEC Global Teamwork meeting data set.
7. Developed an algorithm to process mp4 video recordings from meetings and integrated it with a third party commercial application to perform speech digital signal processing to detect mood, arousal, valence, and temper of participants during project meetings. The results are aggregated at individual and team level.
8. Explored diverse mock-up GUI feedback options to visualize the mood, arousal, valence, and temper at individual and team level that could enable team members and the team to self-regulate and improve their future performance.
9. Developed moment-by-moment (sec-by-sec) body movement analytics, visualization, and behavior archetype identification algorithms. The body movement data sets of global learners were collected in real-time during the global team meetings using the PBL Lab eRing cloud-based application and service. The body movement analysis and indicators provide insights into nonverbal interaction and engagement patterns during communicative events.

10. Developed visualization tools that integrate the diverse indicators, e.g. talk/no talk, movement, mood, arousal, valence.
11. Identified performance indicators of productive, disruptive, and less effective interaction archetypes at individual and team level.

We will further consider experimenting and integrating other rich big data sets from ubiquitous, wearable physiological sensors such as Heart Rate Variability (HRV), brainwaves, as well as work space senor data and link them with smart wearable devices such as Google Cardboard for virtual reality (VR) immersive feedback, and Microsoft Hololens for augmented reality (AR) feedback of team interaction projected in the context of the physical/real world i.e. learning or work space.

We are currently in the process to document and submit to Stanford's Office of Technology Licensing (OTL) an invention disclosure of Arche.

Relevance to contextual futures for smart personal devices and thought leadership

The **Arche** concept-proving project explored and develop innovative analytics and indicators, and scientific breakthrough interaction archetypes that will provide a fresh lens through which researchers and educators can examine distributed PBL education programs and distributed knowledge work settings. The investigation lead to better understanding and future improvements of collaborative distance-learning and knowledge work, and will provide recommendations for further developments of smart devices, applications, and workspaces to improve learning, teamwork, and productivity.

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